Contents

Preface ...(vii) Acknowledgement ...(ix) PART - I: BASIC BIOCHEMISTRY CHAPTER - 1 Introduction to Biochemistry ...3 Cell ...3 Composition of cell ...3 Elements ...3 Macromolecules or biomolecules ...4 Structural hierarchy of organism ...4 Chemical composition of organism ...4 Types of cells ...5 Prokaryotic Cells ...5 Eukaryotic Cells ... 7 Comparison between prokaryotes and eukaryotes ...12 Biochemical Organisation of Cell Membrane ...12 Composition of membrane ...13 Structure of membrane ...13 Transport of the Molecules Across Membranes ...14 Transport of Metabolites or Solutes ...14 Mechanism of transport system ...14 Passive transport ...14 Active transport ...16 Types of transport system ...16 Transport of Macromolecules ...17 Endocytosis ...17 Exocytosis ...17 Disorders of Membrane Transport System ...18 Bioenergetics (or) Biochemical Thermodynamics ...18 Terms used in bioenergetics ...19 Relationship between the change of free energy, enthalpy and entropy ...20 Biological Oxidation ...21

Redox potential ...21

Co-enzyme System Involved in Biological Oxidation ...22 Energy Rich Compounds ...22 Classification of high energy compounds ...23 Adenosine triphosphate (ATP) ...24 Biological significance of ATP ...25 Cyclic adenosine monophosphate (cAMP) ...26 Biological significance of cAMP ...26 Synthesis of ATP 27 Substrate level phosphorylation ...27 Oxidative phosphorylation ...28 Phosphorous oxygen ratio (P:O) ...28 Site of oxidative phosphorylation in ETC ...28 Energetic of oxidative phosphorylation ...28 Mechanism of oxidative phosphorylation ...29 Inhibitors of oxidative phosphorylation ...31 Electron Transport Chain (ETC) or Respiratory Chain or Electron Transport System (ETS) ...32 Mitochondria ...32 Mechanism of ETC ...33 Components of ETC ...33 Inhibitors of ETC ...35 Probable Questions ...37 Part-A: Multiple Choice Questions ...37 Key for Multiple Choice Questions ...41 Part-B: Short Answers ...41 Part-C: Long Answers ...42 CHAPTER - 2 Enzymes ...43 Properties ...43 Nomenclature ...44 Classification ...45 Mechanism of Enzyme Action ...46

Formation of enzyme-substrate complex ...47 Lock and key model or Fischer's template theory ...47

Induced fit theory or Koshland's model ...47

Substrate strain theory47	Chemical Reactions of Monosaccharides93
Mechanism of enzyme catalysis48	Biological Significance of Carbohydrates100
Thermodynamics of Enzymatic Reactions49	Metabolism of Carbohydrates101
Factors Affecting Enzyme Action49	Transport of Glucose101
Enzyme Inhibition54	Glycolysis104
Reversible enzyme inhibition (REI)54 Irreversible enzyme inhibition57 Allosteric enzyme inhibition58	Definition104 Types104 Pathway104
Enzyme Regulation59	Regulation109
Allosteric regulation59 Latent enzyme activation61 Metabolic pathways compartmentation62 Enzyme synthesis control62 Enzyme degradation62 Iso-enzyme63	Importance/Significance109 Energetics109 Metabolic disorders109 Conversion of Pyruvate to Acetyl CoA110 Citric Acid Cycle110
Co-enzymes63 Types of co-enzymes63 Vitamin co-enzymes63 Non-vitamin co-enzymes63 Nucleotide co-enzymes69 Protein co-enzymes69	Other names110 Definition110 Pathway111 Importance/Significance114 Regulation114 Energetics114 Energetics of Glucose Oxidation114
Iso-enzyme69	Aerobic condition114
Therapeutic and diagnostic applications of	Anaerobic condition114
iso-enzymes69 Applications of Enzymes71 Therapeutic applications71 Analytical applications72 Applications in genetic manipulation72	Gluconeogenesis115 Definition115 Pathway115 Significance123 Regulation123
Industrial applications72 Diagnostic applications72	Hexose Mono Phosphate (HMP) Shunt123
Probable Questions74 Part-A: Multiple Choice Questions74 Key for Multiple Choice Questions79 Part-B: Short Answers80 Part-C: Long Answers80	Other names123 Definition123 Pathway123 Significance126 Metabolic disorder127 Regulation127
DADT II DIOMOLECTURO A ITO	Glycogen Metabolism127
PART - II: BIOMOLECULES & ITS METABOLISM	Glycogenesis128
Chapter - 3	Definition128 Pathway128
Carbohydrates & Its Metabolism85	Glycogenolysis131
Classification85	Definition131 Pathway131
Chemical Nature90	

