B.Sc. BIOCHEMISTRY (Honors)

Preamble

As one of the basic science disciplines which lead to biotechnological advancement, Biochemistry is a branch of science that explores the chemical processes within and related to living organisms. It focuses on processes at cellular and molecular level. A trained biochemist employs chemical knowledge and bio-analytical skills, in order to unravel biological problems pertaining to physiological processes, diseases related to their malfunctions, diagnostics, prevention, therapy and prognostics. Considering far-reaching advances in modern biology in 21st century, it is imperative to incorporate emerging concepts of biochemistry in academic curriculum. The proposed pattern is designed for multi-faceted development of students, giving the freedom to choose a combination of courses of study from Biochemistry as well as from the allied disciplines. While 14 discipline Specific Courses with 70 credits (12 with practical components for 61 credits and 3 without practical for 9 credits), three discipline specific Electives (9 credits) provide fundamental and advanced courses in Biochemistry, two vocational courses for 6 credits, research project in VIII semester provides much needed orientation and exposure to experimental research. With the Biochemistry major, the candidate can choose a minor from other disciplines such as Botany, Zoology, Environmental science, physics, Electronics, Mathematic, and other allied disciplines for 34 credits, depending on the subject's expertise available in the respective College, University or Institutions.

Further, 24 credit courses shall be from ability enhancement courses (during first two years), and 4 credits shall be from compulsory environmental studies and Constitution of India. Skill enhancement courses for 8 credits earned over first six semesters include Digital fluency, Artificial intelligence, and Cyber security, and Professional communication. Value based courses of Physical education and health and wellness for 12 credits provide opportunities for personality development.

The curricular framework approved by the Karnataka State Higher Education Council and Govt. of Karnataka as part of National Education Policy (NEP-2020) programme shall thus provide understanding of fundamentals, acquiring practical training and application of thesubject knowledge in diversified areas of Biochemistry equipping students with requisite knowledge, skill and personality.

Programme Learning Outcomes

Broad outcomes that a student with B.Sc. (Honours) programme in Biochemistry should be able to demonstrate may involve academic, personal, behavioural as well as entrepreneurial and social competencies as follows;

- demonstrate an experiential learning and critical thinking of the structure and function of both prokaryotic and eukaryotic cells (including the molecular basis and role of sub-cellular compartmentalization)
- demonstrate an understanding of the principles, and have practical experience of, a wide range of biochemical techniques (e.g. basic molecular biology, cell biology and microbiology methods, spectrophotometry, the use of standards for quantification, enzyme kinetics; macromolecular purification, chromatography electrophoresis, etc.) and data analysis and competent interpretation.
- ability to use skills in specific areas related to biochemistry such as industrial production, technology development, clinical, health, agriculture, community development, etc.
- curiosity and ability to formulate biochemistry related problems and using appropriate concepts and methods to solve them.
- demonstrate skills to publish research findings, and awareness of IP rights, and scientific publication ethics and problems of plagiarism articulation of ideas, scientific writing and authentic reporting, effective presentation skills.
- having conversational competence including communication and effective interaction with others, listening, speaking, and observational skills.
- collaboration, cooperation and realizing the power of groups and community, ability to work in a group, community.
- ability to grasp ideas and to turn ideas into action related to biochemical mechanisms and processes related to industries, industrial production, health and agriculture, etc.
- creativity, innovation and risk-taking ability, and social skills to build great teams.

Graduate Attributes for B.Sc. (Honors) in Biochemistry

Graduates with strong academic knowledge, discipline-specific and generic skills complemented with social responsibility are greatest asset of the country. The curriculum frame work under NEP for Biochemistry graduates aims to build the following attributes;

Disciplinary Knowledge:

- Ability to comprehend fundamental concepts of biology, chemistry and apply basic principles of chemistry to biological systems.
- Ability to relate various interrelated physiological and metabolic events.
- Ability to critically evaluate a problem and resolve to challenge blindly accepted concepts
- Ability to think laterally and in an integrating manner and develop interdisciplinary approach
- Good experimental and quantitative skills and awareness of laboratory safety
- A general awareness of current developments at the forefront in biochemistry and allied subjects.
- Awareness of resources, and their conservation.

Communication Skills

- Ability to speak and write clearly in English and local language
- Ability to listen to and follow scientific viewpoints and engage with them.
- Ability to understand and articulate with clarity and critical thinking one's position.

Critical Thinking

- Ability to conceptualize critical readings of scientific texts in order to comprehend.
- Ability to place scientific statements and themes in contexts and also evaluate them in terms of generic conventions.

Problem Solving

- Ability to make careful observation of the situation, and apply lateral thinking and analytical skills.

Analytical Reasoning

- Ability to evaluate the strengths and weaknesses in scholarly texts spotting flaws in their arguments.
- Ability to use scientific evidences and experimental approach to substantiate one's argument in one's reading of scientific texts.

Research Skills

- Ability to formulate hypothesis and research questions, and to identify and consult relevant sources to find answers.
- Ability to plan and write a research paper.

Teamwork and Time Management

- Ability to participate constructively in class room discussions.
- Ability to contribute to group work.
- Ability to meet a deadline.

Scientific Reasoning:

- Ability to analyse texts, evaluating ideas and scientific strategies.
- Ability to formulate logical and convincing arguments.

Reflective Thinking:

- Ability to locate oneself and see the influence of location; regional, national, global on critical thinking.

Self-Directing Learning

- Ability to work independently in terms of organizing laboratory, and critically analysing research literature.

Digital Literacy

- Ability to use digital sources, and apply various platforms to convey and explain concepts of biochemistry.

Multicultural Competence

- Ability to engage with and understand cultures of various nations and respect and transcend differences.

Moral and Ethical Values

- Ability to interrogate one's own ethical values, and to be aware of ethical and environmental issues.

- Ability to read values inherited in society and criticism *vis-a-vis* the environment, religion and spirituality, as also structures of power.

Leadership Readiness

- Ability to lead group discussions, to formulate questions related to scientific and social issues.

Life-long Learning

- Ability to retain and build on critical thinking skills, and use them to update scientific knowledge and apply them in day-to-day business.

Model Program Structures for the Under-Graduate Programs in Universities and Colleges in Karnataka

Bachelor of Arts (Basic/ Hons.)/ Bachelor of Science (Basic/Hons.)/Bachelor of Commerce (Basic/Hons.)/ Bachelor of Business Administration (Basic/Hons.)/Bachelor of Social Works (Basic/Hons.)/Bachelor of Computer Applications (Basic/Hons.) etc.

The Government of India has notified NEP-2020 on July 29, 2020 based on Dr.Kasturirangan Committee's Report. The objective is to bridge the gap between the current system of education and what is required in the 21st century. It is to have Holistic and Multidisciplinary Under-Graduate Education to produce employable graduates with integrated personality.

The Government of Karnataka had constituted a Task to suggest an Implementation Framework for NEP-2020. It had also constituted two sub-committees, one on Curriculum Reforms in Higher Education and the other on Governance and Regulations.

The Task Force has suggested NEP-2020 Implementation Framework for Karnataka. The State Government has accepted the action plan and taken steps to implement NEP-2020, as per the Implementation Roadmap suggested by the Task Force.

The Sub-committee on Curriculum Reforms in Higher Education had suggested a Draft Curriculum Framework for Undergraduate Programs in various disciplines. The State Govt. had also constituted Faculty-wise Committees to consider this draft framework to formulate program structures in their faculties. These Committees have submitted their reports. The latter were considered in the meetings of all the Vice Chancellors. The following Model Program Structures were designed for various Under-Graduate Programs in Arts, Science, Commerce and Management. The Subject Committees constituted to design and draft the curriculum in their subjects have to follow these Model Program Structures. The Terminology used in these Program Structures are.

Discipline Core (DSC) refers to Core Courses/Papers in a Core Discipline/Subject

Discipline Elective (DSE) refers to Elective Courses/Papers in the Core Subject or Discipline.

Open Elective (OE) refers to Elective Courses/Papers in a non-core Subject across all disciplines.

Program Structures also contain Ability Enhancement Compulsory Courses (AECC), Languages, Skill Enhancement Courses (SEC) (Both skills and value based). Pedagogy involves L+T+P model. Generally subjects with practical involve L+P, while the subjects without practicalinvolve L+T model. The numbers in parentheses indicate credits allotted to various courses/papers as per definitions of Choice Based Credit System (CBCS). Generally 1 hour of Lecture or 2 hours of practical per week in a semester is assigned one credit. Generally core subject theory courses/papers will have 3 or 4 credits, while practical are assigned 2 or 3 credits.

Job opportunities in Biochemistry Core Course

Exit After one year: *CERTIFICATE COURSE*

Knowledge	*Skill Acquired*	*Employability*
Fundamental properties of elements, atoms, acids and bases, metals, non-metals, alloys and composites. Biological significance of elements. Understanding of chemical bonding, Physical properties of molecules, chemistry of toxic chemicals. Chemical kinetics, Colligative properties, Properties of matter and electro chemistry, fundamentals and applications of nuclear and radio chemistry. Classification, structure, reactivity and biological significance of major organic compounds. A general scientific spirit of inquiry	*Numerical calculations, data generation and analysis, including the application of data transformations. laboratory, safety and precautions, proficiency in preparation of laboratory reagents, use of glassware, Demonstration of basic oxidation and reduction reactions, primary and secondary standards. Handling basic instruments.* *Communication interpersonal and leadership skills, and ability enhancements complementing the core biochemistry, Entrepreneurship*	Small and medium size chemistry/pharma based laboratories; as Jr. laboratory assistant assisting chemists/scientists. QC assistants in Laboratories dealing with QC service. Toiletries, chemicals, perfumery, oil industries, distilleries/ textiles/ pollution control units Entrepreneurship

Exit after two year: *Diploma COURSE*

Basic chemistry of natural compounds, alkaloids, terpenes, heterocyclic compounds, drugs, stereochemistry, biological relevance of these compounds, outlines of Photochemistry and environmental chemistry. History of Biochemistry, Comprehensive knowledge and hand-on training in laboratory techniques of biochemistry. Analytical instrumentation and methodology	*Acquaintance with analytical techniques that will permit them to study the biological system. Demonstrating skills of fractionating organic compounds.* *Hands on experience of handling instruments and analysis of data.* *Improving personality traits, team work, organizing abilities. Communication skills*	Assistants in Health care/paramedical laboratories. Supervision and maintenance of laboratories. QC assistants in analytical laboratories dealing with biochemical/clinical/Food processing/pharma industrial settings. Marketing Entrepreneurial opportunities, Material safety data sheet maintenance, curation of chemical/drug stores, chemical store keeping

