

University of PYAY
Department of Chemistry
Syllabus for BSc Degree
Biochemistry Specialization
2019–2020
First Year (Semester I)

Module No. BC 1101

CHAPTER I

1. QUANTUM NUMBERS AND ELECTRON CONFIGURATIONS

1.1 Quantum Numbers

1.2 Rules Governing the Allowed Combinations of Quantum Numbers

1.3 Shells and Sub-shells of Orbitals

1.4 Possible Combinations of Quantum Numbers

1.5 Electron Spin: The Fourth Quantum Numbers

1.6 The Pauli Principle

1.7 Pauli Exclusion Principle

1.8 Electron Configurations of the Elements

1.8.1 The Aufbau Principle

1.8.2 Valence Electrons

1.9 Blocks in the Periodic Table

SUMMARY

CHAPTER II

2. THE FOUNDATIONS OF CHEMISTRY

2.1 Density and Specific Gravity

2.2 Heat Transfer and the Measurement of Heat

2.3 Concentrations of Solutions

2.4 Properties of Liquid

2.5 Intermolecular Attractions and phase changes

2.6 Viscosity

- 2.7 Surface Tension
- 2.8 Capillary Action
- 2.9 Evaporation
- 2.10 Vapour pressure
- 2.11 Boiling points and Distillation
- 2.12 Heat Transfer Involving Liquids

CHAPTER III

3. GASES AND KINETIC MOLECULAR THEORY

- 3.1 Composition of the atmosphere and Some common properties of Gases
- 3.2 Pressure
- 3.3 Boyle's Law: The volume–pressure relationship
- 3.4 Charles' Law: Volume–temperature relationship
- 3.5 Avogadro's law and the standard Molar Volume
- 3.6 Summary of Gas Laws: The ideal Gas Equation
- 3.7 Newton's law of Partial Pressures
- 3.8 The Kinetic Molecular Theory
- 3.9 Deviation from Ideal Gas Behavior

CHAPTER IV

4. INTRODUCTION TO BIOCHEMISTRY

- 4.1 Introduction to Biochemistry
 - 4.1.1 A knowledge of Biochemistry is Essential to All Life Sciences
 - 4.1.2 A Reciprocal Relationship Between Biochemistry and Medicine has Stimulated Mutual Advances
 - 4.1.3 Normal Biochemical Processes are the Basis of Health
- 4.2 Biomolecules: The Molecules of Life
 - 4.2.1 The Elementary Composition of Human Body
 - 4.2.2 Biomolecules are Compounds of Carbon with a Variety of Functional Groups
 - 4.2.3 Cell contain a Universal Set of Small Molecules
 - 4.2.4 Macromolecules are the Major Constituents of Cells

4.2.4.1 Complex Biomolecules (proteins, nucleic acids, carbohydrates, fats)

4.3 Cellular Foundation

4.3.1 Cells are Structural and Functional Units of All Living Organisms

4.3.1.1 Prokaryotes and Eukaryotes

4.3.1.2 Plant Cell and Animal Cell

4.3.1.3 Introduction to Cell Organelles

(i) Cell Wall

(ii) Cytoskeleton

(iii) The Genetic Material

(iv) Ribosomes and Protein Production

(v) Role of the Endoplasmic Reticulum

(vi) Mitochondria

(vii) Chloroplasts

(viii) Golgi Apparatus

(ix) Peroxisomes

(x) Vacuoles

(xi) Lysosomes

4.3.2 Experimental Approach

4.3.2.1 Isolation of Molecules

4.3.2.2 Determination of the Structure of Biomolecules

4.3.2.3 Analysis

First Year (Semester II)

Module No. BC 1102

(I) Carbohydrates of Biochemical Importance

- Monosaccharides
- Hexoses
- Glycosides
- Deoxy sugars
- Amino sugars (Hexosamines)
- Disaccharides
- Polysaccharides
- Carbohydrates of cell membrane

(II) Water and pH

- Body water, intracellular fluid and extracellular fluids
- Water as ideal biologic solvent
- Hydrogen bonds and molecular structure
- Water as a nucleophile
- Ionization of water
- pH
- Buffer solution

Second Year (Semester I)