Glycogen Storage Diseases133	β-Oxidation of unsaturated fatty acids166 β-Oxidation of fatty acids in peroxisomes166
Von-Gierke's disease134	α-Oxidation of Fatty Acids166
Diabetes Mellitus136	ω-Oxidation of Fatty Acids167
Regulation of Carbohydrate Metabolism137	Metabolic Water & Fatty Acid Oxidation167
Allosteric regulation137 Hormonal regulation138	Ketone Bodies Metabolism167
Effect of calcium140	
Glucose Tolerance Test (GTT)140	Ketogenesis168
Preparation of subject140	Regulation of ketogenesis171
Procedure140	Ketolysis171
OGTT for diabetes140 OGTT for gestational diabetes141	Metabolic Disorders of Ketone Bodies Metabolism171
Galactose Tolerance Test142	Denovo Synthesis of Fatty Acids173
Procedure142	FAS complex178
Probable Questions142	Regulation179 Synthesis of unsaturated fatty acid180
Part-A: Multiple Choice Questions142 Key for Multiple Choice Questions147	Synthesis of long chain fatty acid180
Part-B: Short Answers148 Part-C: Long Answers148	Comparison of Fatty Acid Synthesis and β-oxidation of Fatty Acids180
CHAPTER - 4	Metabolism of Cholesterol181
Lipids & Its Metabolism151	Biosynthesis of Cholesterol181
	Regulation187
Classification of Lipids151	Biological Significance of Cholesterol188
Biological Significance of Lipids154	Degradation of Cholesterol188
Fatty Acids154	Synthesis of bile acids189
Classification of Fatty Acids154	Synthesis of steroid hormones from cholesterol191
Classification based on total number of	Synthesis of adrenocorticosteroids191 Synthesis of steroid sex hormones194
carbon atoms155	Synthesis of vitamin-D194
Classification based on length of hydrocarbon chain155	Metabolic Disorders of Lipid Metabolism198
Classification based on nature of	Hypercholesterolemia198
hydrocarbon chain155	Atherosclerosis199
Nomenclature of Fatty Acids155	Fatty liver199 Obesity201
Biological Significance of Fatty Acids157	Biosynthesis of Triglycerides or
Fatty Acid Oxidation157	Triacylglycerols (TG) 202
β-Oxidation of Fatty Acids157	Activation of fatty acid202
Definition157	Activation of glycerol203 Addition of acyl groups for the
Stages involved158 Oxidation of palmitic acid163	formation of triacylglycerol203
Energetic of palmitic acid β-oxidation164	Biosynthesis of Phospholipids205
Metabolic disorder165 β-Oxidation of odd carbon chain fatty acids165	Synthesis of lecithin and cephalin205
p Oxidation of our outpoil origin latty acids 100	Synthesis of phosphatidylserine206