Exit after three years: *B.Sc. degree*

Knowledge	***Skill Acquired***	***Employability***
Comprehensive knowledge of biomolecules: higher order structure s of proteins, nucleic acids and their functions. Bioenergetics, metabolism, enzyme kinetics, basic molecular biology, industrial microbiology, Immunology recombinant DNA technology. Understanding interrelated physiological and metabolic events. Overall knowledge ofavenues for research and higher academic achievements in the field of biochemistry and allied subjects.	*Basic skills in clinical laboratory techniques, Immunology and molecular biological experimental skills. Demonstrate the overall ability to independently design experiment and analyse data. Basic statistical handling of data.* *Oral and written skills to convey scientific experimental results. Ability to understand research findings and disseminate to common public. Teaching skills*	Scientific assistants in biotech based industries. Chemical/pharma/animal feeds/scientific data mining, / Forensic science labs. Blood Banks, Public heath support staff, Clinical research, Drug discovery R&D, Medical coding, medical transcription, Medical content writing Teaching at secondary school level
B.Sc. (Hons.)		
Introduction to advanced concepts in Biochemistry; Molecular Biology, Recombinant DNA technology, Clinical Biochemistry/ Plant Biochemistry, Immunology, Nutrition and Dietetics, Biochemical Pharmacology, Research methodology, Bioinformatics skills, data analysis, Pharmacogenomics, Introduction to Intellectual property rights. A strong theoretical and practical knowledge of clinical and molecular setting, core research *exposure.*	*Skills to isolate, identify and quantify biomolecules. Conducting independent research as part of project work. Hands-on training in modern techniques of Molecular biology. Recombinant DNA techniques, Computational skills, Prism, graph pad, Excel, Scientific writing skills: general articles, research reviews, Debating on scientific inventions and social implications.*	Research staff in modern biology laboratories, Industries, Research Institutions. Clinical Biochemist, Forensic science technician, Biomedical scientist, Nutrition Dept. Pharma and Clinical research industries, R&D divisions of Pharma industries, Vaccine industry. Medical coding, Bioinformatics, Medical content writing, Patent examiner, Toxicological asst. Medical Science Liaison officer,

IIA. Model Program Structures for the Under-Graduate Programs in Universities and Colleges in Karnataka

Bachelor of Arts (Basic/ Hons.)/ Bachelor of Science (Basic/Hons.) insubjects with practical, with one major and one minor (Biochemistry major with suitable minor)

Sem.	Discipline Core (DSC) (Credits) (L+T+P)	DisciplineElective(DSE) / Open Elective (OE) (Credits) (L+T+P)	Ability Enhancement Compulsory Courses (AECC), Languages (Credits) (L+T+P)	Skill Enhancement Courses (SEC)			Total Credits
				Skill based (Credits) (L+T+P)	Value based (Credits) (L+T+P)		
I	Biochem.1(4+2) Discipline B1(4+2)	OE-1 (3)	L1-1(3), L2-1(3) (4 hrs each)	SEC-1:Digital Fluency (2)(1+0+2)	Physical Education -Yoga (1)(0+0+2)	Health & Wellness (1) (0+0+2)	25
II	Biochem.2(4+2) Discipline B2(4+2)	OE-2 (3)	L1-2(3), L2-2(3) (4 hrs each) Environmental Studies (2)		Physical Education-Sports (1)(0+0+2)	NCC/NSS/R&R(S&G)/ Cultural (1) (0+0+2)	25
	Exit option with Certificate (50 credits)						
III	Biochem.3(4+2) Discipline B3(4+2)	OE-3 (3)	L1-3(3), L2-3(3)(4 hrs each)	SEC-2:ArtificialInte-lligence(2)(1+0+2)	Physical Education-Sports (1)(0+0+2)	NCC/NSS/R&R(S&G)/ Cultural (1) (0+0+2)	25
IV	Biochem.4(4+2) Discipline B4(4+2)	OE-4 (3)	L1-4(3), L2-4(3)(4 hrs each) Constitution of India (2)		Physical Education - Sports (1)(0+0+2)	NCC/NSS/R&R(S&G)/ Cultural (1) (0+0+2)	25
	Exit option with Diploma (100 credits) OR Choose any one of the core subjects as Major and the other as Minor						
V	Biochem.5(3+2) Biochem.6(3+2) Discipline B5(3+2)	Vocational-1 (3)		SEC-3: SEC such as Cyber Security(2) (1+0+2)	Physical Education-Sports (1)(0+0+2)	NCC/NSS/R&R(S&G)/ Cultural (1) (0+0+2)	22
VI	Biochem.7(3+2) Biochem.8(3+2) Discipline B6(3+2)	Vocational-2 (3) Internship (2)		SEC-4: Professional Communication (2)	Physical Education - Sports (1)(0+0+2)	NCC/NSS/R&R(S&G)/ Cultural (1) (0+0+2)	24
	Exit option with Bachelor of Arts, B.A./ Bachelor of Science, B.Sc. Basic Degree (with a minimum of 146credits) or continue studies with the Major						
VII	Biochem.9(3+2) Biochem.10 (3+2) Biochem.11(3)	Biochem. E-1(3) Biochem. E-2(3) Res. Methodology (3)					22
VIII	Biochem.12(3+2) Biochem.13(3) Biochem.14(3)	Biochem. E-3(3) Research Project (6)*					20
	Award of Bachelor of Arts Honours, B.A. (Hons.)/ Bachelor of Science Honours, B.Sc. (Hons) degree in a discipline (with a minimum of 188 credits)						

In lieu of the research Project, two additional elective papers/ Internship may be offered.

II-C. Model Program Structures for the Under-Graduate Programs in Universities and Colleges in Karnataka

Bachelor of Arts (Basic/Hons.)/ Bachelor of Science (Basic/Hons.) with one core subject with practical and the other without practical

Sem.	Discipline Core (DSC) (Credits) (L+T+P)	DisciplineElective(DS / Open Elective (OE) (Credits) (L+T+P)	Ability Enhancement C mpulsory Courses (AECC), Languages (Credits) (L+T+P)		Skill Enhancement Courses (SEC)			Total credits
					Skill based (Credits) (L+T+P)	Value based (Credits) (L+T+P)		
I	Discipline A1(4+2) Discipline B1(3), B2(3)	OE-1 (3)	L1-1(3), L2-1(3) (4 hrs each)		SEC-1:Digital Fluency (2)(1+0+2)	Physical Education - Yoga (1)(0+0+2)	Health & Wellness (1) (0+0+2)	25
II	Discipline A2(4+2) Discipline B3(3), B4(3)	OE-2 (3)	L1-2(3), L2-2(3) (4 hrs each)	Environmental Studies (2)		Physical Education - Sports (1)(0+0+2)	NCC/NSS/R&R(S&G)/ Cultural (1) (0+0+2)	25
	Exit option with Certificate (50 credits)							
III	Discipline A3(4+2) Discipline B5(3), B6(3)	OE-3 (3)	L1-3(3), L2-3(3)(4 hrs. each)		SEC-2:ArtificialInte-lligence(2)(1+0+2)	Physical Education - Sports (1)(0+0+2)	NCC/NSS/R&R(S&G)/ Cultural (1) (0+0+2)	25
IV	Discipline A4(4+2) Discipline B7(3), B8(3)	OE-4 (3)	L1-4(3), L2-4(3)(4 hrs. each)	Constitution of India (2)		Physical Education - Sports (1)(0+0+2)	NCC/NSS/R&R(S&G)/ Cultural (1) (0+0+2)	25
	Exit option with Diploma (100 credits)/ Choose any one Discipline as Major, the other as the Minor							
V	Discipline A5(3+2), Discipline A6(3+2) Discipline B9(3)	Discipline A, E-1(3) Vocational-1 (3)			SEC-3: SEC such as Cyber Security(2)(1+0+2)	Physical Education - Sports (1)(0+0+2)	NCC/NSS/R&R(S&G)/ Cultural (1) (0+0+2)	23
VI	Discipline A7(3+2), Discipline A8(3+2) Discipline B10(3)	Discipline A,E-2(3) Vocational-2 (3)			SEC-4: Professional Communication (2)	Physical Education - Sports (1)(0+0+2)	NCC/NSS/R&R(S&G)/ Cultural (1) (0+0+2)	23
	Exit option with Bachelor of Arts, B.A. /Bachelor of Science, B. Sc. Basic Degree (with a minimum of 146 credits) or continue studies with the Major							
VII	Discipline A9(3+2), Discipline A10(3+2) Discipline A11(3)	Discipline A,E-3(3) Internship (2) Res.Methodology (3)						21
VIII	Discipline A12(3+2), Discipline A13(3), Discipline A14(3)	Discipline A, E-4(3) Research Project (6)*						20
	Award of Bachelor of Arts Honours, B.A. (Hons) /Bachelor of Science Honours, B.Sc. (Hons) degree in a discipline (with a minimum of 187 credits)							

In lieu of the research Project, two additional elective papers/ Internship may be offered.

Semester	1 (First)
Course title	Chemical foundation of Biochemistry -1
Course credits:	4
Total contact hours:	56
Duration of end semester assessment	02h
Formative assessment marks	40
Summative assessment marks	60

Course learning Outcome:

- Understanding of Biochemistry as a discipline and milestone discoveries in life sciences that led to establishment of Biochemistry as separate discipline.
- Fundamental properties of elements, their role in formation of biomolecules and in chemical reactions within living organisms.
- Understanding of the concepts of mole, mole fraction, molarity, etc. and to apply them in preparations of solutions of desired strengths.
- Revisit to fundamentals of chemical bonds, electronic configuration, theories of bond formation.
- Unique property of water as a universal solvent and its importance in biological system.
- Understanding of fundamentals of physical phenomena associated with Adsorption, Viscosity, Distribution law, Osmotic pressure, etc. and their importance in living organisms.
- Understanding of concepts of acids, bases, indicators, pKa values, etc. Acquiring numerical skills

UNIT-1: Introduction to Biochemistry 14hrs

Origin of life, Miller's experiment, types of organisms, prokaryotes, eukaryotes, unicellular multicellular, compartmentalization of functions in lower and higher organisms, and common physiological events of organisms (RQ), chemical composition of living organisms, subcellular organelles: Structure, function and interrelationship.

SI units, Mass, volume, temperature, amount, length and time, an overview of the metric system, atomic weight, molecular weight, equivalent weight, basicity of acids, acidity of bases, Avogadro`s number, molarity, normality, molality, Dalton concept, mole concept, concentration, mole to molar conversion, oxidation number and its significance, density and specific gravity, their significances.

UNIT-2: Atomic structure and chemical bonds 14 hrs

Structure of an atom, electrons and Quantum numbers, orbitals, shapes of orbitals, s, p, d, and f sub shells, K, L, M, N, O, P, and Q shells. Illustration of Pauli`s exclusion principle, Aufbau principle, and Hund`s rule, electron configuration: up to atomic number 20, octet rule. Formation and properties of non-covalent and covalent bonds,

hydrogen bonds, ionic bonds, van der Waals interactions, London forces, dipole-dipole interactions, electrostatic interactions, and hydrophobic interactions. Sigma, pi and co-ordinate bonds, back bonding, corresponding energy associated, outline of theories of bonding: Valence bond theory, Molecular orbital theory and crystal field theory.

UNIT-3: Buffers and colligative properties 14hrs

Acids, bases, Arrhenius concept, Lowry and Bronsted concepts, Lewis concept. Buffers, composition, pH, pH scale, Henderson-Hasselbalch equation, titration curve of H_3PO_4,pK value, isoelectric pH, ionization of HCl, CH_3COOH, NH_4OH, H_2SO_4. Colligative properties and anomalous colligative properties of solutions, structure of water based on VSEPR theory, ionic product of water, special properties of water, buffers in animal system. Solutions and types, ionizable solutes, non-ionizable solutes, vapor pressure and its application in distillation, Van't Hoff law – Boyle's and Charles' law, Roult`s law of Relative lowering of vapour pressure (RLVP), boiling point, freezing point, de-icing, osmosis and osmotic pressure determination by Berkeley and Hardley's method, reverse osmosis.

UNIT–4: Electrochemistry and redox reactions 14 hrs

Scope of electrochemistry, electrochemical cells, Daniel cell, galvanic cell, electrode potential and its measurement, electrolysis, types of electrolytes, primary and secondary batteries, electrodes, half-cell reaction, standard electrodes. Laws of thermodynamics, entropy and enthalpy, their relation, Gibb`s energy, free energy change, ions, Redox reactions, types, Stock's notations, change in oxidation number and combination. Endergonic and exergonic reactions with examples, their importance in biological systems, redox potential, application of redox potential, energy linked to redox reactions, reduction of oxygen, oxidation and reduction of iron in hemoglobin, biologically active forms of zinc, calcium, nickel, molybdenum, selenium, and cobalt, NAD^+/NADH, $NADP^+$/NADPH, FAD/$FADH_2$, FMN/$FMNH_2$.

