**QUESTIONS FOR THE EXAM IN BIOLOGICAL CHEMISTRY**

1. **Simple proteins. Enzymes. Vitamins.**
2. Proteins: functions of the proteins. Primary, secondary, tertiary, quaternary structure of proteins. Protein folding. Role of chaperones in protein folding.
3. Classification of proteins. Biologically important peptides. Color reactions for proteins and amino acids (Biuret reaction, Ninhydrin reaction, Xantoprotein test, Milon’s reaction, Nitriprusside Test).
4. Physical and chemical properties of proteins: ionization, hydration, solubility. Formation of the protein’s hydration shell. Isoelectric point of protein.
5. Precipitation of proteins (reversible and irreversible). Salting out.
6. Protein denaturation. Factors of denaturation. Properties of denatured protein. Renaturation (reversible denaturation).
7. Chemical nature and structure of enzymes. Holo-enzymes. Structure. Classification of the cofactors. Apo-enzymes, co-enzymes, prosthetic groups. Isoenzymes. Zymogens.
8. General properties of enzymes. Influence of pH and temperature on enzymes’ activity.
9. Specificity of enzymes. The types of specificity.
10. Nomenclature and classification of enzymes. Principles of qualitative estimation of enzymes.
11. Active center of enzymes. Structure and properties. Allosteric center of enzymes. Allosteric enzymes. Key enzymes.
12. Mechanism of enzyme action. Factors affecting enzyme activity: enzyme concentration, substrate concentration, product concentration. Michaelis constant.
13. Regulation of enzyme activity by covalent modification. Partial (selective) proteolysis. Phosphorylation — dephosphorylation. Activation of enzyme activity. Allosteric activators
14. Inhibition (reversible and irreversible, competitive and non-competitive). Clinically useful competitive inhibitors of enzyme activity.
15. Enzymes in diagnostics and therapy. Immobilized enzymes.
16. Vitamins. General characteristics of vitamins. Nomenclature and classification of vitamins. Comparison of two types of vitamins: water-soluble and lipid-soluble. Vitamin deficient states.
17. Folic acid. Biological functions. Causes for folate deficiency. Clinical manifestations of folic acid deficiency. Folate antagonists.
18. The Structure and metabolism of ascorbic acid. Biochemical functions of ascorbic acid. Ascorbic acid as antioxidant. Clinical manifestations of ascorbic acid deficiency.
19. **Metabolism. Biological Oxidation.**
20. Metabolism. The purposes of the metabolism. Catabolism and anabolism. Metabolic pathways (central and specific, linear and cyclic).
21. The characteristics of the enzymes’ class - oxidoreductases. Pyridine-dependent dehydrogenases. Block-structures of co-enzymes NAD+, NADP+. Organization of electron transport chain I type.
22. The characteristics of the enzymes’ class - oxidoreductases. Flavin-dependent dehydrogenases. Block-structures of co-enzymes FAD, FMN. Organization of electron transport chain II type.
23. Adenilate system of the cell, its participation in energy exchange. Ways of ATP synthesis: substrate-level, oxidative and photosynthetic phosphorylation.
24. The definition and the stages of biological oxidation. Tissue respiration. The structure of the respiratory chain components, enzyme complexes, co-enzymes, functioning mechanism.
25. The diagram of the respiratory chain, phosphorylation points, the mechanism of an electro-chemical gradient formation. H+-ATP-synthase. The chemiosmotic Mitchell theory. Phosphorylation ratio (P/O) for various substrates supplying hydrogen to the respiratory chain. Regulation of the respiratory chain and H+ - ATP-synthase.
26. Causes for the hypoenergetic states development. Uncoupling of oxidative phosphorylation (mechanism, uncoupling agents). Inhibitors of electron transport and oxidative phosphorylation.
27. Reactive oxygen species. Generation of free radicals. Stages of the lipid peroxidation. Clinical significance of free radicals. Free radicals scavenger systems. Antioxidants.
28. Lipid-soluble vitamins. General characteristics. Vitamin E. Biochemical role of vitamin E. Deficiency manifestations of vitamin E.
29. Central metabolic pathway. Definition, localization in the cell. Oxidative decarboxylation of pyruvate as a central metabolic pathway. Pyruvate dehydrogenase complex (enzymes, co-enzymes, scheme of reactions). Biological significance of the oxidative decarboxylation of pyruvic acid.
