# ST. JOSEPH'S COLLEGE (AUTONOMOUS)

# BENGALURU-27

Re-accredited with **'A++' GRADE with 3.79/4 CGPA** by NAAC
Recognized by UGC as College of Excellence

## DEPARTMENT OF BIOCHEMISTRY

**SYLLABUS FOR UNDERGRADUATE PROGRAMME**

# For Batch 2020-2023

# FOREWORD

## Board of Studies

The First four semesters of the Biochemistry syllabus for the batch 2020-2023 has been approved by the board of studies meeting held on 3rd May 2021..

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. Dr. Vishnu Janardhan, Industry Representative
4. Prof. Mohanadas, Professor of Chemistry, Department of Biochemistry, St. Joseph's College (Autonomous), Bangalore
5. Prof. Sandra Misquith, Professor of Chemistry, Department of Biochemistry, St. Joseph's College (Autonomous) Bangalore.

## Advisory Board Members:

The department would also like to place on record that the syllabus was designed keeping in mind the wide scope of the subject, the job potential and the future of the students who graduate in the subject. After consultation of several syllabi and obtaining the opinion of several prominent people in the field the syllabus was designed.
The members of the department would like to acknowledge all those who have greatly contributed to the framing of the syllabus. These include:

1. Prof. Jenny Loertscher, Prof. of Biochemistry, University of Seattle, USA
2. Prof.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.Devaraj, Chairman and Professor of Biochemistry, BCU
6. Prof.Sarada Subramanian, Professor of Neurochemistry, NIMHANS
7. Dr. Vishnu Janardhan Industry Representative (Scientist – 1)

# Part B

## B.Sc. BBZ Curriculum

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

# SUMMARY OF CREDITS IN BIOCHEMISTRY

| DEPARTMENT OF BIOCHEMISTRY (UG) (2020-2023) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **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-120 | Inorganic and Physical Chemistry | 60 | 04 | 04 | 30 | 70 | 100 |
| Practical | BCH-1P1 | Stoichiometry and Volumetric Analysis | 33 + 11 | 03 +1 | 02 | 15 | 35 | 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-220 | Physical and Organic Chemistry | 60 | 04 | 04 | 30 | 70 | 100 |
| Practical | BCH-2P1 | Physical Chemistry for biologists | 33 + 11 | 03 + 1 | 02 | 15 | 35 | 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-320 | Inorganic, environmental and organic chemistry | 60 | 04 | 04 | 30 | 70 | 100 |
| Practical | BCH-3P1 | Organic synthesis, purification and characterisation | 33 +11 | 03 + 1 | 02 | 15 | 35 | 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-420 | Analytical techniques in Chemistry - 1 | 30 | 02 | 02 | 15 | 35 | 50 |
| Theory | BCHOE-420 | Introduction to Forensic Science | 30 | 02 | 02 | 15 | 35 | 50 |
| Practical | BCH-4P1 | Separation, isolation and characterization of biomolecules | 33 + 11 | 03 + 1 | 02 | 15 | 35 | 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-5120 | Elements, molecules and macromolecules | 45 | 03 | 03 | 30 | 70 | 100 |
| Practical | BCH-5P1 | Estimation of food quality and identification of adulterants | 33 + 11 | 03 + 1 | 02 | 15 | 35 | 50 |
| Theory | BCH-5220 | Analytical techniques in Chemistry -2 | 45 | 03 | 03 | 30 | 70 | 100 |
| Practical | BCH-5P2 | Project work -I | 44 | | | - | - | - |
| **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-6120 | Bioenergetics and biological oxidation, metabolism and diseases of metabolism | 45 | 03 | 03 | 30 | 70 | 100 |
| Practical | BCH-6P1 | Enzymology and nucleic acid chemistry | 33 + 11 | 03 +1 | 02 | 15 | 35 | 50 |
| Theory | BCH-6220 | Recent developments in the field of Biochemistry | 45 | 03 | 03 | 30 | 70 | 100 |
| Practical | BCH-6P2 | Project work - II | 44 | | 02 | 30 | 70 | 100 |
| **Total Number of credits:** | | | | | 10 | | | |

| **CORE COURSES (CC)** | |
|---|---|
| Course Title | Code Number |
| Inorganic and Physical Chemistry | BCH-120 |
| Physical and Organic Chemistry | BCH-220 |
| Inorganic, Environmental and Organic Chemistry | BCH-320 |
| Analytical techniques in Chemistry - 1 | BCH-420 |
| Introduction to Forensic Biochemistry using case studies | BCHOE - 420 |
| Elements, molecules and macromolecules | BCH-5120 |
| Analytical techniques in Chemistry - 2 | BCH-5220 |
| Bioenergetics, biological oxidation, metabolism and diseases of metabolism | BCH-6120 |
| Recent developments in the field of Biochemistry | BCH-6220 |
| Volumetric Analysis | BCH-1P1 |
| Physical chemistry practical | BCH-2P1 |
| Organic synthesis, separation, purification and identification of groups | BCH-3P1 |
| Separation, isolation and characterization of biomolecules | BCH-4P1 |
| Estimation of food quality and identification of adulterants | BCH-5P1 |
| Project Work - I | - |
| Enzymology and nucleic acid chemistry | BCH – 6P1 |
| Project Work -II | BCH – 6P2 |

| DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE) | |
|---|---|
| Course Title | Code Number |

| GENERIC ELECTIVE COURSES (GSE)[For Physical Sciences, Arts and Commerce UG Students] | |
|---|---|
| Course Title | Code Number |
| Introduction to Forensic Sciences | BCHOE- 420 |
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| SKILL ENHANCEMENT COURSE (SEC) – Any practical oriented and software based courses offered by departments to be listed below | |
|---|---|
| Course Title | Code Number |
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| VALUE ADDED COURSES (VAC) Certificate courses that add value to the core papers can be listed | |
|---|---|
| Course Title | Code Number |
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| 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 120** |
| Paper Title | **Inorganic and Physical Chemistry** |
| Number of teaching hours per week | 04 |
| Total number of teaching hours per semester | 60 |
| Number of credits | 04 |