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3. Inorganic Chemistry, 2004, Catherine E and Sharpe AG, ACS publication
4. Inorganic Chemistry, 2015, Overton, Rourke, Weller, Armstrong and Hagerman, Oxford Press.
5. Physical Chemistry: A molecular approach, 2019, Donald A, McQuarrie and Simon JD, Viva Books Publication.
6. Physical chemistry 2019,Atkins P, Paula JD, Keeler J, 11th edition, Oxford press
7. Biochemical Calculations, 1976, Irwin H. Siegel 2nd Ed. John Wiley and Sons.
8. A biologist's Physical Chemistry, 1976, 2nd Edition, J Gareth Morris, Edward Arnold Ltd.

Pedagogy: Lectures/problem solving/ assessments/group discussions/industrial visits

Formative Assessment	
Assessment occasion	**Weightage in marks**
Continuous evaluation and class test	**20**
Seminars/Class work	**10**
Assignments/Discussions	**10**
Total	**40**

Semester-I: Practical-I

Semester	1 (First)
Course title	Volumetric Analysis, Practical -1
Course credits:	2
Total contact hours:	4 hrs/week
Duration of end semester assessment	03h
Formative assessment marks	25
Summative assessment marks	25

Course Outcome: The Course Objective is to provide experimental practice of quantitative and qualitative analysis. Also, it provides training in physical chemistry laboratory techniques. Upon successful completion, students should develop skills in handling instruments and understand its application in research work.

- Understanding Good laboratory practices in a chemistry/biochemistry laboratory.
- Learn safety and precautionary measures for working in a laboratory.
- Develop skill and proficiency in preparation of laboratory reagents.
- Use of handling of glass wares, minor equipment for conducting experiments.
- Develop skills to prepare standard chemical solutions and secondary standards.
- Demonstration of basic oxidation and reduction reactions.

Experiments:

1. Calibration of volumetric glassware's (Burette, pipette, standard flasks).
2. Concept of molarity, molality and normality. Calculation and preparation of molar solutions (Problems to be given for exams). Calculation and preparation of normal solutions and percent solutions and dilute solutions
3. Preparation of standard Sodium carbonate solution, standardization of HCl (Methyl orange) and estimation of NaOH in the given solution. (Methyl orange or phenolphthalein).
4. Preparation of standard Oxalic acid. Standardization of NaOH and estimation of H_2SO_4 in the given solution (phenolphthalein).
5. Preparation of standard Oxalic acid. Standardization of $KMnO_4$ and estimation of H2O2 in the given solution.
6. Preparation of standard $K_2Cr_2O_7$. Standardization of $Na_2S_2O_3$ and estimation of $CuSO_4$ in the given solution.
7. Preparation of ZnSO4. Standardization of EDTA and estimation of total hardness of water using Eriochrome black-T indicator.
8. Preparation of standard potassium phthalate. Standardization of NaOH and estimation of HCl in the given solution. (Phenolphthalein).
9. Estimation of sulphuric acid and oxalic acid in a mixture using standard sodium hydroxide solution and standard potassium permanganate solution.
10. Preparation of standard Potassium dichromate and estimation of ferrous/ferric mixture using diphenylamine indicator (Demonstration).

11. Preparation of standard oxalic acid solution. Standardization of NaOH solution and estimation of acidity in vinegar.
12. Preparation of standard potassium biphthalate solution, standardization of sodium hydroxide solution and estimation of alkalinity of antacids.
13. Preparation of standard Oxalic acid solution. Standardization of $KMnO_4$ solution and estimation of calcium in milk.
14. Preparation of buffers; phosphate, bicarbonate and acetate buffers
15. Construction of Daniell Cell and measurement of emf.

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3. Practical Chemistry, O. P. Pandey, D. N. Bajpai, and S. Giri, S. Chand and Co. Ltd.
4. Principles of Practical Chemistry- M. Viswanathan
5. Instrumental Methods of chemical Analysis B.K Sharma.
6. Experiments in Physical Chemistry R.C. Das and B. Behra, Tata Mc Graw Hill
7. Advanced Practical Physical Chemistry J.B.Yadav, Goel Publishing House
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9. Practical Chemistry K.K. Sharma, D. S. Sharma (Vikas Publication).
10. General Chemistry experiment – Anil J Elias (University press).
11. Vogel textbook of quantitative chemical analysis G.H. Jeffery, J. Basset.
12. Quantitative chemical analysis S. Sahay (S. Chand & Co.).
13. Practical Chemistry, O P Pandey, D N Bajpai, Dr S Giri. S. Chand Publication
14. College Practical Chemistry, V K Ahluwalia, Sunitha Dingra, Adarsh Gulati
15. Practical Physical Chemistry- B. Viswanathan, P S Raghavan, MV Learning Publication.

Pedagogy*: Lab work/ problem solving/ assessments/group discussions/industrial visits*

Formative Assessment	
Assessment occasion	**Weightage in marks**
Continuous evaluation and class test	**15**
Record / viva voce	**10**
Total	**25**

Second Semester

Course Title	Chemical foundation of biochemistry -2
Course credits	**04**
Total contact hours	**56**
Duration of End semester Assessment	**02**
Formative Assessment Marks	**40**
Summative assessment Marks	**60**

Course Outcome:

- These topics will enable students to understand the fundamentals of chemical processes in biological systems
- Appreciation of the roles of metals, non-metals, transition metals and coordination compounds in biological systems.

Course Outcomes/Program Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
Aptitude	X	X										
Critical thinking	X	X										
Subject clarity	X	X										
Analytical Skills	X	X										

Course content

UNIT-1: Chemical kinetics and colloids 14 Hours

Introduction, Rate of reactions, rate law or rate equation, molecularity and order of a reaction with examples, velocity constant or rate constant and half-life period expressions for zero, first and second order reactions with derivations (a=b and a ≠b), rate constant of irreversible reaction, kinetics of reversible reaction (without derivation). Numerical problems. Effect of temperature, pressure and catalyst on rate of reaction, Arrhenius equation and Arrhenius interpretation of energy of activation. Transition state theory with brief explanation.

Colloids: true solutions, classification, peptisation, purification, ultrafiltration, Brownian movements, electric properties, coagulation, mutual, lyophilic sols, boiling, dialysis, electro- and persistent dialysis, addition of electrolytes, colloids in daily life and applications. Emulsion, types, micelles with biomolecules and its biological applications.

UNIT-2: Nomenclature of Organic Compounds: 14 Hours

Classification, naming- IUPAC nomenclature, compounds containing one, two functional groups with chains, homologous series. Stereochemistry, geometrical and structural isomerism, conformation and free rotation. Optical isomerism, symmetry of elements, plane polarized light and optical purity, calculations. Nomenclature of enantiomers, epimers, racemic mixture, resolution. Fischer and Newmann projection formulae, molecule with one and two chiral and achiral centers, spyrines. Priority rules; E and Z (CIP rules), R and S, D and L notations, absolute (r and s) and relative (d and l) configuration. Role of stereochemistry in biological systems.

UNIT-3: Organometallic Compounds 14 Hours

Metal atom linked organic compounds. Preparation of Grignard reagents and structure, limitations, protonolysis and reactions. Organolithium compounds, preparation and reactions. Organozinc compounds. Organoboranes its mechanisms. Ferrocenes. Organomercury compounds: Methods of preparation and applications, reactions– mercuration of aromatic compounds, solvomercuration, oxymercuration- demercuration. Organosilicon compounds: Methods of preparations and applications, general reactions of trialkyl silyl halides with ethers, esters, carbamides, epoxides and acetals.

Porphyrins and Metal ions: Role of metal ions in biological systems, Fe, Cu, Zn, structure and functions of porphyrins, metalloporphyrins and iron-sulphur clusters with suitable examples and their role in biological systems.

UNIT-4: Inorganic Chemistry 14 Hours

Nomenclature of inorganic molecules and coordination compounds, formula. IUPAC nomenclature. Central metal ion, ligand, coordination number, sphere, complex ion, oxidation number of central atoms, homoleptic and heteroleptic complexes. Isomerism in complexes, structural, ionization, solvate (hydrate), linkage and coordination, Stereoisomerism, geometrical, optical isomerism with simple inorganic complexes. Applications of qualitative/ quantitative analysis, photographic, metallurgy, medicine, catalysis and biosystems.

Chemical toxicity: Introduction, poisons, lead, mercury, aluminium, arsenic, corrosives, cyanide, irritants, phosphorus, CO_2, SO_2, SO_3, NO_2, halides and acid fumes, poisoning; sources, signs and symptoms. Free radicals: introduction, definition, generation and scavenger systems.

REFERENCES

1. Physical Chemistry, 2006, Peter Atkins. 8thedition, W.H. Freeman and Company
2. Inorganic Chemistry: 2006, Principles of structure and Reactivity, Huheey JE, Keiter EA, Keiter RL, Pearson Education India
3. Stereochemistry: Conformation and Mechanism, 2009, Kalsi PS, New Age International Publications
4. Introduction to Stereochemistry, 2012, Kurt Mislow, Dover Publications
5. A text book of Organic Chemistry, 2016, Raj K Bansal, 6th edition, New Age International Publications
6. Advanced Inorganic Chemistry,1999, Cotton et.al, 6th edition, A Wiley-

International
7. Principles of physical Chemistry, Puri, Sharma and Pathania.
8. Physical Chemistry, R.L. Madan, G.D. Tuli. S. Chand and Co.
9. A Text Book of Physical Chemistry, K.L. Kapoor, Vol.2. McMillan Publisher, India Ltd.
10. Advanced Organic Chemistry, Bahl and Bahl.
11. Principles of oraganometallic Chemistry, 1991, P. Powell, 2nd Edition, ELBS.
12. Inorganic Chemistry, 1983, 3rd Edition, J.E. Huheey, Harper International.
13. Organic Chemistry, Claden J., Greeves, N., Warren, S. 2012, Oxford University Press.
14. Inorganic Chemistry, 1987, R.W. Hay, Ellis Harwood.
15. Bioinorganic Chemistry, 2002, R.M. Roat-Malone, John-Wiley.
16. Basic Organometallic chemistry, 2nd Edition, B.D. Gupta and A.J Elias.

Pedagogy: Lab work/ problem solving/ assessments/group discussions/industrial visits

Formative Assessment	
Assessment occasion	**Weightage in marks**
Continuous assessment/Class test	**20**
Seminars/class work	**10**
Assignment/open discussion	**10**
Total	**40**

Practical-2

Course title	Qualitative and quantitative analysis
Course credits	02
Total contact hours	4 Hours/Week
Duration of end semester assessment	03
Formative assessment marks	25
Summative assessment marks	25

Course Outcome: The Course Objective is to provide experimental practice of quantitative and qualitative analysis. Also, it provides training in physical chemistry laboratory techniques. Upon successful completion, students should develop skills in handling instruments and understand its application in research work.

Experiments:

1. ***Systematic Semi-micro qualitative Analysis of Inorganic salt Mixtures***

   (a) Systematic semi micro qualitative analysis of two acid and two basic radicals in the given inorganicsalt mixture. The constituent ions in the mixture to be restricted to the following (Any four binary mixtures shall be given)

   Anions: HCO_3^-, CO_2^-, Cl^-, Br^-, NO_3^-, BO_3^{3-} SO_4^{2-},and PO_4^{3-}

   Cations: Pb^{2+}, Al^{3+}, Fe^{2+}, Fe^{3+},Mn^{2+}, Zn^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mg^{2+}, K^+, Na^+ and NH^+.