Synthesis of phosphatidylinositol207 Synthesis of phosphatidylglycerol	Transamination236
and cardiolipin207	Definition236
Synthesis of plasmalogens208	Most important features236
Synthesis of sphingomyelins208	Mechanism238
Hormonal Regulation in Lipid Metabolism209	Deamination238
Probable Questions210	Oxidative deamination238 Non-oxidative deamination240
Part-A: Multiple Choice Questions210 Key for Multiple Choice Questions214	Decarboxylation241
Part-B: Short Answers214	Urea cycle or Kreb's-Henseleit Cycle242
Part-C: Long Answers215	Pathway242
HAPTER - 5	Disposal of urea244
rotein and Amino Acid Metabolism217	Regulation of urea cycle245 Relationship between urea cycle and TCA cycle245 Metabolic disorders of urea cycle245
Classification of Proteins218	Importance of blood urea247
Functional classification of proteins218 Chemical nature and solubility	Metabolism of Phenylalanine and Tyrosine247
classification of proteins218	Degradation of phenylalanine & tyrosine248
Nutritional classification of proteins221	Biosynthesis of melanin251
·	Biosynthesis of thyroid hormones253
Structure of Proteins222	Biosynthesis of catecholamines254
Primary structure of proteins223	Biological significance of catecholamines254
Secondary structure of proteins223	Biosynthesis of 5-hyroxytryptamine (5-HT) or
Tertiary structure of proteins224	Serotonin and Melatonin256
Quaternary structure of proteins225	Biological significance of serotonin257
Biological Significance of Proteins225	Biological significance of melatonin258
Structural or static function225	Metabolic Disorders of Amino Acid Metabolism258
Dynamic function225	Phenylketonuria (PKU)258
Amino Acids226	Albinism260
Classification of Amino Acids226	Alkaptonuria260
	Tyrosinemia261
Structural or chemical classification	Hyperbilirubinemia262
of amino acids226	Jaundice262
Nutritional classification of amino acids230 Polarity classification of amino acids230	Hemolytic jaundice262 Hepatic jaundice or
Fat of metabolism of amino acid classification230	hepatic jaundice of hepatocellular jaundice262
	Obstructive jaundice or
Nomenclature of Amino Acids231	regurgitation jaundice262
Biological Significance of Amino Acids231	Porphyria263
Standard amino acids231	Hepatic porphyria263 Erythropoietic porphyria263
Non-standard amino acids231	
Amino Acid Pool232	Catabolism of Heme264
Nitrogen Balance234	Probable Questions267
Positive nitrogen balance234	Part-A: Multiple Choice Questions267 Key for Multiple Choice Questions271
Negative nitrogen balance234	Part-B: Short Answers272
General aspects of Amino Acid Metabolism235	Part-C: Long Answers272
Constal doposits of Athinio Asia Metabolishi200	-

CHAPTER - 6

Nucleic Acid & Its Metabolism ...275

Classification or Types of Nucleic Acids ...275

Composition of Nucleic Acid ...275

Nitrogen bases ...275 Sugars ...279

Nomenclature of Nucleotides ...280

Biological Significance of Nucleic Acids ...281

Biosynthesis of Purine Nucleotides ...282

Pathway ...283

Inhibitors of purine nucleotide synthesis ...287

Synthesis of AMP and GMP from IMP $\,...287\,$

Synthesis of purine nucleoside diphosphate and purine nucleoside triphosphate ...289