**Objectives of the paper:**

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

**Course Content:**

**Atomic structure:** In this unit students will study the fundamentals of atomic structure that will help them conceptualize how an atom appears.
Electromagnetic radiation – (wave length, frequency, velocity, wave number) electromagnetic spectrum, Nature of wave particle.
Quantum numbers & their significance (Principal quantum number, Azimuthal quantum number(1) , Magnetic quantum number (m) and Spin quantum number [s] )
Shapes of Atomic orbitals – s, p and d orbitals.
Pauli Exclusion Principle, Aufbau Principle, Hund's rule of maximum multiplicity-cause of stability of half-filled and completely filled energy levels.
Electronic configuration of elements up to At No.54, (n+l rule, 2n2, order of energy levels to be followed)
Oxidation numbers – concept, difference between valency and oxidation number, and computation. Calculation of equivalent weights of oxidising and reducing agents. (Self-study) **10 h**

**Chemical bonding:** Students will be able to not only conceptualise how molecules are formed from atoms but be able to create models of any molecule real or imaginary by knowing and understanding the forces that hold atoms together.
Ionic bond -factors favouring formation – lattice energy – energetics of Ionic bond formation (NaCl as example). Born – Haber cycle – for NaCl. Calculation of lattice energy; Characteristics of ionic compounds (self-study).
Covalent bond- definition, pictorial representation of covalent bond formation in $H_2$, HCl, $NH_3$, $CO_2$ and $N_2$.
Valence bond theory – postulates, Sigma and pi bonds Hybridization of orbitals and directoral characteristics – sp,$sp^2$, $sp^3$(egs- methane, ethene and acetylene) Resonance forms of $H_2$ and Benzene. VSPER theory-Shapes of $H_2O$, $NH_3$, $H_3O^+$, $SF_4$,$ClF_3$ and $ICl^-$
Molecular Orbital Theory – postulates, atomic orbitals and molecular orbitals; conditions for the formation of molecular orbitals. LCAO – Bonding and antibonding molecular orbitals; comparison between bonding and

antibonding molecular orbitals. Shapes of molecular orbitals (by s-s, s-p, p-p overlap) – pictures to be given. Molecular orbital diagrams for the formation of $H_2$, He and $O_2$. Polarisation concept, Fajan's rule, bond length, bond angle and bond energy, dipole moment. Coordinate bond – Donor, acceptor, representation of the formation of co-ordinate bond in $H_3O^+$, $NH_4^+$. Chelates – ligands, chelates in biological systems (mention chlorophyll, vitamin $B_{12}$, haeme, catalase as examples) Hydrogen bond – inter and intramolecular hydrogen bond- anomalous properties of HF, $H_2O$, $NH_3$ and nitro phenols; Van- der Waals forces – definition. Concept of hydrophobic interactions. **15 h**

**Liquids:** As the living system is mainly composed of water, students require to possess a thorough understanding of liquids and their properties to correlate it with the functioning of living organisms. This unit seeks to give them a fundamental understanding of liquids.
Properties of liquids –vapour pressure, viscosity and surface tension. Relationship between vapour pressure and boiling point, freezing point-heat of fusion.
Viscosity-Definition, units, experimental determination using Ostwalds viscometer. Viscosity and shape/size of molecules.
Surface tension:- Definition, units, experimental determination using stalagmometer. Surfacants – effect of sufactants on surface tension.
Viscosity and Surface tension in everyday life (self-study). **6h**

**Solutions and Colligative properties:** Most living tissues like blood tears, etc are solutions, an understanding of solutions and their properties are required to understand the living system.
Concentration units – molarity, molality, normality, mole fraction – simple problems (self study).
Types of solutions – homogenous and heterogeneous, factors influencing solubility– nature of solvent, solute, temperature, pressure and practice size. Solubility curves– plots showing solubility of sodium chloride, potassium nitrate, lead nitrate and sodium sulphate against temperature. Henry's law – statement, Applications. Colligative properties– Definition, Relative lowering of vapour pressure. Raoults' law of relative lowering of vapour pressure, Osmosis- preparation of copper ferrocyanide semi permeable membrane,
Osmotic pressure – measurement by Berkley – Hartley method. Theory of dilute solutions – Laws of osmotic pressure - Van't Hoff Boyle's law, Van't Hoff Charles' law and Avogardro's law. Hypo-, hyper- and isotonic solutions. Donnan membrane equilibrium and its applications. Elevation in boiling point, ebullioscopic constant. Depression in freezing point, cryoscopic constant. Limitations of colligative properties. Abnormal molecular weights and the van't Hoff factor – degree of association, Degree of dissociation
Simple problems related to the above topics (self-study) **9h**