   (b) Qualitative analysis of NPK fertilizers

2. Determination of density and viscosity of the given liquid using specific gravity bottle and Ostwald's viscometer.
3. Determination of density and surface tension of the given liquid using specific gravity bottle and stalagmometer.
4. Determination of molecular weight of non-volatile solute by Walker-Lumsden method.
5. Determination of rate constant of decomposition ofH_2O_2 using $KMnO_4$ by volumetric analysis method using ferric chloride as catalyst.
6. Determination of distribution coefficient of benzoic acid between water and benzene or iodine between water and carbontetra chloride Separation of Two Components from given Binary Mixture of Organic Compounds Qualitatively.(Types of binary mixtures-Solid– Solid, Solid–Liquid, Liquid – Liquid)
7. Verification of Beer's Law.

   (i) Estimation of unknown concentration of a biomolecule by using colorimeter

   (ii) Determination of molar extinction coefficient
8. Calibration of pH meter and determination of pH of aerated soft drinks.

REFERENCES

1. Vogel's Qualitative Inorganic Analysis, 2012, Svehla, G. Pearson Education,.
2. Quantitative Chemical Analysis, 2009, Mendham, J. Vogel's Pearson,.
3. Practical Chemistry, O. P. Pandey, D. N. Bajpai, and S. Giri, S. Chand and Co. Ltd.
4. Principles of Practical Chemistry, M. Viswanathan
5. Instrumental Methods of chemical Analysis B.K Sharma.
6. Experiments in Physical Chemistry R.C. Das and B. Behra, Tata Mc Graw Hill
7. Advanced Practical Physical Chemistry J.B.Yadav, Goel Publishing House
8. Advanced Experimental Chemistry. Vol-I J.N.Gurtu and R Kapoor, S.Chand and Co.
9. Practical Chemistry K.K. Sharma, D. S. Sharma (Vikas Publication).
10. General Chemistry experiment – Anil J Elias (University press).
11. Vogel textbook of quantitative chemical analysis G.H. Jeffery, J. Basset.
12. Quantitative chemical analysis S. Sahay (S. Chand & Co.).
13. Practical Chemistry, O P Pandey, D N Bajpai, Dr S Giri. S. Chand Publication
14. College Practical Chemistry, V K Ahluwalia, Sunitha Dingra, Adarsh Gulati
15. Practical Physical Chemistry- B. Viswanathan, P S Raghavan, MV Learning Publication.

Pedagogy*: Lab work/ problem solving/ assessments/group discussions/industrial visits*

Formative Assessment	
Assessment occasion	**Weightage in marks**
Continuous evaluation and class test	**15**
Record / viva voce	**10**
Total	**25**

Biochemistry Open Elective for First Semester

Course title	*Biochemistry in Health and Disease*
Course credits	**03**
Total contact hours	**42**
Duration of end semester examination	**02**
Formative assessment marks	**40**
Summative assessment marks	**60**

Course Outcome: This open elective course offering to students of various streams gives knowledge about health and various terminologies used in health and disease conditions; Difference between communicable and non-communicable diseases; Health promotion and treatments for various diseases and disorders.

UNIT-1: Health and wellness: *14hours*

WHO definition of health, Health and hygiene, General health care, Factors affecting health, Indices and evaluation of health, Disease patterns in developed and developing world; Classification of diseases-Endemic, Epidemic, Pandemic; Professional health hazards.

Disease conditions: Acute disease, chronic disease, Incurable disease, Terminal disease, Illness, disorders, Syndrome, Pre-disease.

Treatment: Psychotherapy, Medications, Surgery, Medical devices, and Self-care.

Dimensions of Health: Physical, Mental, Spiritual, Emotional, Environmental, and Philosophical.

UNIT–2 Diseases and disorders *14 hours*

Communicable diseases: Tuberculosis, Cholera, Typhoid, Conjunctivitis.

Sexually transmitted diseases (STD): Information, statistics, and treatment guidelines for STD, Prevention: Syphilis, Gonorrhea, AIDS.

Non-communicable diseases: Malnutrition Undernutrition, Overnutrition, Nutritional deficiencies; Anemia, Stroke, Rheumatic heart disease, Coronary heart disease, Cancer, blindness, accidents, mental illness, Iodine deficiency, Fluorosis, Epilepsy, Asthma.

Genetic disorders: Down's syndrome, Klinefelter's syndrome, Turner's syndrome, Thalassemia, Sickle cell anemia.

Lifestyle disorders: Obesity, Liver cirrhosis, Diabetes mellitus, Hypertension (Causative agents, symptoms, diagnosis, treatment, prognosis, prevention)

UNIT–3 Health and awareness *14 hours*

Preventing drug abuse, Oral health promotion by tobacco control. Mental hygiene and mental health: Concepts of mental hygiene and mental health, Characteristics of mentally healthy person, Warning signs of poor mental health, Promotive mental health, strategies and services, Ego defense mechanisms and implications, Personal and social adjustments, Guidance and Counseling.

Infection control: Nature of infection, Chain of infection transmission, Defenses against infection transmission

REFERENCES

1. Modern Nutrition in Health and Disease, 2006, 10th Edition, Maurice E. Shils, Moshe Shike, A Catharine Ross.
2. Clinical Biochemistry and Metabolic Medicine, 2012, Eighth Edition, Martin Andrew Crook, CRC Press,
3. Nutrition and Health in Developing Countries, 2000, Editors: R. Semba and M.W. Bloem, Humana Press.

Pedagogy: Lectures/desk work/book chapter/problem solving/discussion/assignment

Formative assessment	
Assessment occasion	**Weightage in marks**
Class test (2 class tests)	**20**
Seminars/class work	**10**
Assignment/open discussion	**10**
Total	**40**

Biochemistry Open Elective for Second Semester

Course title	*Nutrition and Dietetics*
Course credits	**03**
Total contact hours	**42**
Duration of end semester examination	**02**
Formative assessment marks	**40**
Summative assessment marks	**60**

Course outcomes:

- Knowledge about energy requirements and the Recommended Dietary Allowances.
- understanding the functions and role of macronutrients, their requirements and the effect of deficiency and excess
- Understand the impact of various functional foods on our health
- To be able to apply basic nutrition knowledge in making foods choices and obtaining an adequate diet.
- Competence in connecting the role of various nutrients in maintaining health and learn to enhance traditional recipes.

UNIT–1 Basic concepts of Nutrition: 14 Hrs

Introduction, Basic principles of a balanced diet to provide energy and nutrients. Composition of foods and proximate analysis of foods. Calorific value of foods and Basal metabolism. Basal Metabolic Rate (BMR), Factors affecting BMR, Energy requirements for different physical activities, Specific dynamic action of food, Nutritive value of proteins. Energy requirements and recommended dietary allowance (RDA) for infants, children, and pregnant women. Protein calorie malnutrition.

UNIT–2 Macronutrients and Micronutrients 14 Hrs

Carbohydrates-Digestible and non-digestible, Dietary fibres, Essential fatty acids, lipoproteins and cholesterol. Essential amino acids, Fortification of foods, Protein requirement for different categories.

Vitamins: Sources, requirements, functions and deficiency symptoms of Vitamin-C, Thiamine, Riboflavin, Pyridoxine, Folic acid, VitaminB_{12}. Absorption of fat-soluble vitamins- A, D, E and K.

Micronutrients: Source, Daily requirement, functions and deficiency disease symptoms of Macrominerals (Ca, P, and Cl) and microminerals/trace elements (I, Fe, Zn and Se).

UNIT-3 Dietetics and Diet Therapy 14 Hrs

Food pyramid; Diet planning and introduction to diet therapy. Nutritional requirements for different age groups, anemic child, expectant women, and lactating women. Diet planning for prevention and cure of nutritional deficiency disorders.
Diet therapy: Functional foods, Anthropometric measurements, dietary considerations during fever, malaria, and tuberculosis. Prevention and correction of obesity, underweight, and metabolic diseases by diet therapy. Dietary interventions to correct and/or manage the gastro-intestinal diseases (indigestion, peptic ulcer, constipation, diarrhoea, steatorrhoea, irritable bowel syndrome. Functional food-based diet therapy for diabetes, cardiovascular disease and cancer.

REFERENCES:

1. Clinical Dietetics and Nutrition, 2002, 4th Edition, Antia FP and Abraham P, Oxford University Press; ISBN-10: 9780195664157.
2. Oxford Handbook of Nutrition and Dietetics, 2011, Webster-Gandy J, Madden A and Holdsworth M. Oxford University Press, Print ISBN-13:9780199585823.
3. Krause's Food, Nutrition and Diet therapy, 2003, Mahan KL and Escott-Stump S., Elsevier, ISBN: 9780721697840.
4. Human Nutrition and Dietitics.1986, Passmore R. and Davidson S. Churchill Livingstone Publications, ISBN-10: 0443024863.
5. Rosemary Stanton's Complete Book of Food & Nutrition, 2007, Simon & Schuster Publishers, Australia, ISBN 10: 0731812999
6. Food Science and Nutrition, 2018, Roday S.Oxford University Press Publishers, ISBN: 9780199489084/0199489084.
7. Food Science, 2007, Srilakshmi S. New Age International (P) Limited Publishers, ISBN: 9788122420227/ 8122420222.

Pedagogy: Mooc/Lectures/book chapter/problem solving/assignment

Formative Assessment	
Assessment occasion	**Weightage in marks**
Class test (2 class tests)	**20**
Seminars/class work	**10**
Assignment/open discussion	**10**
Total	**40**

Model question paper pattern for End semester Theory Examination

Time:2 h **Max. Marks: 60**

Note: all sections are compulsory

SECTION – A

1. Answer ***any five*** of the following; 5x2= 10a)
   b)
   c)
   d)
   e)
   f)
   g)

SECTION –B

Answer ***any five*** of the following; 5x4=20

2.
3.
4.
5.
6.
7.

SECTION – C

Answer ***any three*** of the following; 3x10=30

8.
9.
10.
11.

- ***Note: Section C shall include sub questions a and b either for 5+5 or 6+4***

Model question paper pattern for End semester Practical ExaminationTime:

3 h **Max. Marks: 25**

1. Marks for procedure writing	5 Marks
2. Marks for Viva – Voce	5 Marks
3.Marks for performing experiment	15 Marks

SEMESTER - III

COURSE TITLE	**BIO-ORGANIC CHEMISTRY**

COURSE CREDITS	**04**
TOTAL CONTACT HOURS	**56**
DURATION OF ESA	**03**
FORMATIVE ASSESSMENT MARKS	**40**
SUMMATIVE ASSESSMENT MARKS	**60**

Course Outcome:

These topics will enable students to understand the fundamentals of organic chemistry pertinent to their importance in understanding biochemical reactions.

Course Outcomes /Program Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
Aptitude	X	X	X	X								
Critical thinking		X										
Subject clarity	X	X				X	X	X		X		X
Analytical Skill	X				X	X	X	X	X			X

UNIT - 1: Reaction mechanisms and aliphatic hydrocarbons: 14hrs

Introduction, meaning of the term, kinetic and non-kinetic. Fundamental aspects: Homo and heterolytic cleavage. Concept of inductive effect, mesomeric effect, resonance and hyper conjugation. Classification of organic reactions (substitution, addition, elimination and re-arrangement), with two examples for each. Concepts reactive intermediates of the following – free radicals, carbocations and carbanions, carbenes, nucleophiles and electrophiles (Formation and Stability).

Hydrocarbons - Markownikoff's rule. Mechanism of addition of HCl to propene. Peroxide effect, Alkenes – Ozonolysis, oxidation. Alkynes – formation of acetylides and their importance. Dienes– types with examples. Conjugate dienes, 1,3-butadiene – stability, mechanism of addition of HBr.