Module No. BC 2101

1. Introduction to Biomolecules

1.1 Biomolecules

1.1.1 Properties of Biomolecules

1.1.2 Types of Biomolecules

2. Carbohydrates

2.1 Classification

2.2 Structure and Chemistry of Monosaccharides

2.3 Stereochemistry

2.4 Cyclic and Anomeric Forms of Monosaccharides

2.5 Reactions of the Monosaccharides

2.5.1 Mutarotation

2.5.2 Glycoside formation

2.5.3 Reduction and oxidation

2.5.4 Epimerization

2.5.5 Esterification

2.6 Important Monosaccharides

2.7 Disaccharides

2.7.1 Maltose

2.7.2 Lactose

2.7.3 Sucrose

2.8 Oligosaccharides

2.9 Polysaccharides

2.9.1 Important Polysaccharides

3. Lipids

3.1 Fatty Acids

3.1.1 Characteristics

3.1.2 Function

3.1.3 Naming

3.1.4 Reactions

3.1.5 Essential Fatty Acids

3.2 Fat and Oils

3.2.1 Structure

3.2.2 Function

3.2.3 Reactions

3.3 Waxes

3.3.1 Structure

3.3.2 Function

3.4 Glycerophospholipids

3.4.1 Structure

3.4.2 Function

3.4.3 Reactions

3.4.4 Ether-linked fatty acids

3.5 Sphingolipids

3.5.1 Structure

3.5.2 Function

3.6 Sterols

3.6.1 Structure

3.6.2 Function

3.7 Terpenes

3.8 Eicosanoids

3.8.1 Structure

3.8.2 Types

4. Amino Acids

4.1 General Structure

4.1.1 Formula

4.1.2 Stereochemistry

4.1.3 Classification of amino acids

4.2 Essential Amino Acids

4.3 Properties of Amino Acids

4.3.1 Physical Properties

4.3.2 Chemical Properties

4.4 Peptides

4.4.1 Peptide Bonds

4.4.2 Properties of Peptides

5. Nucleic Acids

5.1 Nucleic Acid Building Blocks

5.1.1 Nitrogenous Bases

5.1.2 Phosphate

5.1.3 Ribose and Deoxyribose Sugars

5.2 Formation of Nucleosides and Nucleotides

5.2.1 Nucleosides

5.2.2 Nucleotides

5.3 Nucleic Acid

6. Vitamins

6.1 Vitamin supply

6.2 Lipid- soluble Vitamins

6.2.1 Vitamin A

6.2.2 Vitamin D

6.2.3 Vitamin E

6.2.4 Vitamin K

6.3 Water – soluble Vitamins

6.3.1 Vitamin B1 (thiamine)

6.3.2 Vitamin B2

6.3.3 Folate

6.3.4 Niacin

6.3.5 Pantothenic acid

6.3.6 Vitamin B6

6.3.7 Vitamin B12

6.3.8 Vitamin C

6.3.9 Vitamin H

References

Module No. BC 2102

CHAPTER I

1. INTRODUCTION

1.1 Introduction to Enzymology

Definition of Enzyme

1.2 Nature of Enzymes

1.2.1 Chemical Nature of Enzymes

1.3 Composition of Enzymes

1.4 Nomenclature and Classification

1.5 Coenzymes and Cofactors

1.6 Roles of Coenzymes

1.7 Isozymes

CHAPTER II

2. ENZYME CATALYSIS

2.1 Introduction to Enzyme Catalysis

2.2 Active Site

2.3 Transition State

2.4 Catalysis

2.5 Specificity of Enzymes

2.6 Mechanism of Enzyme Action

2.6.1 Emil Fisher's Lock and Key or Rigid Template Model

2.6.2 Substrates Induce Conformational Changes in Enzymes

2.6.2.1 Induced Fit

2.7 Entropy

2.8 Strain and Distortion

2.9 Transition-State Stabilization

2.10 Transition-State Analogs

CHAPTER III

3. ENZYME PURIFICATION

3.1 Introduction

3.2 Enzyme Solubilization Technique

3.3 Selection of the Isolating Medium

3.4 Techniques used for Enzyme Isolation

3.4.1 Pestle and mortar

3.4.2 Blender

3.4.3 Ultra- Sonicator

3.4.4 Acetone powder

3.5 Methods of Enzyme Purification

3.5.1 Salting out

3.5.2 Chromatographic separation of the enzyme proteins