**Acids, Bases and Buffers:** To understand how the pH is maintained in the living system a basic knowledge of acids, bases and buffers is essential. In this unit students will be exposed to these fundamentals that will help them analyse and appreciate the need to maintain pH in the living system.
Modern concepts of acids and bases - Arrhenius, Lowry - Bronsted and Lewis concepts. Limitations of each concept.
Strong and weak acids - ionisation constant $K_a$ and $pK_a$ of weak acids, comparison of acid strength on this basis,
Ionic product of water, common ion effect, solubility product and ionic product of sparingly soluble salts and conditions for precipitation. and in qualitative analysis –in prediction of selective precipitation of second and forth group basic radicals, precipitation of third group basic radicals.
Hydrolysis of salts– pH of salt solutions. Hydrogen ion concentration- pH, *pH of some biological fluids and its importance (*self-study*).*
Buffers-definition, types, buffer action and buffer capacity. pH of buffers-Henderson– Hasselbalch equation-derivation, preparation of buffers, problems. *Biological buffers (self-study)* **10 h**

**Electrochemistry:** Most reactions occurring in the living system are redox reactions. The basics of electrochemistry will act as the foundation for understanding these reactions.
Strong and weak electrolytes – definition and examples (self-study).
Activity and activity coefficient – concepts. Activity and mean activity of the electrolyte. Mean ionic activity. Ionic strength- classification of electrolytes as 1:1, 2:2, 2:1 electrolytes with examples.
Electrochemical cells: conventions of representing galvanic cells, half-cell reactions and cell reaction;
Reversible electrodes and cells – definition. Types - Cation reversible electrode, anion reversible electrode, redox

electrode. (Examples and electrode reactions to be given)
Single electrode potential – Nernst equation, Factors affecting single electrode potential.
Standard Electrode Potential (definition). Reference electrodes – primary reference (Standard hydrogen electrode), secondary reference electrodes (calomel, quinhydrone and glass electrodes).
Electrochemical series- to predict the ease of oxidation, displacement reaction to calculate standard emf of cell;
Ion selective electrodes- concept, types and applications. **10 h**

References


1. General Chemistry: The essential concepts by Raymond Chang and Jason Overby 6th Edition (Indian). Publishers: University Science Books
2. Physical Chemistry for biosciences 11th edition by Raymond Chang Publishers: University Science Books
3. Physical chemistry for biologists by 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 120**

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

| Topic | Number of Hours | Total marks for which the questions are to be asked (including bonus questions) |
|---|---|---|
| Atomic Structure | 10 | 16 |
| Chemical Bonding | 15 | 24 |
| Liquids | 6 | 9 |
| Solutions and Colligative properties | 9 | 15 |
| Acids bases and Buffers | 10 | 16 |
| Electrochemistry | 10 | 16 |
| | | |
| **TOTAL** | **60** | **96** |
| **Maximum marks for the paper (Excluding bonus question)= 70** | | |

# Practical I

## BCH 1P1 – Volumetric analysis

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

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

**Course Content:**
Errors & Standard Deviation: Exponential notation – expression of a large number in an exponential form; purposes, positive and negative powers of 10.
Graphical representation of data – Types of graphs, Advantages of showing data in graphical form.
Calibration of glass ware; Introduction to Volumetric Analysis-Estimation of NaOH using Std. HCl
Introduction to RBPT
Estimation of HCl using Std. $Na_2CO_3$
Redox Titration $KMnO_4$ with Oxalic acid
Define RBPT problem
Complexometric titration: Estimation of $Zn^{2+}$ using EDTA
Preparation of RBPT CHARTS.
Presentation of the charts by each group.
Discussion of materials required.
Preparation of solutions
Standardize / check solutions
Do the main experiments individually

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

Repetition
Viva

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

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

| | |
|---|---|
| Semester | II |
| Paper Code | **BCH 220** |
| Paper Title | **Physical and Organic Chemistry** |
| Number of teaching hours per week | 04 |
| Total number of teaching hours per semester | 60 |
| Number of credits | 04 |

**Objectives of the paper:**

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

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

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

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

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

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

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

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

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

**Assignment Topic:** Thermodynamics of nitrogen fixation **6 h**

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

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

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

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

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

**Assignment Topic:** ATP and its role in biosynthesis **3 h**

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

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

Integrated rate law- first order (no derivation) - half-life period-numericals on half-life period
Pharmacokinetic analysis- rate constant for second order reaction- determination of rate constant by graphical method.
The temperature dependence of reaction rates- The Arrhenius equation-Determination of Arrhenius parameters-numericals
**Assignment Topic:** Enzyme mechanisms **6 h**

**Phase rule:** This unit strives to illustrate how phases coexist. This will help students to appreciate the coexistence of polar and non-polar substances that go to making up the living system
Definitions of Phase & Components, Criterion of phase equilibrium, Gibb's phase rule (no derivation) . Application of phase rule to one component system –water system, Two component system-water-potassium iodide (freezing mixtures). Solutions of liquids in liquids– ideal solutions and Raoult's and Henry's law. Non-ideal solutions-vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions- azeotropes –HCl - $H_2O$ and water-ethanol system. Distillation of solutions-Lever rule. Partial miscibility of liquids (Water – Phenol). Critical Solution Temperature (lower and upper). Effect of impurity on CST. Immiscibility of liquids. Principle of steam distillation. Nernst distribution law- statement, deviations from distribution law due to association and dissociation of the solute in one of the solvents. Applications of distribution law– solvent extraction. **10 h**

**Colloids**
Types of colloidal systems, electrical properties of colloids. Emulsions and emulsifiers; Gels; *Applications of emulsions in lipid chemistry (self-study).* **2 h**