UNIT - 2: Mechanism of Substitution, Elimination and Addition reactions 14 hrs

SN_1 and SN_2 reactions on tetrahedral carbon, energy profile diagrams, Stereochemistry, factors affecting SN_1 and SN_2 reactions.

The Elimination reactions- E_1, E_2 and E_{1cb} reaction, Zaitsev rule. Stereochemistry of E_1 & E_2 reactions, E_1 & E_2 elimination in cyclic compounds.

Addition reactions - Aldehydes and Ketones - nucleophilic addition of acetals & ketals. Addition of ammonia, primary amines and other ammonia derivatives. Conjugate addition - addition in alpha and beta unsaturated aldehydes and ketones, 1, 2 and 1,4 addition.

Carbonyl compounds General properties. Keto-enol tautomerism. Mechanisms: addition of HCN to acetaldehyde, Claisen and aldol condensations. Quinones: o and p-benzoquinones- structure and properties.

UNIT - 3: Mechanism of electrophilic aromatic substitution reactions 14 hrs

Aromatic compounds - aromaticity, criteria for aromaticity, anti-aromatic and non-aromatic compounds with examples. Mechanism of electrophilic aromatic substitution reactions- halogenation, nitration, sulfonation, Friedel Crafts alkylation and Friedel Crafts acylation. Relative reactivity of substituted benzenes, polycyclic benzenoid hydrocarbons.

Role of coenzymes – definition of coenzymes, Structure and role of thiamine pyrophosphate in decarboxylation of alpha- keto acids, Biotin in carboxylation of important biochemical reactions ofcarbohydrate and lipid metabolism.

Vit B_{12} - role in rearrangement reactions.

Vit B_2 - role in redox reactions with suitable examples.

UNIT – 4 : Bio-organic compounds 14 hrs

Alcohols: Classification, monohydric alcohols: examples, general and distinguishing reactions. Dihydric alcohols: glycols, Tri hydric alcohols: glycerol – synthesis from propene, properties and uses.

Phenols: Classification, electronic interpretation of acidity of phenols, mechanism of Kolbe, Reimer– Tiemann and bromination reactions.

Hydroxy acids: Structure & properties: lactic acid, citric acid and isocitric acid. Dicarboxylic acid: maleic and fumaric acid. Ketoacids: pyruvic, α-ketoglutaric, oxaloacetic acid.

Amines: Classification, properties, functional group – Basicity of amines, acylation. Reaction with HNO_2 & Schiff's base formation. Distinguishing reactions of primary, secondary and tertiary amines.

Heterocyclic compounds: Definition, classification with examples, structure and biological importance of furan, pyrrole, thiophene, pyridine, pyran, thiazole, pyrimidine, purine, indole, imidazole. Aromaticity and basicity of pyrrole and pyridine.

Terpenes: Definition, Isoprene rule, classification, isolation, Structure and biological importance

of menthol, camphor, farnesol, phytol, lanosterol, lycopene and dolichols.

Steroids: Basic ring structure in steroids. Structure and biological importance of cholesterol, phytosterols, ergosterol, cortisol, β-estradiol, testosterone, and aldosterone. Bile acids (Mono, Di & Tri cholic acids).

Alkaloids: Definition, classification based on their structure and biological functions, Isolation of alkaloids, structure and physiological action of morphine, nicotine and atropine.

REFERENCES:

1. Textbook of Organic Chemistry 22 nd Edition S. Chand Publishers 2019.
2. Organic Chemistry. Vol.I. Fundamental principles. I. L .Finar. 6th Edn. ELBS , 2002
3. Organic Mechanisms, Peter Sykes, Longman, 1977
4. Organic Chemistry. R.T. Morrison and R.N.Boyd. 6th Edn. Prentice Hall, India, 2018
5. Lehninger- Principles of Biochemistry; DL Nelson and MM Cox [Eds), 6th Edn. Macmillan Publications 2012
6. Chemistry- An Introduction to General, Organic and Biological Chemistry, 7th Edn. Karen C. Timberlake, Benjamin Cummings, 1999
7. Reaction Mechanisms at a glance, ed. M. Moloney, Blackwell Science 2000.

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING /ASSIGNMENT

Formative Assessment	
ASSESSMENT OCCASION	**WEIGHTAGE IN MARKS**
CLASS TEST (2 CLASS TESTS)	20
SEMINARS / CLASS WORK	10
ASSIGNMENT/ OPEN DISCUSSION	10
TOTAL	40

SEMESTER - III

PRACTICALS - III

COURSE TITLE	**BIO-ORGANIC CHEMISTRY**
COURSE CREDITS	**02**
TOTAL CONTACT HOURS	**4 Hours/ Week**
DURATION OF ESA	**03**
FORMATIVE ASSESSMENT MARKS	**25**
SUMMATIVE ASSESSMENT MARKS	**25**

Course Outcome:

This course aims to familiarize students with the principles of organic chemistry and basic Qualitative analysis of organic compounds. Course Objective is to provide experimental practice of preparation of organic compounds and extraction of biologically important compounds.

Experiments:

I. Systematic Qualitative Analysis of organic compound (6 practical's)

1. Urea	2. Glucose	3. Aniline
4. Benzoic Acid	5. Salicylic acid	6.Benzaldehyde
7. Acetophenone	8. Chlorobenzene	9. Nitrobenzene

II. Preparation of following organic compounds (2 practical's)

1. Acetylation : Preparation of acetyl salicylic acid from salicylic acid.
2. Oxidation: Preparation of benzoic acid from benzaldehyde.
3. Nitration : Preparation of m-dinitrobenzene from nitrobenzene.
4. Hydrolysis : Preparation of benzoic acid from ethyl benzoate.

III. Extractions:

1. Extraction of caffeine from tea leaves
2. Extraction of starch from potatoes
3. Extraction of casein from milk

REFERENCES:

1. Practical Organic Chemistry: Qualitative Analysis by S.P. Bhutani, A. Chhikara 2009
2. Textbook of Practical Organic Chemistry Including Qualitative Organic Analysis by Arthur Israel Vogel 2003
3. Comprehensive practical organic chemistry- preparation and quantitative analysis. V. K. Ahluwalia and Renu Aggarwal 2004
4. Practical Hand Book of Systematic Organic Qualitative Analysis. Md. Rageeb Md. Usman, S. S. Patil 2017
5. Laboratory Manual of Inorganic & Organic Chemistry (Qualitative Analysis) Kalpa Mandal, Sonia Ratnani 2020

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING/ ASSIGNMENT

Formative Assessment	
ASSESSMENT OCCASION	**WEIGHTAGE IN MARKS**
CONTINUOUS EVALUATION AND CLASS TEST	15
RECORD / VIVA VOCE	10
TOTAL	25

SEMESTER – III

OPEN ELECTIVE – 1

COURSE TITLE	**BIOCHEMICAL TECHNIQUES**
COURSE CREDITS	**03**
TOTAL CONTACT HOURS	**42**
DURATION OF ESA	**03**
FORMATIVE ASSESSMENT MARKS	**40**
SUMMATIVE ASSESSMENT MARKS	**60**

Course Outcome:

- Develop competence in handling various chromatographic, electrophoretic and isotope techniques and apply them in isolating and characterizing different biological molecules

UNIT - 1 **14 hrs**

Microscopy: Different types of microscopes – Principle and applications of light microscope. Electron microscopy – TEM, SEM, applications. Fluorescence and confocal microscopes used in fine structure studies.

Centrifugation Techniques: Introduction, basic principle and applications of sedimentation. Centrifuges and their use - small bench centrifuges, refrigerated centrifuges - large capacity and high speed, continuous flow centrifuges, ultracentrifuge - preparative and analytical and density gradient centrifuge.

UNIT – 2 **14 hrs**

Chromatography: Introduction, classification of chromatographic techniques. Principle and applications of paper chromatography, Thin layer chromatography, Column chromatography-Adsorption chromatography, Gel permeation, Ion exchange chromatography, Affinity chromatography, Gas chromatography, FPLC, High performance/pressure liquid chromatography

Electrophoresis Techniques: Introduction, principle and applications of electrophoretic techniques - Paper electrophoresis, starch-gel electrophoresis, polyacrylamide gel electrophoresis (native and SDS), agarose gel electrophoresis, isoelectric focusing, isotachophoresis.

UNIT – 3 **14 hrs**

Isotope Techniques: Introduction to isotopes; radioisotopes. Radioactive decay, Units of radioactivity, Measurement of radioactivity- GM counters, Scintillation counters, autoradiography. Applications of radioisotopes in the biological Sciences.

Spectroscopy: Introduction, Nature of electromagnetic radiations. Beer-Lamberts law. Principle and applications of spectroscopic techniques in biochemical investigation - UV-Vis spectroscopy, Colorimetry, Fluorescence spectroscopy, Infrared spectroscopy, Circular dichroism (CD) spectroscopy, Electron spin resonance (ESR), Atomic Absorption spectroscopy (AAS), Nuclear Magnetic resonance (NMR) spectroscopy and Mass spectroscopy.

REFERENCES:

1. Modern experimental Biochemistry: Rodney Boyer, 3rd Edn. Benjamin Cummings , 2000
2. Practical Skills in biomolecular sciences : R Reed, D.Holmes, J Weyers and A.Jones 1998
3. Physical Biochemistry: David Frifielder 2nd Edition , 1983
4. Biophysical chemistry Upadya and Upadya , 2016
5. Introductory practical Biochemistry: SK Sawhney and Randhir Singh, 2001

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING /ASSIGNMENT

Formative Assessment	
ASSESSMENT OCCASION	**WEIGHTAGE IN MARKS**
CLASS TEST (2 CLASS TESTS)	20
SEMINARS / CLASS WORK	10
ASSIGNMENT/ OPEN DISCUSSION	10
TOTAL	40

SEMESTER – III

OPEN ELECTIVE - 2

COURSE TITLE	**HORMONES - BIOCHEMISTRY AND FUNCTION**
COURSE CREDITS	**03**
TOTAL CONTACT HOURS	**42**
DURATION OF ESA	**03**
FORMATIVE ASSESSMENT MARKS	**40**
SUMMATIVE ASSESSMENT MARKS	**60**

Course Outcome:

- Understand the function of hormones and their regulation.
- Know how hormonal systems act in an integrated manner to regulate overall body functions.
- Understand how failure of these normal physiologic functions and integrations are associated with some endocrine disorders.

UNIT – 1: Signalling **14 hrs**

Introduction to concept of systems. Hormones – definition, classification (origin, chemical nature, location and mechanism of action) and intercellular communication. Chemical signaling- endocrine, paracrine, autocrine, and neuroendocrine mechanisms. Mechanism of hormone action: synergism, antagonism, permissive effects. Physiological role of pituitary, pineal, thyroid and parathyroid hormones. Introduction to the hypothalamus as the true master gland with releasing hormones and inhibitory substances. Neurohypophysis and its secretions – ADH and oxytocin. Outline of feedback regulation of secretion of hormones. Overview on signal transduction pathways for steroidal and non- steroidal hormones (one example each).

UNIT – 2: Physiology of hormone action **14 hrs**

Physiological role of pancreas, adrenal, and placenta. Introduction to Gastrointestinal hormones and Neurotransmitters (Acetyl Choline, GABA, Serotonin). Mechanism of action, target tissues, and the physiological effects of gastrointestinal hormones. Structure and functions of sex hormones. Hormones during ovarian and uterine phases of menstrual cycle; placental hormones; role of hormones during parturition and lactation. Hormone receptors: receptors in the cell membrane and in the cell. Secondary and tertiary messengers (cAMP and Ca^{+2}).