3.5.3 Ion exchange chromatography

3.5.4 Adsorption chromatography

3.5.5 Gel filtration chromatography

3.5.6 Affinity chromatography

3.5.7 Dialysis and Ultrafiltration

CHAPTER IV

4. ENZYME KINETIC

4.1 Introduction

4.2 Simple One-Substrate Enzyme Kinetics

4.3 Experimental Determination of Michaelis-Menten

4.4 Two- Substrate Enzyme Kinetics

Module No. BC 2103

1. SEPARATION TECHNIQUES

1.1 Introduction

1.1.1 Classification of Separation Techniques

1.2 General Methods of Separation

1.2.1 Zonal Methods

1.2.2 Frontal Methods

1.2.3 Displacement Methods

2. CHROMATOGRAPHY

2.1 History of Chromatography

2.1.1 Paper Chromatography

2.1.2 Thin Layer Chromatography

2.1.3 Ion Exchange Chromatography

2.1.4 Gel Permeation Chromatography

2.1.5 Affinity Chromatography

2.1.6 Gas Chromatography

2.1.7 Supercritical Fluid Chromatography

2.1.8 High Performance Liquid Chromatography

2.1.9 Capillary (Zone) Electrophoresis

3. ELECTROPHORESIS

3.1 Introduction

3.2 General Features of Electrophoresis

3.3 Native protein electrophoresis

3.4 Polyacrylamide Gel Electrophoresis in The Presence of SDS (SDS-PAGE)

3.4.1 Gradient PAGE

3.5 Isoelectric Focusing

3.6 2D Electrophoresis

3.7 Staining, Densitometry and Blotting

3.8 Capillary Electrophoresis

3.9 Proteomics

4. CENTRIFUGATION METHODS

4.1 Introduction

4.2 Sedimentation and Relative Centrifugal g Force

4.3 Centrifugal Force in Different Rotor Types

4.3.1 Swinging-Bucket Rotors

4.3.2 Fixed-Angle Rotors

4.3.3 Vertical Rotors

4.4 Clearing Factor (k)

4.4.1 Materials Used to Generate a Gradient

4.5 Types of Centrifugation Techniques

4.5.1 Differential Centrifugation

4.5.2 Rate-Zonal Centrifugation

4.5.3 Isopycnic Centrifugation

4.6 Harvesting Samples

4.6.1 Analytical Ultracentrifugation

4.7 Sedimentation Velocity Analysis

4.7.1 Sedimentation Equilibrium Analysis

4.8 Selected Examples

4.8.1 Analytical Ultracentrifugation for Quaternary Structure Elucidation

4.8.2 Isolation of Retroviruses by Self-Generated Gradients 18

4.8.3 Isolation of Lipoproteins from Human Plasma

5. SPECTROPHOTOMETRY

5.1 Spectroscopy

5.1.1 UV/VIS Spectroscopy

5.2 Use of Spectrophotometers

5.3 Spectrophotometer Design

5.3.1 Lambert-Beer Law

5.4 Mass Spectrometry

5.4.1 The Mass Spectrum Fragmentation

5.5 Infrared Spectroscopy

5.5.1 Stretching and Bending Vibrations

5.5.2 Obtaining an Infrared Spectrum

5.5.3 The Functional Group and Fingerprint Regions

6. FLUOROMETRY

6.1 Introduction to Fluorescence

6.1.1 Phenomena of Fluorescence

6.1.2 Jablonski Diagram

6.1.3 Characteristics of Fluorescence Emission

REFERENCES

Second Year (Semester II)

Module No. BC 2104

(I) Nutrition

- Nutrient requirements in human
- Energy requirements in human
- Macronutrient
- Minerals
- Dietary recommendation
- Nutrition and chronic diseases
- Protein-calorie malnutrition

Module No. BC 2105

(I) Biochemistry of Digestion and Absorption

- Digestion of carbohydrates
- Protein digestion
- Gastric juice composition
- Proteolytic enzymes
- Pepsin, Trypsin, Chymotrypsin