**Introduction to Organic Chemistry:** Students will be introduced to the compounds of carbon that occur naturally. They will correlate what they have studied in earlier units of both first and second semester with the study of carbon compounds.
Structural formulas: dash, condensed and bond-line formulas.
Resonance theory, curved arrows in resonance structures, rules for writing resonance structures, resonance contribution.
Physical properties and molecular structures of organic compounds, ionic compounds: ion– ion forces, intermolecular forces (van der Waals forces), boiling points, solubilities.
Use of curved arrows in illustrating reactions,
Heterolysis of bonds: carbocations and carbanions, electrophiles and nucleophiles,
Strengths of Bronsted-Lowry acids and bases; the acidity constant $K_a$; acidity and $pK_a$; predicting the strength of bases,
Relationship between structure and acidity. Effect of hybridization, inductive effect and delocalization on acidity: carboxylic acids versus alcohols.
Comparisons of conjugate acid–base strengths based on inductive effects of other functional groups.
Effect of Solvents on acidity.
Organic compounds as bases
*Self-study: Functional groups: alkyl halides, alcohols, phenols, ethers, amines, aldehydes and ketones, carboxylic acids, esters, amides and nitriles, end chapter problems.* **7 h**

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

IUPAC nomenclature of alkanes; branched alkanes; cycloalkanes. alkyl halides, alcohols, alkenes, cycloalkenes and alkynes
Physical properties of alkanes;
Conformations- Newman projection and sawhorse formula.
Conformational analysis of ethane; butane.
Relative stabilities of cycloalkanes-ring strain. Conformations of cyclohexane. Axial and equatorial bonds of cyclohexane. Monosubstituted cyclohexane **8h**

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

Enantiomers and chiral molecules; molecules with one chiral centre;
Test for chirality: plane of symmetry;
Naming enantiomers in the R, S- system. D,L system of nomenclature.
Optical activity. Molecules with more than one chiral centre. Fischer projection formula.
Separation of enantiomers, resolution.
Significance of Chirality in biological system. **8 h**

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

Alkyl halides nomenclature (revise); Nucleophilic substitution reaction, Kinetics of $SN_2$ reaction, mechanism and stereochemistry of $SN_2$ reaction. Kinetics of $SN_1$ reaction, mechanism and stereochemistry of $SN_1$ reaction. Carbocations structure and stability. Racemisation. Factors affecting $SN_1$ and $SN_2$ reactions. Elimination reactions of alkyl halides. The $E_2$ and $E_1$ reaction mechanisms. Substitution versus elimination. **10 h**

References


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


## BLUEPRINT

Code number: **BCH 220**

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

| Topic | Number of Hours | Total marks for which the questions are to be asked (including bonus questions) |
|---|---|---|
| Biochemical thermodynamics | 6 | 10 |
| Chemical Equilibrium | 3 | 5 |
| Kinetics of life processes | 6 | 10 |
| Phase rule | 10 | 16 |
| Colloids | 2 | 3 |
| Introduction to Organic | 7 | 11 |

| | | |
|---|---|---|
| chemistry | | |
| Alkanes | 8 | 12 |
| Stereochemistry | 8 | 13 |
| Alkyl halides | 10 | 16 |
| **TOTAL** | **60** | **96** |
| **Maximum marks for the paper (Excluding bonus question)= 70** | | |

## Practical II

## BCH 2P1 – Physical Chemistry Practical

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

**Course Objectives:**

This course aims to make students learn how various physical parameters can be determined. By the end of this course students should be able to critically analyse and execute experimental techniques on all the theoretical concepts they have 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 percentage composition of a binary mixture by viscosity method.
3. Determination of density and surface tension of a given liquid using a stalagmometer.
4. Determination of standard electrode potential.
5. Potentiometric estimation of FAS
6. Determination of $pK_a$ of a weak acid
7. Molar conductance of electrolytes.
8. Enthalpy of fuels
9. Any other suitable experiment.
10. RBPT
11. Viva

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

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

| | | |
|---|---|---|
| | | have studied. |

| | |
|---|---|
| Semester | III |
| Paper Code | **BCH 320** |
| Paper Title | **Inorganic, Environmental and Organic Chemistry** |
| Number of teaching hours per week | 04 |
| Total number of teaching hours per semester | 60 |
| Number of credits | 04 |

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

**Course Content:**

**Bio-inorganic and Environmental Chemistry**: This unit focusses on the role of metal ions in the biological system.

Metal ions in biological systems; Transition metal ions and oxidation states;
Types of ligands; Role of iron in myoglobin, haemoglobin and cytochromes; Copper in haemocyanin, Magnesium in chlorophyll, Cobalt in vitamin B-12 and Molybdenum in nitrogenase; Metalloenzymes;
Geometrical and optical isomerism in coordination complexes. **8 h**

**Environmental Toxicology:** In this unit the biochemical hazards of the use of chemicals in the environment will be studied

Biochemical toxicology- toxicity and detoxification of Pb, Hg, Cd. LD and ED values of major toxicants. Water pollution: Treatment of sewage and industrial effluents (tanning and electroplating); Pesticides hazards – DDT, Malathion, lindane and 2,4-D. Brief Introduction to Bioremediation and Phytoremediation with applications. **7 h**

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

Alkenes and alkynes nomenclature. E, Z system of designating alkene, diastereomers;
relative stabilities of alkenes; Electrophilic addition of HX to alkenes: mechanism; Markovnikov's rule.
Acid catalysed hydration of alkenes; Oxidative cleavage of alkenes.
1,3-butadiene; stability of conjugated dienes; 1,4 addition, kinetic vs thermodynamic control. Diels Alder reaction.
Acidity of terminal alkynes and their utility as nucleophiles in C-C bond formation. **7h**