UNIT – 3 **14 hrs**

Clinical endocrinology- Blood, plasma, serum - Separation and storage. Methods of hormone estimation, assay systems, normal range of hormones in tissues and clinical conditions leading to abnormal levels with interpretations. Thyroid function test - Determination of T3, T4, and TSH. Infertility profile: Determination of LH, FSH, TSH, estrogen, progesterone, total testosterone, free testosterone. Major manifestations of disease of the endocrine pancreas, thyroid, hypothalamus and pituitary disease.

REFERENCES:

1. Norman AW, Litwack G (1997), Hormones, 2nd Edition, Elsevier Publications.
2. Bolander F (2004), Molecular Endocrinology, 3rd Edition, Elsevier Publications.
3. Rifai N (2007), Teitz Fundamentals of Clinical Chemistry, 6th Edition, Elsevier Publications.
4. Henry's Clinical Diagnosis and Management by Laboratory Methods (2011), 22nd Edition,Elsevier.
5. Vasudevan DM (2011), Text book of Medical Biochemistry, 6th Edition, Jaypee Publishers.
6. Chatterjea MN & Shinde R (2012), Text book of Medical Biochemistry, 8th Edition, JayppePublications.
7. Bishop ML, Fody EP, Schoeff LE (2013), Clinical Chemistry: Principles, Techniques, andCorrelations, 7th Edition, Wiley Publications.
8. J N Singh (2017), Biochemistry General, Hormonal and Clinical - 1st Edition, Atithi booksPublishers.
9. Rifai N (2017), Teitz Text book of Clinical Chemistry and Molecular Diagnostics, 6th Edition Saunders Publications.

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING /ASSIGNMENT

Formative Assessment	
ASSESSMENT OCCASION	**WEIGHTAGE IN MARKS**
CLASS TEST (2 CLASS TESTS)	20
SEMINARS / CLASS WORK	10
ASSIGNMENT/ OPEN DISCUSSION	10
TOTAL	40

SEMESTER – IV

COURSE TITLE	ANALYTICAL BIOCHEMISTRY
COURSE CREDITS	04
TOTAL CONTACT HOURS	56
DURATION OF ESA	03
FORMATIVE ASSESSMENT MARKS	40
SUMMATIVE ASSESSMENT MARKS	60

Course Outcome:

- Understanding the concept of biological sample preparation
- Appreciate chemistry and application of analytical instruments.
- Get acquainted with Care & Maintenance of Equipment & Chemicals.
- Clinically relevant biochemical analysis for deeper understanding of all biochemical components i.e., Proteins, Electrolytes, Hormones etc.
- Basic knowledge of clinical and forensic analytical methods and their principles.

Course Outcomes /Program Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
Aptitude	X	X	X	X								
Critical thinking		X				X						
Subject clarity	X	X						X				X
Analytical Skill				X	X	X	X	X	X	X	X	X

UNIT - 1: Biological sample preparation and fractionation 14hrs

Introduction and objectives of bioanalysis and extraction of molecules from tissues and cells. Sample preparation types of sample - live, postmortem extraction of macromolecules from tissues; fractionation - liquid-liquid, liquid-solid and precipitation methods.

Centrifugation - Introduction, principles of centrifugation, angular velocity, sedimentation, sedimentation coefficient, centrifugal field, relative centrifugal field. Types of centrifugation- Preparative and analytical. Differential, density gradient and ultra-centrifugation. Basic instrumentation; types of rotors and their design. Laboratory centrifuge; operational instruction and applications. Analytical centrifuges- Optics; Application in sub-cellular fractionation. Care and maintenance of instrument.

UNIT - 2: Chromatography **14 hrs**

History of chromatography. General principle of chromatography. Classification based on stationary and mobile phase - Planar and column chromatography, based on types of mobile and/or liquid phase - adsorption and partition - Gas chromatography and liquid chromatography. Based on stationary phase-thin layer chromatography, Paper chromatography – Ascending, descending and circular, 2-D chromatography, Rf value.

Principles, methodologies and applications of adsorption-, partition-, ion-exchange-, gel-filtration-and affinity- chromatography. Advanced chromatography- working principle and applications of HPLC, FPLC, UPLC and GLC.

UNIT - 3: Electrophoretic and radio isotopic methods **14 hrs**

Electrophoresis- General principle of electrophoresis, velocity of a charged molecule in the applied electric field, relevance of Ohm's law in electrophoretic separations. Supporting media for electrophoresis; work of Tiselius, paper, cellulose acetate, agarose, polyacrylamide. Chemistry of polymerization of acrylamide gels, methodology and applications of native PAGE and SDS-PAGE, 2-D electrophoresis. Identification of proteins post electrophoresis- dyes and in-gel biological activities. Applications of agarose gel, pulse field electrophoresis, capillary electrophoresis and isoelectric focusing. Principle and applications of immune-electrophoresis.

Radioisotopic methods: 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 – GM counter and scintillation counters (only principal and working) Applications of radioisotopes – ^{3}H, ^{14}C, ^{131}I, ^{60}Co and ^{32}P. Biological effects of radiations. Radiolabelling, safety measure in handling radio isotopes.

UNIT – 4: Spectroscopy **14 hrs**

Wave particle duality of light, electromagnetic spectrum. Beer's law and its limitations, determination of molar absorption coefficient of molecules. Principle, design and application of colorimeter and UV-Vis spectrophotometer. Working principle and application of flame photometer and fluorimeter. Principle and application of IR, Raman, ESR, NMR, AAS and Mass spectroscopy.

REFERENCES:

1. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer 2011
2. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8th Edn. Andreas Hoffman and Samuel Clockie, Ed., Cambridge University Press, 2018.
3. Biochemistry and Molecular Biology; 5th Edn. D. Papachristodoulou, A. Snape, W.H. Elliott, and D. C. Elliott, Oxford University Press 2014

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING /ASSIGNMENT

Formative Assessment	
ASSESSMENT OCCASION	**WEIGHTAGE IN MARKS**
CLASS TEST (2 CLASS TESTS)	20
SEMINARS / CLASS WORK	10
ASSIGNMENT/ OPEN DISCUSSION	10
TOTAL	40

SEMESTER - IV

PRACTICALS - IV

COURSE TITLE	**ANALYTICAL BIOCHEMISTRY**
COURSE CREDITS	**02**
TOTAL CONTACT HOURS	**4 Hours/ Week**
DURATION OF ESA	**03**
FORMATIVE ASSESSMENT MARKS	**25**
SUMMATIVE ASSESSMENT MARKS	**25**

Course Outcome: The Course Objective is to provide experimental practice of analytical techniques in Biochemistry. Upon successful completion, students should develop skills in handling instruments and understand its application in research work.

- Sourcing and handling biological samples.
  Develop skill and proficiency in basic techniques;
- Centrifugation,
- Chromatography,
- Electrophoresis and
- Spectroscopy.

Experiments:

1. Isolation of human lymphocytes using clinical centrifuge.

2. Determination of packed cell volume/ hematocrit.

3. Separation of basic, acidic and aromatic amino acids by ascending/descending and circular paper chromatography.

4. Separation of plant pigments by gel-permeation chromatography.

5. Separation of lipids by thin layer chromatography.

6. Determination of void volume of a gel-filtration column.

7. Recording the absorption spectrum of riboflavin and determination of λ_{max}.

8. Colorimetric estimation of glucose by DNS method.

9. Estimation of DNA by diphenylamine method.

10. Electrophoretic separation of plasma proteins.

REFERENCES :

1. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer ,2011
2. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8th Edn. Andreas Hoffman and Samuel Clockie, Ed., Cambridge University Press, 2018.
3. Biochemistry and Molecular Biology; 5th Edn. D. Papachristodoulou, A. Snape, W.H. Elliott, and
   D. C. Elliott, Oxford University Press ,2014

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING /ASSIGNMENT

Formative Assessment	
ASSESSMENT OCCASION	**WEIGHTAGE IN MARKS**
CONTINUOUS EVALUATION AND CLASS TEST	15
RECORD / VIVA VOCE	10
TOTAL	25

SEMESTER – IV

OPEN ELECTIVE -1

BIOCHEMICAL TOXICOLOGY

COURSE TITLE	**BIOCHEMICAL TOXICOLOGY**
COURSE CREDITS	**03**
TOTAL CONTACT HOURS	**42**
DURATION OF ESA	**03**
FORMATIVE ASSESSMENT MARKS	**40**
SUMMATIVE ASSESSMENT MARKS	**60**

Course Outcome: This open elective course offered to various streams gives basic idea about biochemical basis of various effects of toxins/ pharmaceuticals and an outline of process involved in toxicity testing and drug dosing.

- Categorize the classes of toxicants/drugs and know specific examples
- State the routes of exposure to toxins/drugs;
- Explain the processes of absorption, metabolism and elimination of toxins/drugs; and
- Explain environmental and physiological factors that affect toxicant metabolism

UNIT – 1 Fundamentals of Toxicology and Dose response 14 hrs

Scope of toxicology; why should we know about toxins/xenobiotics (drugs) and What makes a substance toxic? Grading toxicity, Use of animal studies for toxicity, *in vitro* toxicity, organ toxicity (liver and kidney toxicity). Indicators of toxicity/drug effects; biomarkers. Concentration and site of action, dose response, effect of route of administration, ED_{50}, LD_{50}/TD_{50}. Hazard and risk assessment, risk management, acceptable daily intake (ADI) and tolerable daily intake (TDI).

UNIT – 2 Disposition of Toxins 14 hrs

Outline of ADME process - toxin/drug uptake, entry into cells and systemic circulation. Effect of size, shape, solubility, and charge on their uptake. Major sites of absorption – skin, intestine,

and liver. Role of transporters and plasma proteins in distribution. Plasma levels of toxins/drugs, plasma half-life. Excretion - kidney, biliary excretion.

Metabolism - types of metabolic changes of foreign compounds, biotransformation/detoxification reactions, phase-1 and, phase -2 reactions. Nature of phase-1 and phase 2 enzymes.

UNIT - 3 Targets of toxic damages and Biochemical Mechanism of toxicity 14 hrs

Damage caused by toxins/drugs on liver, kidney, gall bladder and lungs. Methods of identifying the damages.

Mechanism of biochemical toxicity; chemical carcinogens - benzo[a]pyrene, tamoxifen.

Liver necrosis: carbon tetrachloride, valproic Acid, and iproniazid,

Kidney damage: chloroform, antibiotics- gentamycin,

Lung damage: 4-Ipomeanol,

Neurotoxicity: isoniazid, parquet, primaquine, cyclophosphamide.

REFERENCES:

1. Biopharmaceuticals Biochemistry and Biotechnology 2nd Edn. Gary Walsh, John Wiley & Sons, Ltd, England , 2003.
2. Fundamentals of Experimental Pharmacology, Ghosh,M.N. 2nd Edition, Scientific Book Agency, Kolkatta , 1984.
3. Introduction to Biochemical Toxicology, 3rd Edn., Ernest Hodgson , Robert C. Smart; Wiley-Interscience; , 2001
4. Principles of Biochemical Toxicology, John A. Timbrell, 4th Edn. 2009, Taylor & Francis
5. Remington Pharmaceutical Sciences, Lippincott, Williams and Wilkins, 2000

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING /ASSIGNMENT

Formative Assessment	
ASSESSMENT OCCASION	**WEIGHTAGE IN MARKS**
CLASS TEST (2 CLASS TESTS)	20
SEMINARS / CLASS WORK	10
ASSIGNMENT/ OPEN DISCUSSION	10
TOTAL	40

SEMESTER – IV

OPEN ELECTIVE - 2

PLANT BIOCHEMISTRY

COURSE TITLE	**PLANT BIOCHEMISTRY**
COURSE CREDITS	**03**
TOTAL CONTACT HOURS	**42**
DURATION OF ESA	**03**
FORMATIVE ASSESSMENT MARKS	**40**
SUMMATIVE ASSESSMENT MARKS	**60**

Outcomes:

- Understand the plant cell, photosynthesis, transporters and important primary metabolites.
- Illustrate plant growth regulators, plant's responses to various biotic and abiotic stresses.
- Explain about plant secondary metabolites and their functional importance.