- Digestion of lipids
- Absorption from the gastrointestinal tract
- Enzyme deficiency

Module No. BC 2106

(I) Proteins

- Myoglobin and Haemoglobin
- Function of myoglobin and haemoglobin
- The oxygen dissociation curve
- Mutant human haemoglobins

Third Year/ First Year Honours (Semester I)

Module No. BC 3101/ 3201

(I) Basic Concepts of Metabolism

- Metabolic map
- Catabolic and Anabolic pathway
- Regulation of metabolism
- Transduction by intracellular receptors
- Transduction by cell-surface receptors
- Intracellular messenger systems

(II) Bioenergetics and Oxidative Phosphorylation

- Free energy
- ATP as an energy carrier
- Electron transport chain
- Oxidative phosphorylation

Module No. BC 3102/ 3202

(I) Glycolysis

- Transport of glucose into cells
- Reactions of glycolysis
- Alternate fates of pyruvate
- Energy yield of glycolysis

- Clinical notes
- Hormonal regulation of glycolysis

Module No. BC 3103/ 3203

(I) Citric Acid Cycle

- Reaction of the citric acid cycle
- Stoichiometry of the citric acid cycle
- Regulation of the citric acid cycle

(II) Hexose Monophosphate Pathway and Uronic Acid Pathway

- Oxidative reactions
- Non-oxidative reactions
- Uses of NADPH
- Glucose-6-phosphate dehydrogenase deficiency
- Uronic acid pathway

Module No. BC 3104/ 3204

(I) Glycogen Metabolism

- Structure and function of glycogen
- Synthesis of glycogen
- Degradation of glycogen
- Regulation of glycogen synthesis and degradation
- Glycogen storage diseases

(II) Gluconeogenesis

- Reaction unit to gluconeogenesis
- Substrates for gluconeogenesis
- Regulation of gluconeogenesis

Third Year / First Year Honours (Semester II)

Module No. BC 3105/ 3205

(I) Metabolism of Monosaccharides and Disaccharides

- Fructose Metabolism
- Galactose Metabolism
- Lactose Metabolism

(II) Glycosaminoglycans

- Structure of glycosaminoglycans
- Structure of proteoglycans
- Synthesis of glycosaminoglycans
- Degradation of glycosaminoglycans
- Micopolysaccharidoses

(III) Glycoproteins

- Structure of glycoproteins
- Synthesis of glycoproteins
- Lysosomal degradation of proteins

Module No. BC 3106/ 3206

(I) Fatty Acid and Triacylglycerol Metabolism

- Structure of fatty acid
- De Novo synthesis of fatty acid
- Mobilization of stored fats and oxidation of fatty acids
- Specialized fatty acids
- Ketone bodies

Module No. BC 3107/ 3207

(I) Phospholipid Metabolism

- Structure of phospholipids
- Synthesis of phospholipids
- Degradation of phospholipids

Module No. BC 3108/ 3208

(I) Cholesterol and Steroid Metabolism

- Structure of cholesterol
- Synthesis of cholesterol
- Degradation of cholesterol
- Bile acids and bile salts
- Plasma lipoproteins
- Steroid hormones

Fourth Year/ Second Year Honours (Semester I)

Module No. BC 4101/ 4201

(I) Amino Acid Metabolism

- Removal of nitrogen from amino acids
- Metabolism of ammonia
- Urea cycle
- Biosynthesis of non-essential amino acids

(II) Nitrogen Metabolism

- Overall nitrogen metabolism
- Digestion of dietary proteins
- Transport of amino acid into cell
- Catabolism of the carbon skeletons of amino acids
- Role of folic acid in amino acid metabolism
- Metabolic defects in amino acid metabolism

Module No. BC 4102/ 4202

(I) Glycolipid Metabolism

- Structure of glycosphingolipids
- Synthesis of glycosphingolipids
- Degradation of glycosphingolipids
- Sphingolipidoses

Module No. BC 4103/ 4203

(I) Enzyme Catalysis

- 5 Role of cofactors in enzyme catalysis: NAD/NADP⁺, FMN/FAD, coenzyme A, biotin, TPP, pyridoxal phosphate, cobalamin, tetrahydrofolate