**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, regioselectivity– examples**4 h**

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

Preparation of organolithium and organomagnesium compounds. The Grignard reaction. Reactions of organolithium and organomagnesium compounds with compounds containing acidic hydrogen; epoxides. Alcohols from Grignard reagents. **3 h**

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

Modern theories of the structure of benzene. Huckel rule; aromatic, antiaromatic and nonaromatic species in benzenoid and heterocyclic systems (5 and 6 membered rings with examples from biological systems). General mechanism of electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel-Crafts acylation and alkylation). Influence of substituents (alkyl; -OH, halogen and nitro) on the reactivity of the ring and the orientation of the incoming electrophile. Acidity of phenols. Kolbe reaction and Reimer Tiemann reaction**10 h**

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

Synthesis of aldehydes by the oxidation of primary alcohols and by the reduction of acyl chloride, esters and nitriles.
Synthesis of ketones by ozonolysis, oxidation of secondary alcohols, Friedel Craft's reaction and using Grignard reagent.
Nucleophilic addition to carbonyl compounds: mechanism of addition using strong nucleophiles and acid catalyzed nucleophilic addition. Relative reactivity of aldehydes and ketones.
Addition of alcohols - hemiacetals and acetals, mechanism of acid-catalysedacetal formation.
Addition of amines (primary and secondary amines, hydrazine and hydroxylamine).
Addition of HCN - mechanism. Wittig reaction (no mechanism, few examples).
Oxidation of aldehydes and ketones; acidity of α-hydrogen, enolate ion.
Keto enol tautomerism; Base-catalysed aldol reaction, dehydration of aldol product (mechanism of both), crossed aldol reactions.
Claisen-Schmidt reaction (mechanism excluded). Addition to α, β-unsaturated aldehydes and ketones (mechanism excluded). Michael addition (mechanism excluded) **10 h**

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

Preparation of carboxylic acids by the oxidation of aldehydes and primary alcohols; hydrolysis of cyanohydrins, nitriles; and by carbonation of Grignard reagents.
Nucleophilic substitution at the carboxylic carbon - general mechanism.
Relative reactivity of acid derivatives.
β- dicarbonyl compounds: acidity, Claisen condensation with mechanism, crossed Claisen condensation. Acetoacetic ester synthesis – alkylation and acylation. Malonic ester synthesis – alkylation.**7 h**

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

Basicity of amines, comparison of basicity of 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's rearrangement.
Action of nitrous acid on 1º, 2º and 3º amines. Replacement reactions and coupling reactions of arenediazonium salts. Hofmann elimination. **4 h**

References


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


## BLUEPRINT

Code number: **BCH 320**

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

| Topic | Number of Hours | Total marks for which the questions are to be asked (including bonus questions) |
|---|---|---|
| Bioinorganic and environmental chemistry | 8 | 13 |
| Environmental toxicology | 7 | 11 |
| Alkenes and Alkynes | 7 | 11 |
| Alcohols, ethers and epoxides | 4 | 7 |
| Aldehydes and ketones | 10 | 16 |
| Organometallic compounds | 3 | 5 |
| Aromatic hydrocarbons | 10 | 16 |
| Carboxylic acids | 7 | 11 |
| Amines | 4 | 6 |
| **TOTAL** | **60** | **96** |

# Practical III

## BCH 3P1 – Organic synthesis, purification and characterisation
## (11 sessions 3h/week + 1 h/ week self-study)

**Course objectives:**

Develop skills to prepare useful organic compounds in the laboratory.
Analyse common organic reagents and compounds based on their properties.
Apply the properties of functional groups of organic compounds to carry out selective organic reactions.
Verify reactivity of organic functional groups.

**Course content:**

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

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

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

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

| | | |
|---|---|---|
| CO3 | Create | Be able to develop strategies for the synthesis of new compounds and for the analysis of molecules in the environment. |

| | |
|---|---|
| Semester | IV |
| Paper Code | **BCH 420** |
| Paper Title | **Analytical techniques in Chemistry - 1** |
| Number of teaching hours per week | 02 |
| Total number of teaching hours per semester | 30 |
| Number of credits | 02 |

**Objectives of the paper:**
This paper aims to expose students to basic analytical techniques which will help them in future to analyse structure function relationships of molecules

**Course Content:**

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

*Types-Crystalline and Amorphous. Size and Shapes (self-study).*
Definition of Space Lattice and Unit cell.
Symmetry elements in crystals.
Laws of Crystallography, Weiss and Miller Indices with simple numericals.
Crystal systems with examples.
Defects in crystalline solids – Schotky&Frenkel defects.
X – ray; diffraction of crystals - Braag's equation. Advantages and disadvantages of studying the structure of biomolecules by X-ray crystallography **8 h**

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

Fundamental laws relating to photochemistry. Chemiluminescence; Bioluminescence; Photocatalysis and photochemical reactions.**3 h**

**Spectroscopy – Theoretical aspects:**
Ever since the discovery of the hydrogen spectrum the different wavelengths of light have been exploited to study molecular structure. This unit gives the student the fundamentals behind the use of 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 λmax, Є and A, observed transitions in a typical UV-vis spectrum, effect of conjugation on λmax.
Spectrophotometry including ELISA and their applications in biological investigations / experiments. **3h**

**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. **3 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.**7 h**

**Mass Spectrometry:**
Basic principles of mass spectrometry –soft ionization techniques – applications of MALDI and SELDI for understanding biomolecules.
Self Study: Analysis of different types of spectra and identification of simple compounds **3 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