30. Sources and utilization of acetyl CoA. Functions of the citric acid cycle (CAC). Reactions of the Krebs cycle. Biological significance of the CAC. Regulation of the CAC.
31. **Metabolic pathway of carbohydrates.**
32. Functions of the carbohydrates in organism. Carbohydrates digestion, end products, digestion impairments. The role of cellulose and pectines in the human diet. Absorption of glucose, galactose and fructose.
33. Blood glucose. Regulation of blood glucose content. Mechanisms of hormonal regulation (insulin, epinephrine, glucagon, glucorticoids etc.). Determination of glucose concentration in blood (the principle of glucose oxidase method).
34. Glycogen synthesis, purpose, sequence of reactions, expenditure of energy and regulation. Aglycogenosis.
35. Degradation of glycogen in the liver, sequence of reactions, regulation. Glycogenoses.
36. Glycolysis, its biological role, subcellular localization, phases, reactions, energy yield and mechanism of ATP formation. Glycolysis regulation, key enzymes.
37. Glycogenolysis in the muscles, sequence of reactions, regulation. Cory cycle. Biological significance.
38. Gluconeogenesis (purpose, substrates, key reactions and enzymes, regulation, expenditure of energy).
39. Aerobic oxidation of glucose to CO2 and H2O (stages, energy yield, mechanisms of ATP formation).
40. Pentose phosphate pathway (PPP) of glucose oxidation. Reactions of the oxidative phase in details. Biological significance and regulation of PPP.
41. Fructose metabolism in details. Hereditary fructose intolerance.
42. Galactose metabolism in details. Galactosemia. Galactokinase deficiency.
43. **Metabolic pathway of lipids**
44. Lipids, general characteristics, classification. Characteristic and biological role of lipid groups (chemical formulas and terminology of acylglyceroles and glycerophospholipids; sphingophospholipids, glycolipids, sulfolipid structures). The staples abundant to triacylglycerols (TG), phospholipids (PL) and cholesterol esters (CE).
45. Stages of lipids metabolism. Digestion of lipids, phases. Emulsification (purpose, factors, stabilization of fatty emulsion). Bile, bile acids (primary, conjugated, secondary). Enterohepatic re-circulation of bile acids. Hydrolysis of diet lipids (enzymes, conversion patterns). Absorption (mechanisms, micellar dissolution, fate of micelles).
46. Re-synthesis of triacylglyceroles and glycerophospholipids in enterocytes. Transport forms of lipids in the blood. Structure and metabolism of chylomicrons.
47. Synthesis of TAG and glycerophospholipids in the liver and fatty tissue (role of lipotropic factors).
48. β-oxidation of fatty acids. Subcellular localization of the process, activation of fatty acids, transport to mitochondria. Oxidation reactions, association with the process of oxidative phosphorylation, energetic yield. β-oxidation of fatty acids with an odd number of carbons, unsaturated fatty acids.
49. Oxidation of glycerol in details. Regulation, biological significance, energetics.
50. Mechanism activation of hormone sensitive lipase. Lipolysis in details. Biological significant.
51. Fatty acid synthesis. Connection with glycolysis, pentose phosphate pathway of glucose metabolism, Krebs cycle. The importance of CO2, ATP, NADPH·H+, biotin. The multienzyme complex for fatty acid synthesis. Activators and inhibitors of fatty acid synthesis.
52. Ketogenesis: tissue and subcellular localization, substrates, reactions. Molecular mechanisms of ketonemias in diabetes mellitus and fasting. Utilization of ketone bodies (interconversions, activation, involvement into metabolism, energy yield of oxidation).
53. Transport of lipids by blood. The structure and metabolism of VLDL (very low density lipoproteins), IDL (intermediate density lipoproteins), LDL (low density lipoproteins), HDL (high density lipoproteins). Biochemistry of atherosclerosis, atherogeneity index.
54. Cholesterol, biological role, biosynthesis (tissue and subcellular localization, substrates, phases, reactions of the 1st phase, regulation). Mechanisms of maintaining cholesterol balance in cells.
55. Fate of cholesterol. Formation of bile acids and bile salts. Regulation. Cholelithiasis.
56. **Nitrogen- containing biomolecules. Metabolic pathway of amino acids. Nucleotide metabolism.**
57. Functions of the protein in organism. Nitrogen balance. Types of nitrogen balance under physiologic conditions and in pathology. Essential, non-essential, semi-essential amino acids. Requirements in proteins. The biological value of food proteins
58. Digestion of proteins. General characteristic of proteases, their substrate specificity. Endopeptidases, exopeptidases.