UNIT - 1 **14 hrs**

Plant cell- structure and molecular components: Cytoskeleton- an overview. Plant cell division, cell cycle. Outlines of energy production in plant cells, Carbon assimilation and nitrogen assimilation.

An overview of photosynthesis; C3, C4 plants and crussulacean acid metabolism (CAM); photorespiration; Phytochromes, cryptochromes and phototropins. Non-protein thiols and sulfur cycle.

Plant cell membranes and membrane transport: Introduction to plant cell membranes and membrane constituents. Organization of transport systems across plant membranes; Different types of transporters in plant cell and organelle membranes; classification and importance of H^+-ATPases. Ion channels-properties and significance; Aquaporins and water transport.

Important primary metabolites of plants: Properties, function and applications of cellulose, starch, sucrose, oligosaccharides; fructans, gums, mucilages, poly unsaturated fatty acids, lignin, suberin, surface waxes, sulfides and sweet proteins.

UNIT - 2 **14 hrs**

Plant growth regulators: Role of auxins, cytokinins, gibberellins, abscisic acid, ethylene, brassinosteroids, polyamines, jasmonic acid and salicylic acid.

Plant responses to biotic stresses: Introduction; plant pathogens and diseases; plant defense systems - hypersensitive response; systemic acquired resistance; induced systemic resistance; Plant biotic stress response to pathogens and insects.

Plant responses to abiotic stress - Salt stress, drought and heavy metal stress responses; osmotic adjustment and significance of osmotic agents such as proline, sugar alcohols and quaternary ammonium compounds. An overview of oxidative stress and oxidative damage - antioxidant enzymes and stress tolerance.

UNIT - 3 **14 hrs**

Plant Secondary Metabolites
Introduction and definition. An overview of primary metabolism contribution to secondary metabolites biosynthesis. Classification of plant secondary metabolites.

Alkaloids: General characteristics and classification with examples. Contribution of amino acids for alkaloid biosynthesis. Isolation and purification of alkaloids. (S)-Seticuline-the chemical chameleon.

Phenolics: General characteristics and classification with examples - flavonoids and anthocyanins. Isolation and purification of phenolics.

Terpenoids: General characteristics and classification with examples. Isoprene rule. Isolation and purification of terpenoids.

Applications of secondary metabolites: in plants' defense; in insects' signalling, morphogenesis and defense. Physiologically active secondary metabolites in modern medicine and therapeutic compounds for human ailments.

REFERENCES:

1. Lehninger's Principles of Biochemistry - Nelson & Cox. CBS Publishers & Distributors, 2013
2. Principles of Biochemistry - Moran, Horton, Scrimgeour, Perry. Pearson, 5th Edition , 2011

3. Plant Biochemistry - P.M. Dey & J.B. Harborne. Hart Court Asia Pvt Ltd. 1997
4. Plant Biochemistry and Molecular Biology - P. Lea & Richard C Leegood.,John Wiley & Sons. 1999
5. Introduction to Plant Biochemistry - Goodwin and Mercer. CBS Publisher and Distributors. 2005
6. Biochemistry and Molecular Biology of Plants - Buchanan, Greussem and Jones. American Society of Plant Physiologists. 2000
7. Natural Products from plants. Peter B. Kaufman, Leland J. Cseke, Sara Warber, James A. Duke, Harry L. Brielmann, CRC Press, Boca Raton 1999.
8. Natural Products Targeting Clinically Relevant Enzymes. Paula B. Andrade, Patricia Valentao David M. Pereira. Wiley-VCH Verlag GmbH & Co 2017
9. Plant Cell Tissue and Organ Culture: Fundamental Methods - O.L. Gamborg& G.C. Phillips Narosa Publishers, New Delhi , 1995.
10. Kant R. Sweet proteins – Potential replacement for artificial low calorie sweeteners. Nutrition J. 2005; 4:5 doi:10.1186/1475-2891-4-5.
11. Misaka T. Molecular mechanisms of the action of miraculin, a taste-modifying protein. Seminars Cell Develop Biol. 24:222-225, 2013.
12. Temussi PA. Natural sweet macromolecules: how sweet proteins work. Cell Molec Life Sci CMLS. 63:1876-1888, 2006

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING /ASSIGNMENT

Formative Assessment	
ASSESSMENT OCCASION	**WEIGHTAGE IN MARKS**
CLASS TEST (2 CLASS TESTS)	20
SEMINARS / CLASS WORK	10
ASSIGNMENT/ OPEN DISCUSSION	10
TOTAL	40

B.Sc III & IV SEMESTERS
MODEL QUESTION PAPER
BIOCHEMISTRY

TIME : 2.5 h MAX. MARKS : 60

NOTE: ALL SECTIONS ARE COMPULSORY

SECTION – A

1. Answer any FIVE of the following 5 x 2 = 10
   a.
   b.
   c.
   d.
   e.
   f.
   g.

SECTION – B

Answer any FOUR of the following 4 x 5 = 20

2.
3.
4.
5.
6.
7.

SECTION – C

Answer any THREE Questions 3 x 10 = 30

8. .
9.
10.
11.
12.

Note*: Section C may include sub questions a, b*

B.Sc III & IV SEMESTERS
MODEL QUESTION PAPER
BIOCHEMISTRY

TIME : 3 h **OPEN ELECTIVE** MAX. MARKS : 60

NOTE : ALL SECTIONS ARE COMPULSORY

SECTION – A

1. Answer any FIVE of the following 5 x 2 = 10
   a.
   b.
   c.
   d.
   e.
   f.
   g.

SECTION – B

Answer any FOUR of the following 4 x 5 = 20

2.
3.
4.
5.
6.
7.

SECTION – C

Answer any THREE Questions 3 x 10 = 30

8.
9.
10.
11.
12.

Note*: section C may include sub questions a, b*

INTERNAL ASSESMENT (as on 4th October meeting proceedings)

DISCIPLINE CORE	DISCIPLINE /OPEN ELECTIVE	PRACTICLAS
60 + 40 (IA)	60 + 40 (IA)	25 + 25 (IA)
Class Test -20	Class Test -20	Continuous evaluation & class test - 15
Seminars /Class work - 10	Seminars /Class work – 10	Record / Viva - 10
Assignment /Open discussion - 10	Assignment /Open discussion - 10	

B.Sc. Biochemistry -Fifth Semester
Biochemistry -V

40 h

Unit – I

Carbohydrates

Biological importance. Monosaccharides: open chain and Haworth ring structure of glucose, galactose, mannose, ribose, xylose, fructose. Epimers and Anomers; definition and examples. Brief review on configurational and conformational aspects of carbohydrates. Derived monosaccharides: structures and biological importance of -Amino sugars: glucosamine and galactosamine and their N-acetylated forms, N-acetylneuraminia acid and N-acetyl muramic acid-Sugar phosphates: D-ribose-5-Phosphate, β-D-ribose-5-Phosphate, glucose-6-Phosphate and fructose-1,6-diphosphate -Sugar acids: types with examples. Disaccharides: Structure of sucrose, maltose, lactose, isomaltose, cellobiose and trehalose. Brief discussion on reducing property. Polysaccharides: Classification with examples. Partial structure and importance of homo and hetero polysaccharides (starch, glycogen, cellulose, chitin, hyaluronic acid, heparin and chondroitin sulphate). Blood group antigens and bacterial glycosaminoglycans with examples, proteoglycans. Glycoproteins: structure and functions. Lectins: characteristics and biological importance, Cardioglycosides.

10 h

Unit – II

Lipids

Biological importance, classification. Fatty acids: definition, classification, examples and structures. Properties of fatty acids: melting point, solubility. Acylglycerols: mono, di-, triacylglycerols; general structure with examples. Hydrolysis of acylglycerols: acid value, Saponification, saponifactionvalue and its significance, Unsaturation in acyl glycerols- iodine number and iodine number of different oils. lipid peroxidation Phosphoglycerides: structure and biological roles of phosphatidyl choline, phospatidyl ethanolamine, phosphatidyl serine, phospatidyl inositol. Sphinogolipds: structure of 4-sphingenine, ceramides and sphingomyelin and their biological importance. Glycosphingolipids: Biological importance and general structure of cerebrosides and gangliosides. Prostaglandins: definition and example, biological role of prostaglandins in general, Structure of PGE_2 and PGF_2.Thromboxanes and leukotrienes. Waxes: definition, types, biological importance. Lipoproteins: Types and functions, clinical significance. Membrane: common features of membranes, behavior of amphipathic lipids in water, formation of micells, bilayers and vesicles. Biological membranes: fluid mosaic model, composition and functions. Role of cholesterol in biological membrane. Bile acids-origin and functions. Steroids: definition, functions of cholic acid.

10 h

Unit – III

Proteins

Structure and classification of α-amino acids based on the polarity of R group. Amino acids as ampholytes, zwitter ion structure of amino acids, Isoelectric pH. Titration curve of alanine. Reactions of amino acids with ninhydrin, FDNB, Edman's reagent and decarboxylation amino acids. Peptides: structure and conformation, example and function of biologically important peptides. Proteins: Classification based on composition, shape and function with examples. Colour reactions of proteins: bicinchoninic acid (BCA), Lowry, Sakaguchi's and Biuret reaction.
Structural organization of proteins: Primary structure, importance of primary structure by taking

sickle cell anemia as example. Secondary structure -Types: α-helix, β-pleated structure,β-bend and triple helix; example and characteristic features. Tertiary structure and factors stabilizing it. Quaternary structure. Denaturation: denaturating agents and mechanism of denaturation, Renaturation of ribonuclease - Anfinsen's experiment and lysozyme.

10 h

Unit – IV

4. Bioenergetics and Biological Oxidation

Laws of thermodynamics; I & II laws with mathematical expressions. Introduction to bioenergetics, stages of energy transformation-photosynthesis, respiration and utilization of energy. Free energy concepts: free energy change: exergonic and endergonic reactions. Free energy change (ΔG), standard free energy change ($\Delta G°$) and standard free energy change in biological systems ($\Delta G°'$). Biochemical standard state, relationship between $\Delta G°$ and Keq. Numerical problems. High energy compounds: examples, Energy coupling: explanation with suitable examples. Biological oxidation: Comparison of biological oxidation with combustion using glucose as an example. Calculation of thermodynamic efficiency of biological oxidation for a mole of glucose. Redox potential of half reactions of the components of electron transport chain. Problems on calculation of energy yield from biological Red-ox reactions. Electron transport chain: sequence of electron carriers based on $E°$ value indicating the sites of ATP yielding, P:O ratio. Four complexes and their functions, Cytochromes and Non heme iron (NHI) proteins. Reactions (no chemical equations) associated with NAD, FAD, FMN, ubiquinone and coenzyme-Q, salient features of chemiosmotic theory, oxidative phosphorylation.

10 h

Biochemistry Practical - V

3 hrs/week

1. Qualitative analysis of carbohydrates.
2. Qualitative analysis of amino acids and proteins
3. Qualitative analysis of lipids.
4. Preparation of solid derivatives of monosaccharide -osazones.
5. Determination of total Carbohydrate content in cereal by anthrone method.
6. Estimation of amino acids by formal titration.
7. Estimation of ascorbic acid from biological samples by titrimetric method.
8. Determination of iodine value of a lipid.
9. Determination of saponification value of a lipid.
10. Estimation of Calcium from milk.