## BLUEPRINT

Code number: **BCH 420**

Title of the paper: **Analytical techniques in Chemistry - 1**

| Topic | Number of Hours | Total marks for which the questions are to be asked (including bonus questions) |
|---|---|---|
| Solids and X-ray crystallography | 9 | 14 |
| Photochemistry | 3 | 5 |
| Spectroscopy – theoretical aspects | 4 | 6 |
| UV Spectroscopy | 3 | 5 |
| IR spectroscopy | 3 | 5 |
| NMR Spectroscopy | 6 | 10 |
| Mass spectrometry | 2 | 3 |

| | | |
|---|---|---|
| **TOTAL** | **30** | **48** |

## Practical IV

## BCH 4P1 – Separation, isolation and characterization of biomolecules

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

**Course objectives:**

Students will be introduced to the 30 basic molecules that constitute life.
The students will obtain hands-on training in basic separation techniques in biochemistry like electrophoresis, chromatography, etc.
Gain expertise in the isolation and characterization of various biomolecules

**Course content:**

- Brief introduction to biomolecules – their structure and properties
- Separation of plant pigments using paper chromatography.
- Separation of plant pigments by column chromatography using silica gel-G.
- TLC of amino acids.
- SDS-PAGE
- Identification of functional groups by qualitative tests of biomolecules
- Identification of functional groups by IR spectroscopy
- Determination of amount of reducing sugar by DNS method
- Estimation of amino acids by Cd-Ninhydrin method
- Estimation of RNA by orcinol method
- Estimation of DNA by diphenylamine method
- Viva

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

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

| | | |
|---|---|---|
| CO4 | Create | Be able to develop strategies for studying and understanding the structure of molecules and extend it to biomolecules. |

| | |
|---|---|
| Semester | IV |
| Paper Code | **BCHOE 420** |
| Paper Title | **Introduction to Forensic Science** |
| Number of teaching hours per week | 02 |
| Total number of teaching hours per semester | 30 |
| Number of credits | 02 |

**Objectives of the paper:**
This is a 30 hour paper offered for non-biological science students from the arts and commerce. It will introduce them to biochemistry and how it is used to solve forensic data. They will learn to assess cases and try to apply what they have studied to real life situations.

**Course content:**

**Introduction:**

In this unit students will be exposed to the following questions:
What is Forensic biochemistry? A short preview on the development of the subject will be presented.
What are the applications of forensic biochemistry? A brief overview will be discussed to help students get acquainted with terms used in science. **3 h**

**Analysis of evidence found at the crime scene:**

Using an interdisciplinary approach of biology, chemistry, physics and genetics students will be able to identify and analyse material at the crime scene. They will learn how to record data and write a report of their findings.**3 h**

**Qualitative analysis of evidence:**

In this unit students will be introduced to various methods (chemical and biochemical) used to identify non-human biological material.
They will be introduced to different toxins/poisons commonly used and identified in forensic laboratories.
They will also be given a short overview of the mechanism by which these toxins act that result in death.
Students will learn of overdose of drugs. Drugs will be classified by their mode of action and commonly used drugs like analgesics, cannabis, antihistamines, antidepressants, benzodiazepines and "Z" drugs, stimulants, alcohol etc. will be identified by spot tests.**10 h**

**Study of body fluids using separation analysis and optical methods:**

Students will be introduced to different body fluids that are collected at the crime scene.
They will learn how these fluids are identified and what information can be obtained from their analysis.
They will understand the workings of the techniques used for the identification of body fluids including, chromatographic

and electrophoretic techniques, and microscopy.**8 h**

**DNA testing to find out relationship between two humans or between animals:**

In this section students will develop an understanding of what DNA is (brief structure discussion). They will also be given a basis for the method by which DNA is tested – PCR, sequencing (finger printing) and cloning.**6 h**

References:


1. Forensic Science: - A Very short introduction Jim Fraser 2nd Edition Publishers: Oxford University Press
2. Introduction to criminal investigations: Processes, practices and thinking R. Gehl and D. Plecas Publishers: BC Campus
3. Forensic Analysis and DNA in Criminal Investigations: Including Cold Cases Solved by RJ Parker, Hartwell Editing (Editor), Publishers: R J Parker


## BLUEPRINT

Code number: **BCHOE 420**

Title of the paper: **Introduction to Forensic Science**

| Topic | Number of Hours | Total marks for which the questions are to be asked (including bonus questions) |
|---|---|---|
| Introduction | 3 | 5 |
| Analysis of evidence | 3 | 5 |
| Qualitative analysis of evidence | 10 | 16 |
| Study of body fluids using separation analysis and optical methods | 8 | 12 |
| DNA testing | 6 | 10 |
| **TOTAL** | **30** | **48** |

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

| | | |
|---|---|---|
| CO4 | Knowledge | Have developed an understanding of basic concepts in forensic science. |
| CO4 | Understand | Have developed a very good understanding of methodologies used to solving forensic problems |
| CO4 | Apply | Be able to logically deduce the methodologies used in this field |
| CO4 | Analyze | Be able to analyse data and be able to conclude the reasons behind the analysis. |

| | | |
|---|---|---|
| CO4 | Evaluate | Be able to critically evaluate the results obtained and decide the quality of the analysis |
| CO4 | Create | Be able to develop strategies for studying and understanding case studies in forensic science. |

| | |
|---|---|
| Semester | V |
| Paper Code | **BCH 5120** |
| Paper Title | Elements, molecules and macromolecules |
| 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 the elements, molecules and macromolecules that make up the living system. They will appreciate the structure function relationship that exist and understand why elements were chosen for the role they play in the biological system