Salvage pathway for purine

nucleotide synthesis ...289

Regulation of purine nucleotide biosynthesis ...290

Biosynthesis of Deoxyribonucleotides from Ribonucleotides ...290

Regulation ...291

Degradation of Purine Nucleotides ...291

Metabolic Disorders of Purine Metabolism ...294

Biosynthesis of Pyrimidine Nucleotides ...298

Pathway ...298

Regulation ...302

Degradation ...302

Salvage pathway ...302

Metabolic disorders ...303

Structure of DNA ...303

Composition ...304

Schematic representation ...304

Chargaff's rule ...304

DNA double helix ...305

Other types of DNA structure ...307

Denaturation of DNA strands ...308

Organization of Mammalian Genome or Organization of DNA in the Cell ...309

Organization of prokaryotic DNA ...309

Organization of eukaryotic DNA ...309

Structure of RNA ...311

Composition ...311

Comparison between DNA and RNA ...311

Types of RNA ...312

The Central Dogma of Life ...314

DNA Replication ...314

Definition ...314

Replication in prokaryotes ...314

Replication in eukaryotes ...318

Inhibitors of DNA replication ...319

DNA recombination ...320

DNA repair ...321

Transcription ...321

Definition ...322

Transcription in prokaryotes ...322

Transcription in eukaryotes ...324

Inhibitors of transcription ...327

Translation ...328

Variability of cells in translation ...328

Genetic code ...328

Codon-anticodon recognition ...328

Wobble hypothesis ...329

Codon bias ...329

Protein Biosynthesis ...329

Components requirement ...330

Amino acids activation ...330

Proper protein synthesis ...331

Chaperones and protein folding ...332

Post-translational modifications of proteins ...333

Inhibitors of protein synthesis ...333

Probable Questions ...333

Part-A: Multiple Choice Questions ...333

Key for Multiple Choice Questions ...338

Part-B: Short Answers ...339

Part-C: Long Answers ...339

PART - III: CLINICAL BIOCHEMISTRY

CHAPTER - 7

Introduction to Clinical Chemistry ...343

Chemistry Laboratory ...343

Common Clinical Chemistry Tests ...344

Role of the Clinical Chemist in Clinical Chemistry

Laboratory ...344

Organelle Malfunction ...345

Cell Malfunction ...346

Cell Cycle ...348

Phases of cell cycle ...348

Mutations350	Estimation of Urea in Blood and Urine385
Point mutation350 Frame shift mutation351 Probable Questions352 Part-A: Multiple Choice Questions352 Key for Multiple Choice Questions356 Part-B: Short Answers356 Part-C: Long Answers357 Chapter - 8 Kidney Function Tests or Renal Function Tests359 Urinary System359	Estimation of Urea in Blood and Urine385 Nesslerization or Nessler's method385 Principle385 Preparation of reagents385 Procedure386 Berthelot method387 Principle387 Preparation of reagents387 Procedure387 Diacetyl monoxime method388 Principle388 Preparation of reagents388 Preparation of reagents388 Procedure 389 Non-protein nitrogen (NPN)390
Kidney359	Significance390
Nephron361	Estimation of Uric Acid in Blood390
Urine Analysis362 Urine collection362 Physical examination363	Principle390 Preparation of reagents391 Procedure391 Significance391
Chemical examination for inorganic constituents363	Estimation of Uric Acid in Urine392
Chemical examination for organic constituents367	Urine Concentration / Dilution Test392
Chemical examination for abnormal constituents372	Urine concentration test392 Urine dilution test393
Organ Function Test378	Osmolality393
Functions of Kidney378	Urinary Tract Calculi (Kidney Stones)393
Types of Kidney Function Test378 Glomerular Function Test379 Clearance Tests379	Types393 Risk factors394 Symptoms394 Diagnostic test394
Creatinine clearance test379	Treatment394
Procedure379	Probable Questions395
Significance380 Urea clearance test381 Procedure381 Significance381	Part-A: Multiple Choice Questions395 Key for Multiple Choice Questions399 Part-B: Short Answers399 Part-C: Long Answers400
Estimation of Creatinine in Blood382	Chapter - 9
Principle382 Preparation of reagents382 Procedure382 Significance383	Liver Function Test401 Structure of Liver401
Estimation of Creatinine in Urine383	Biological Functions of Liver402
Principle383	Causes of Liver Damage403
Preparation of reagents383	Liver Function Test403
Procedure384 Significance384	Classification403
5	Metabolism of Bile Pigments404

Liver Function Test based on	Estimation of Prothrombin Time (PT)420
Excretory Functions of Liver407	Principle420
Estimation of Bilirubin407	Procedure420
Estimation of Bilirubin in Serum407	Significance421
Icterus Test407	Selected Serum Enzyme Tests421
Van den Bergh Reaction407	Estimation of Serum Glutamate Oxaloacetate Transaminase (SGOT) and Serum Glutamete Pyruvate
Mechanism of reaction407	Transaminase (SGPT)422
Procedure407	Principle422
Significance408	Reagents423
Tests based on Van Den Bergh reaction408	Procedure423
Malloy-Evelyn method408	
Principle408	Significance425
Reagents408	Estimation of Serum Phosphatases425
Procedure409	·
Jendrassik-Grof method410	Estimation of Serum Alkaline Phosphatase426
Principle410	Principle426
Reagents410	Reagents426
Procedure411	Procedure426
	Significance428
Estimation of Bilirubin in Urine412	Significance420
Fouchet's test412	Estimation of Serum Acid Phosphatase428
Principle412	Cimpificanae 400
Reagents413	Significance428
Procedure413	Estimation of Serum Lactate Dehydrogenase428
Gmelin's test413	
	Principle429
Principle413	Reagents429
Procedure414	Procedure429
Estimation of Urobilinogen in Urine414	Significance430
Principle414	Probable Questions431
Reagents414	D (A M III) O () 0 () 404
Procedure414	Part-A: Multiple Choice Questions431
Significance415	Key for Multiple Choice Questions435
Significance413	Part-B: Short Answers435
Bromsulphthalein Test or BSP Test or Dye Test415	Part-C: Long Answers436
Principle415	CHAPTER - 10
Procedure415	Linid Brofile Toots 427
Significance416	Lipid Profile Tests437
Liver Function Tests based on Serum Proteins416	Lipoproteins437
Estimation of Serum Total Proteins416	Structure437
Dringinla 416	Composition438
Principle416	Classification438
Reagents417	Functions439
Procedure417	F. C. CO. T. LOL I. () 400
Significance418	Estimation of Serum Total Cholesterol439
Estimation of Serum Albumin and Globulin418	Estimation of Serum Total Cholesterol by Sackett's Method439
Principle418	Cachotto Motifica100
Reagents418	Principle439
Procedure419	Reagents440
Significance420	Procedure440