(II) Enzyme Kinetics

Module No. BC 4104/ 4204

(I) Porphyrin Metabolism

(II) Nucleotide Metabolism

Module No. BC 4105/4205

(I) Research Methodology

- Basic Concept of Research Methodology
- Literature Survey
- Research Design
- Data Collection and Analysis
- Report Writing and Presentation

Module No. BC 4106/4206

(I) Clinical Biochemistry I

Fourth Year/ Second Year Honours (Semester II)

Module No. BC 4107/ 4207

(I) Vitamins

- Vitamin supplements
- Water-soluble vitamins
- Fat-soluble vitamins
- Deficiency diseases

Module No. BC 4108/ 4208

(I) Metabolism of Xenobiotics

Module No. BC 4109/ 4209

(I) Molecular Biology I

- Basic concepts of genetic information
- Structural levels of nucleic acids

Module No. BC 4110/ 4210

(I) Medical Biochemistry

- Mechanism of action at molecular level of selected antibiotics, anti metabolites, analgesics, hallucinogens and other drugs, mechanism of resistance to antibiotics and other drugs
- Lysosomes and their physiological role
- Cerebrospinal fluid, composition in health and disease

- Blood coagulation, clotting factors, mechanism of coagulation

Module No. BC 4111/4211

(I) Nutritional Biochemistry I

- Overview
- Tables of Inorganic Nutrients
- Sodium, Potassium, Chloride, and Water
- Iodine
- Iron
- Calcium and Phosphate
- Magnesium
- Manganese
- Zinc and Copper
- Molybdenum, Sulfite and Sulfate
- Selenium and Glutathione
- Other Inorganic Nutrients

Module No. BC 4112/4212

(I) Clinical Biochemistry II

Third Year Honours/ MSc (Qualifying) (Semester I)

Module No. BC 5201

(I) Environmental Biochemistry I

Air pollution

- Particular matter
- Compounds of carbon, sulphur, nitrogen and their interactions
- Methods for their estimation
- Their effects on atmosphere

Module No. BC 5202

(I) Hormones I

- Introduction
- Classification of hormones
- Mechanism of hormones action
- Hormone that regulate fuel metabolism
- Hormone that regulate salt and water balance

Module No. BC 5203

(I) Introduction to Secondary Metabolism I

Module No. BC 5204

(I) Molecular Biology II

- DNA replication
- Transcription
- Translation and regulations of gene expression
- Mutation and repair
- Recombinant DNA technology

Module No. BC 5205

(I) Separation Methods of Enzymes, Amino Acids, Proteins and Nucleic Acids

Module No. BC 5206

(I) Biochemical Techniques I

Basic Principles of Biochemical Technology

- Protein purification
- Protein analysis
- DNA analysis
- Fragmentation
- Gel-electrophoresis
- Sanger Dideoxy method
- The polymerase chain reaction

Third Year Honours/ MSc (Qualifying) (Semester II)

Module No. BC 5207

(I) Environmental Biochemistry II

Water pollution

- Types of water bodies and their general characteristics
- Major pollutants in domestic, agricultural and industrial wastes
- Methods of their estimation
- Effects of pollutants on plants and animals
- Treatment of domestic and industrial wastes, solid-wastes and their treatments

Module No. BC 5208

(I) Hormones II

- Hormones that regulate calcium and phosphate metabolism
- Hormones that regulate body size and metabolism
- Hormones that regulate the male reproductive system
- Hormones that regulate the female reproductive system

Module No. BC 5209

(I) Introduction to Secondary Metabolism II

Module No. BC 5210

(I) Bioenergetics and Radioisotopic Techniques

Module No. BC 5211

(I) Biochemical Techniques II

- 6 Chromatography

Module No. BC 5212

(I) Nutritional Biochemistry II

- Overview
- Cancer of the Large Bowel
- Genetic Changes that Result in Cancer
- RAS and the MAP Kinase Signaling Pathway
- Mutations in the RAS Gene and Cancer
- Cadherin Protein
- Epidemiology of Diet and Colon Cancer
- Summary