**Introduction to biochemistry:** **4 h**

- Understanding how life evolved: - insights from the big bang theory to life on earth in order to create scientific interest amongst students in lifeprocesses. Special focus on the scientists who have contributed to our understanding. **1h**
- Fundamental properties of elements, their role in formation of biomolecules and in chemical reactions within livingorganisms. **2h**
- Unique property of water as a universal solvent and its importance in biological system. **1h**

**Biomolecules:**To understand the structure and properties of:

a. **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 importancein biological systems. **6 h**

b. **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. Function of some biologically important peptides – insulin, vasopressin, bradykinin, and some antibiotics.
Proteins – classification based on (i) structure (ii) composition (iii) function with appropriate examples. Structural analysis of proteins – primary, secondary and tertiary structure. Quaternary structure. Understanding protein architecture using haemoglobin as example.**8 h**

**c. 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**

**Enzymology** **8 h**

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

**Biomembranes and their characteristic features**: **6 h**

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

**Biochemical nutrition** **9 h**

- To learn about the glycemic index, balanced diet, micronutrient deficiencies and its remedies, nutraceuticals and their importance, junk foods and theirhazards.
- To understand the need for specialized food for people with special needs - diabetes, pregnancy, inherited geneticdisorders.

- To understand the biochemistry behind lifestyle diseases and how to avoid them – a brief glimpse at the sleep wake cycle, circadian clock and its role in metabolic regulation.

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


## BLUEPRINT

Code number: **BCH 5120**

Title of the paper: **Elements, Molecules and Macromolecules**

| Topic | Number of Hours | Total marks for which the questions are to be asked (including bonus questions) |
|---|---|---|
| Introduction to biochemistry | 4 | 8 |
| Carbohydrates | 6 | 13 |
| Proteins | 8 | 17 |
| Lipids | 4 | 8 |
| Enzymes | 8 | 18 |
| Biomembranes | 6 | 13 |
| Biochemical nutrition | 9 | 19 |
| **TOTAL** | **45** | **96** |

# Practical V

## BCH 5P1 – Estimation of food quality and identification of adulterants

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

**Course objectives:**

- Training in the determination of moisture infood.
- To test adulteration in food and determination of minerals, amino acids and sugars in foods.
- To acquire training to determine saponification value and iodine value of oil and different types offats.

**Practical content**

- Determinationof
  a. Moisture content offoods
  b. Adulterants infood
  c. Calcium inragi
  d. Iron indrumsticks.
- Estimation of vitamin-C in lemon andgooseberries.
- Gravimetric estimation of sulphate as bariumsulphate.
- Estimation of proteins using biuret method
- Estimation of reducing sugars by Hedgedon and Jensenmethod.
- Determination of saponification value of oil orfat.
- Determination of iodine value of oil orfat.
- 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 5220** |
| Paper Title | **Analytical techniques in Chemistry - 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 will be exposed to various analytical techniques that are used to study biomolecules and biomolecular processes.

**Course Content:**

**Separation techniques – centrifugation, chromatography andelectrophoresis 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. **5h**
- Purify proteins by affinity chromatography using epitope tags such as histidine tag, GST tag, Flag tagetc. **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.

**Radioisotopes and their applications: 10 h**

*In this unit students will get a basic understanding of what are 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 (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.
- Detection of radioactivity – GMcounter and scintillation counters (only principal and working)
- Apply the principles of radiochemistry to analytical determination of biomolecules and lifeprocesses.
- Radio immunoassays and radio labeling studies to understand how molecules interact and how they are distributed within a cell.
- Radiolabeling studies to understand how metabolic reactions are taking place
- Safety measures

**Sequencing techniques for proteins,nucleic acids and carbohydrates: 15 h**

In this unit students will be given a comprehensive idea as to how major macromolecules are sequenced and the

importance ofobtaining 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) **3 h**
Cleavage by current methods used for protein sequencing – Automated sequenator.**2 h**
Study the discovery of DNA as genetic material, DNA replication, transcription, DNA repair and translation.**5 h**
DNA sequencing by dideoxynucleotide method. Oligonucleotide synthesis for RNA primers. **2 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


## BLUEPRINT

Code number: **BCH 5220**

Title of the paper: **Analytical techniques in Chemistry - 2**

| Topic | Number of Hours | Total marks for which the questions are to be asked (including bonus questions) |
|---|---|---|
| Separation techniques – centrifugation, chromatography and electrophoresis | 20 | 42 |
| Radioisotopes and their applications | 10 | 22 |
| Sequencing techniques for proteins, nucleic acids and carbohydrates | 15 | 32 |
| **TOTAL** | **45** | **48** |

## Practical VI

## BCH 5P$_2$– 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 | VI |
| Paper Code | **BCH 6120** |
| Paper Title | Bioenergetics, biological oxidation, metabolism and diseases of metabolism |
| 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:**

**Bioenergetics and biological oxidation:** **7 h**

- To learn basic concepts of Bioenergetics,
- Understanding the importance of high energy compounds, electron transport chain; synthesis of ATP under aerobic and anaerobicconditions.
- mechanisms of oxidative phosphorylation andphotophosphorylation.
- To learn the concept and mechanism of ATPsynthesis.

**Metabolism**: **24 h**

Carbohydrate metabolism - Glycolysis and the TCA cycle, gluconeogenesis and the concept of psuedocycles.
To acquire knowledge related to the role of TCA cycle in central carbon metabolism, importance of anaplerotic reactions and redoxbalance.