Estimation of Serum Total Cholesterol by Kim and Goldberg Method441	Immunoturbidimetry460 Immunonephelometry460
Principle441	Label Methods460
Reagents442 Procedure442	Immunoassay460 Competitive binding461
Estimation of Serum Total Cholesterol by Enzymatic Method443	Other Methods461
Principle443 Reagents443 Procedure443	Immunofluorescence461 Immunoelectron microscopy461 Immunostaining461
Significance443	Immunoassay461
Estimation of Serum HDL Cholesterol444 Principle444	Principle461 Labels461 Classification462
Reagents444 Procedure445	Radioimmunoassay (RIA)464
Significance446 Estimation of Serum Triglycerides446	Principle464 Application465
Principle446	Enzyme Linked Immunosorbent Assay (ELISA)465
Reagents446 Procedure447 Significance447	Principle465 Application467
Estimation of serum LDL cholesterol448	Probable Questions467
Significance448	Part-A: Multiple Choice Questions467 Key for Multiple Choice Questions471
Probable Questions448	Part-B: Short Answers471 Part-C: Long Answers472
Part-A: Multiple Choice Questions448 Key for Multiple Choice Questions453	CHAPTER - 12
Part-B: Short Answers453 Part-C: Long Answers454	Water, Electrolytes and Acid-base Balance473
iapter - 11	Water473
munochemical Techniques455	Functions of water473 Distribution of water473
Immunochemistry455	Water Turnover and Balance474
Immunochemical Techniques455	Water intake474
Terms used455 Characteristics456	Water output474 Electrolyte Balance476
Applications456 Principle456 Quantitative precipitin curve456 Classification458	Body fluids electrolyte composition476 Electrolyte distribution476 Osmotic pressure477 Osmolarity477
Particle Methods458	Osmolality477
Agglutination458 Immunoprecipitation459 Immunoelectrophoresis459 Immunofixation460	Regulation of electrolyte balance478 Dietary intake and electrolyte balance479 Dehydration479 Overhydration or water intoxication480 Water tank model480

Determination of Sodium in Body Fluids (Colorimetric Method) ...480

Principle ...481 Reagents ...481

Collection and preparation of specimen ...481

Preparation of protein-free supernatant liquid ...481

Procedure ...481 Significance ...482

Determination of Calcium in Body Fluids (Titrimetric Method) ...482

Principle ...482 Reagents ...483 Procedure ...483

Estimation of calcium in urine ...483

Significance ...484

Determination of Serum Potassium (Turbidimetric Method) ...485

Principle ...485 Reagents ...485 Procedure ...485 Significance ...485

Determination of Chloride in Body Fluids (Colorimetric Method) ...486

Principle ...486 Reagents ...487 Procedure ...487 Significance ...487

Determination of Bicarbonate in Body Fluids (Enzymatic Method) ...488

Principle ...488 Reagents ...488 Procedure ...488 Significance ...489

Acid-base Balance ...489

Production of acids by the body ...489 Production of bases by the body ...490

Maintenance of Blood pH ...490

Blood Buffers ...490

Bicarbonate buffer system ...490 Phosphate buffer system ...491 Protein buffer system ...491

Respiratory Mechanism ...491

Hemoglobin as a buffer ...492Production of bicarbonate (HCO $_3$) by RBC ...492

Renal Mechanism ...493

Excretion of hydrogen cation (H^{*}) ...493 Reabsorption of bicarbonate anion (HCO₃) ...494 Excretion of titratable acid ...494 Excretion of ammonium ions ...496

Carbondioxide – the Central Molecule of pH Regulation ...496

Buffers of Intracellular Fluids (ICF) ...497

Disorders of acid-base balance ...497

Classification ...497
Compensation of acid-base disorders ...498
Anion gap ...498
Metabolic acidosis ...498
Respiratory acidosis ...498
Metabolic alkalosis ...499
Respiratory alkalosis ...499
Mixed acid-base disorders ...499
Acid-base disorders & plasma potassium ...499

Blood Gas Measurement ...499

Probable Questions ...499

Part-A: Multiple Choice Questions ...499 Key for Multiple Choice Questions ...503

Part-B: Short Answers ...504 Part-C: Long Answers ...504

Index ...507