B.Sc. Biochemistry – Fifth Semester
Biochemistry - VI

40h

Unit – I

1. Enzymes:

Brief Introduction, Nomenclature (E.C. No. upto 2nd digit) and classification of enzymes, Holoenzyme, apoenzyme, prosthetic group. Enzyme specificity and theories-Lock and key model, induced fit theory. Active site and its characteristics, Enzyme assay methods, enzyme Units, IU, KCAT & Katal. Chemical nature of enzymes catalysis and energy of activation, Effect of pH and temperature.

Enzyme kinetics of single substrate reactions- Michaelis theory, steady state theory. Michaelis-Menten equation (Noderivation), Significance of Km and V max and their determination using Line Weaver– Burkplots. Monomeric and oligomeric enzymes; cooperativity incatalysis, sigmoidal kinetics, allosteric effectors. Enzyme Inhibition: Types - reversible, irreversible, competitive, non-competitive, un-competitive and mixed inhibitors. Partial inhibition, substrate inhibition and allosteric inhibition. Cofactors- metal cofactors, Coenzymes; definition and role of TPP and PLP).

10 h

Unit – II

2. Nucleic acids:

Nucleosides and nucleotides, configuration and conformation, Composition of RNA and DNA, Physico- chemical properties of nucleic acids - effect of alkali, acid and heat (denaturation and renaturation), features of phosphodiester bond, endonucleases. Complementary base pairing, secondary structure of RNA, features of DNA double helix (Watson-Crick model),Nucleoproteins - histone and nonhistone. Isolation of nucleic acids and sequencing.

10 h

Unit – III

3. Genetic material:

Experimental proofs; Genome organization- from nucleotide to chromatin; the versatility of RNA. Basic features of DNA replication in vivo: semi - conservative replication, bidirectional replication-visualization of replication forks by autoradiography, unique origins of replication, DNA polymerases and DNA synthesis in vitro: Discovery of DNA polymerases, multiple DNA polymerases; the complex replication apparatus: semi- discontinuous synthesis, replication initiation, elongation and termination- Enzymology, outline of DNA replication in eukaryotes.

7 h

4. Mutation:

Mutagens– chemical and physical, Molecular basis of mutation: spontaneous and induced mutations. Types of mutation, reversion and suppression, DNA repair mechanisms- repair systems, direct (photoactivation), excision repair - base excision and nucleotide excision repair.

3 h

Unit – IV

5. Transcription:

Transfer of genetic information: the central dogma, RNA polymerases, different types of RNA polymerases, promoters, regulatory elements, constitutive and inducible promoter, operators.

B.Sc. Biochemistry -Sixth Semester

Biochemistry-VII

40h

UNIT-I

1. Introduction to metabolism

Definition, Anabolism and Catabolism- definition, differences, schematic representation of stages in metabolism.

1h

2.Carbohydrate metabolism

Glycolysis; definition, individual reactions. Irreversible and reversible reactions.Energy requiring and releasing reactions.. Net reaction of glycolysis. Fate of pyruvate- formation of Acetyl-CoA, Ethanol and Lactate. Energetics of Glycolysis. Regulation of Glycolysis. TCA cycle-Individual reactions. Net reaction of TCA cycle. Number of ATP molecule production. Functions of TCA cycle- Amphibolic roles (Anapleorosis)and Biosynthesis of other molecules. Regulation of TCA cycle, energetics of TCA cycle. Pentose phosphate pathways (PPP/ HMP)- Significance, reactions only names of intermediates with flow chart. Gluconeogenesis- Definition and significance, flow chart for gluconeogenesis. CORI cycle-explanation, diagram, CORI diseases. Glycogenolysis- definition, reactions- flow chart. Diabetes, types and the role of Hormones.

9 h

UNIT – II

2. Lipid metabolism:

β-oxidation of saturated fatty acids; individual reactions, enzymes, coenzymes. Energetics of β- oxidation of palmitic acid and stearic acid, role of carnitine, Oxidation fatty acids-with odd number of carbon atoms, fate of propionyl coA, oxidation of unsaturated fatty acids - oleic acid, importance of alpha and omega Oxidation. Fatty acid synthetases; structure and functions. Biosynthesis of fatty acids-general flow chart, difference between fatty acid oxidation and fatty acid synthesis. cholesterol biosynthesis- (chemical reactions up to the formation of mevalonate, remaining reactions may be given as flow scheme). Atherosclerosis-causes. Ketone bodies-examples, cause for the production, utilization, ketonemia and ketonuria.

10 h

UNIT-III

3. Amino acid metabolism:

General reactions: transamination- definition, reactions catalyzed by SGOT and SGPT, Deamination - definition, oxidative and non-oxidative, examples for oxidative deamination- L-glutamate and non-oxidative- serine, aspartic acid and glutamine. Decarboxylation - definition, decarboxylation of glutamic acid, Histidine and DOPA to Dopamine. Urea cycle- individual reactions, Compartmentation in mitochondria and cytosol, regulation of urea cycle. Interrelationship between urea cycle and TCA cycle. Biosynthesis of glycine from serine and choline. Biosynthesis of alanine from transamination reaction. Biosynthesis of cysteine from L- serine. Epinephrine and Nor-epinephrine- importance and biosynthesis from tyrosine. PKU and AKU characteristic features.

6 h

4. Nucleic acid metabolism:

Biosynthesis of purine and pyrimidine nucleotides- origin of nitrogen and carbon atoms of purine and pyrimidine ring. Precursors of purine and pyrimidine biosynthesis. Reactions of conversion of AMP to IMP and Adenosine to inosine. Orotic acid uria- general features. Gout; general features.

4h

Unit – IV

5. Photosynthesis:

Types of Photosynthetic pigments and Photosynthetic unit. Light reactions- photosystem- I and II and their interactions. Synthesis of NADPH, photolysis of water, synthesis of ATP in cyclic and non-cyclic photophosphorylation. Dark reactions - chemical reactions upto the synthesis of fructose-6-phosphate. Trans- ketolation and aldolation reactions (shall be given in the form of flow chart). Interdependence of light and dark reactions. C3 and C4 plants- definition and C4 pathway.

8h

6. Biological Nitrogen Fixation:

Nitrogen cycle, components of nitrogenase complex, stoichiometry of nitrogen fixation, nif genes.

2h

Biochemistry Practical-VII

3 h/week

List of experiments:

1. Estimation of protein by FC method
2. Estimation of Iron using ammonium thiocyanate by Colorimetric method
3. Colorimetric Estimation of Inorganic Phosphate by Fiske Subbarow method
4. Colorimetric Estimation of Creatine and Creatinine by Jaffe's method
5. Colorimetric Estimation of Lactose in milk by D.N.S method
6. Estimation of amino acid (alanine/glycine) using ninhydrin by colorimetric method
7. Estimation of serum cholesterol by Zak's method
8. Extraction of DNA from onions
9. Conductometric titration of amino acid against NaOH.
10. Conductometric titration of amino acid against HCl

B.Sc. Biochemistry – Sixth Semester

Biochemistry –VIII

40 h

Unit – I

1. Industrial Microbiology:

Principles and methods of sterilization; physical and chemical methods with examples.Isolation of pure cultures; enrichment, dilution-plating, streak- and spread-plate and micromanipulations. preservation of pure cultures - sub culturing, lyophilization. Microbial growth kinetics: Growth curve, Measurement of growth (cell count), immobilization of microbes. Fermentation Technology; Use of microorganisms in fermentation, design of fermenters, types, media inoculation. Fermentation types; single, batch, submerged and solid state. Industrial production and uses of the following: Alcohol- ethanol, Organic acids - citric acid, Amino acid - Glutamic acid, Antibiotics-penicillin, Enzymes- amylase and microbial fuel cells.

10 h

Unit-II

2. **Immunology:**

Organs and cells of Immune system - Primary and secondary Lymphoid organs, Dual nature of the immune system. Immunity- Types, Innate immunity: First Line of Defense - skin, mucous membrane and normal micro biota in nonspecific defense. Second Line of Defense - Components of Blood, innate immunity -complement, acute phase proteins and interferons. Mechanism of immune response - phagocytosis and inflammation. Adaptive immunity: cell mediated and humoral immunity, Complement system - Functions, classical and alternate pathways. Antigens - Chemical nature of antigens, hapten, antigenicity, immunogenicity, epitope, idiotopes, super antigens. Antigen processing and presentation. Immunoglobulins - Isotypes, structures and functions IgG, IgM, IgE; Subunit organisation and structure of IgG. Methods of raising antibodies – adjuvants, immune sera. Monoclonal antibodies - production and application. Major histocompatibility complex proteins (MHC): Types, physiological role.Antigen-antibody reactions - Agglutination, Precipitation, Neutralisation, Complement fixation and Opsonisation. Hyper sensitivity reactions- Types and examples, Allergy, Type-I HS reaction and its mechanism. Vaccines- classification, methods of production of live, attenuated vaccines, toxoids, adjuvants. modern vaccines -recombinant, peptide and DNA vaccines.

10 h

Unit III

3. Recombinant DNA Technology:

Concepts and scope of genetic engineering. Basic principles and importance of gene cloning and Recombinant DNA Technology. Tools in Recombinant Technology: Enzymes - Role of DNA polymerase, Class II restriction endonucleases,DNA ligase and RNA ligase, phosphatases and terminal transferases in cloning.Cloning vectors: - Characteristic features of plasmid vectors - pBR322, pUC18., Phage vectors- M13 phage vectors, Cosmids- features and advantages. Shuttle vectors - YAC and BAC vectors. Preparation, Manipulation and Insertion of desired DNA into vector. Transformation, Transduction, Transfection of r-DNA into target host organisms: Calcium chloride mediated gene transfer, Agro bacterium mediated DNA transfer, Electroporation, Microinjection, Liposome fusion and Micro particle bombardment. Cloning and expression in bacteria, Screening and selection of transformants by colony hybridization, Insertional inactivation. Genomic and c-DNA Libraries - outline of their construction and applications.

10 h

Unit IV

4. Molecular and Immunological techniques:

Blotting techniques: principle and applications of Western, Southern and Northern blotting. Probes – Types and characteristics. Molecular biology techniques: PCR- types – RT PCR and Direct PCR - principle, applications. Hybridization techniques - types and applications. Fluorescent In situ Hybridization (FISH), DNA finger printing - RFLP, RAPD, microarrays, Immunochemical techniques: principle and applications of Precipitation-VDRL, agglutination- Widal test, Immunodiffusion, Immuno-electrophoresis, RIA and ELISA- Types, Autoradiography - principle and applications.

10 h

Biochemistry Practical-VIII

3 h / week

1. Identification of antigen by Ouchterlony Immunodiffussion technique.
2. Immunoelectrophoresis of serum or any biological sample.
3. Restriction digestion of DNA and separation by agar-gel-electrophoresis.
4. Ammonium sulphate fractionation of serum proteins. (Demonstration)
5. Separation of serum and plasma from blood.
6. Serum uric acid estimation.
7. Determination of the melting temperature and GC content of DNA.
8. Estimation of serum Ca^{2+}.
9. Study of cell viability /death assay by use of trypan blue and tutorial for MTT assay.
10. Estimation of homocysteine levels in serum
11. Effect of detergents and other membrane active substances on erythrocytes
12. Molecular Visualization Softwares: Pymol and Rasmol for protein structures from PDB
13. Continuous assay of an enzyme
14. Visualization of cells by methylene blue

REFERENCES

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