Lipid metabolism: B-oxidation of fatty acids and an overall view of the synthesis of cholesterol.

Protein and amino acid metabolism: Source and fate of proteins in humans. Production of important molecules from amino acids by transamination, deamination and decarboxylation.
To gain insight into nitrogen metabolism in aquatic and terrestrial animals and the role of kidney inerythropoiesis. Urea cycle
Regulation of metabolic processes with examples from above mentioned processes

**Metabolic disorders and metabolic markers of disease:** **13 h**

- To become aware of the variations in the levels of trigycerides and lipoproteins and their relationship with variousdiseases.
- To gain awareness on muscular dystrophies, the role of steroids in muscle building and the use of hormones in cattle and poultryindustry.
- To learn about the normal constituents of urine, blood and their significance in maintaining goodhealth.
- Exposure to the mechanisms of causation of diseases of liver andkidney.
- Appreciation of the fact that differences in the properties of metabolic enzymes of the host and pathogens can be exploited for the development of newdrugs.
- Togaininsightsintometabolicengineeringfortheproductionofusefulbiomolecules.. Develop understanding of the current concepts related to mechanism ofcancer.

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 6120**

Title of the paper: **Bioenergetics, biological oxidation, metabolism and metabolic diseases**

| Topic | Number of Hours | Total marks for which the questions are to be asked (including bonus questions) |
|---|---|---|
| Bioenergetics and Biological oxidation | 8 | 18 |
| Metabolism | 24 | 52 |
| Metabolic disorders and metabolic markers of disease | 13 | 26 |

| TOTAL | 45 | 96 |
|---|---|---|

## Practical VII

## BCH 6P1 – Enzymology and Nucleic acid Chemistry

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

**Course objectives:**

- To understand the concepts for preparation ofbuffers.
- Acquiring training to estimate activity ofenzymes.
- To determine pH optimum, Km and Vmax of enzymes and to analyse enzyme kinetics.
- To determine optimum temperature for the activity of anenzyme.
- Acquire learning to isolate RNA, DNA, total nucleic acids and total RNA from bacteria, yeast and plant tissues and to check for purityusing absorption maxima and agarose gel electrophoresis.

**Practical content:**

- Preparation of triple buffer using the phosphate-citrate system and determination of pH using pHmeter.
- Isolation of urease and demonstration of itsactivity
- Isolationofacidphosphataseanddemonstrationofitsactivity
- DeterminationofspecificactivityofsalivaryamylasebyDNS
- Time course of ureasereaction
- Influence of substrate concentration, temperature and pH on the rate of enzymaticreaction
- Determination of Km and Vmax of salivaryamylase
- 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 a good knowledge of metabolic processes and how they are regulated.. |
| CO4 | Understand | Have developed a very good understanding of how all processes are interconnected and deregulation can lead to disease conditions. |
| CO4 | Apply | Be able to apply their knowledge in understanding the nature of metabolic processes and disease conditions. |
| CO4 | Analyze | Be able to analyse case studies and predict what the process is and where it could be going wrong. |
| CO4 | Evaluate | Be able to critically evaluate their analysis. |
| CO4 | 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 6220** |
| 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 focusses on the various recent developments in Biochemistry. A large number of nobel prizes in Chemistry and 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:**

**Molecular biology and fundamentals of genetics: 15 h**

- Analysecodingandnon-codingregionsofeukaryoticgenomeandtheirimportance.
- Exposure with the importance of *E. coli lac* operon, PCR, expression vectors and their importance inBiotechnology.
- To produce insulin using recombinant DNAtechnology.
- Acquaintance with the merits and demerits of transgeniccrops.

**Bioinformatics and techniques for identification of biomolecules in tissue samples**:**15 h**

- Exposure to the concepts of genomics, proteomics, metabolomics and their importance in humanhealth.
- 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 – proteins, nucleic acid and carbohydrate microarrays

**Mutational analysis: 15 h**

- Mutation screening technique - single stranded conformation polymorphism (SSCP) analysis and DNA heteroduplex analysis.

- Site directed mutagenesis, DNA libraries, oligonucleotide synthesis and artificial gene synthesis,
- CRISPR/Cas9 technology
- 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.

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 GenesXII, 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.


## BLUEPRINT

Code number: **BCH 6220**

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) |
|---|---|---|
| Molecular biology and fundamentals of genetics | 15 | 32 |
| Bioinformatics and techniques for identification of biomolecules in tissue samples | 15 | 32 |
| Metabolic disorders and metabolic markers of disease | 15 | 32 |
| **TOTAL** | **45** | **96** |

## Practical VIII

## BCH 6P$_2$ – Project Work - 2

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

**Course Objectives:**

Same as those stated under project work -1 as it is a continuation of the work that began in the previous semesters.

**Course content:**

Literature review, execution of experiments. Tabulation and consolidation of results, Report (not more than 100 pages of which only one third can be introduction. No website addresses to be given as references)

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

| | | |
|---|---|---|
| CO4 | Knowledge | Have a good knowledge of the current trends in biochemistry |
| CO4 | Understand | Have developed a very good understanding of the concepts involved in these new areas. |
| CO4 | Apply | Be able to apply their knowledge in trying to understand the latest publications in these fields. |
| CO4 | Analyze | Be able to analyse papers published and comprehend the same. |
| CO4 | Evaluate | Be able to critically evaluate others results and see how there is in comparison. |
| CO4 | Create | Be able to design and execute studies in fast emerging fields in the domain of the biological system. |