59. Digestion of proteins in stomach, duodenum, small intestine. Role of hydrochloric acid in digesting proteins. Absorption of free amino acids. Hartnup’s disease. Cystinuria.
60. Putrefaction of amino acids. Detoxification of toxic products. Putrefaction of tryptophan. Detoxification of indole.
61. Amino acid pool of the cell — its sources and utilization. Conversion of α- amino group.
62. Transamination reactions, aminotransferases, co-enzyme function of vitamin B6. Biological significance of ALT and AST. Evaluation of amino transferases activity in serum, clinical-diagnostic value.
63. Indirect deamination - its transdeamination. Scheme. Biological significance.
64. Ways of ammonia binding in cells (reductive amination of α-ketoglutarate, synthesis of glutamine and asparagine). Transport forms of ammonia. Glucose- alanine cycle. Biological significance.
65. Mechanism of toxic action of ammonia and detoxification of ammonia in the nervous tissue.
66. Ornithine cycle of urea formation (cycle pattern, substrates, enzymes, energetic supply, relation to the citric acid cycle, regulation). Fate of urea.
67. Ammonia salts formation in kidneys (source of ammonia, the role of glutaminase and glutamate dehydrogenase, the significance of renal glutaminase activation in acidosis).
68. Nonprotein blood nitrogen (main components and their relative content). Principle of determination and clinical-diagnostic significance.
69. Decarboxylation of amino acids, enzymes, co-enzymes. Biogenic amines (tryptamine, serotonin, histamine, γ-aminobutyric acid), catecholamines (dopamine, norepinephrine, epinephrine). Reactions of biosynthesis, biological role.
70. Fate of carbon skeletons. Glycogenic, ketogenic and glycoketogenic amino acids. Pathways of amino acid synthesis.
71. Metabolic fate of tyrosine. Biosynthesis of catecholamines. Parkinsonism. Biosynthesis of melanin. Albinism.
72. Catabolism of phenylalanine in liver. Phenylketonuria. Alcaptonuria.
73. Metabolic fate of methionine. Biological significance of transmethylation reactions. Biosynthesis of carnitine, phosphotidylcholine, adrenaline.
74. Synthesis of creatine. Biological significance of creatine phosphate. Fate of branched-chain amino acids. Maple syrup urine disease.
75. **Nucleotide metabolism**
76. Nucleoprotein metabolism. Digestion of nucleoproteins in the digestive tract (significance, steps, enzymes).
77. Degradation of purine nucleotides (reactions, uric acid as an end-product of catabolism). Disorders of purine metabolism (hyperuricemia and gout, urolithiasis).
78. Biosynthesis of purine nucleotides de novo (sources of nitrogen and carbon of a purine ring, participation of folic acid, main intermediate products, key enzyme, regulation). The notion of nucleotide re-synthesis from free nitrogenous bases and nucleosides.
79. Degradation of pyrimidine nucleotides (end products and their fate).
80. Biosynthesis of pyrimidine nucleotides (substrates, process pattern, key enzyme, regulation, role of vitamins).
81. Salvage pathway for purines and pyrimidines. Lesch- Nyhan syndrome.
82. Synthesis of deoxyribonucleotides. Regulation.
83. Primary, secondary and tertiary structures of DNA (peculiarities of the structure, varieties, types of stabilizing bonds).
84. Replication, biological role, substrates, enzymes, molecular mechanism.
85. Transcription, biological role, substrates, enzymes, RNA processing.
86. Modern understanding of protein biosynthesis. Translation (activation of amino acids, initiation, elongation, termination, post translational processing). Substrate specificity of aminoacyl-tRNA synthetases. tRNA and its role in protein biosynthesis.
87. Regulation of protein biosynthesis in the cell at a genetic level.
88. Posttranslational modification of protein molecules, kinds, biological role.
89. **Mechanism action of hormones**
90. Properties of hormones. Peculiarities of biological action. Examples of hormones which realized their effect via different types of receptors. Hormone receptors, classification, structure of receptors.
91. Effector systems and second messengers of hormonal signal into the cell. Mechanisms of second messengers’ formation and activation. Adenyl cycle system.
92. Role of calcium in the hormonal signal transduction mechanism. Phosphotidyl inositol phosphate system.
93. Hormones of the adrenal medulla. The chemical nature, scheme of synthesis, Mechanism of signal transduction, effects on metabolism. Pheochromocytoma..
94. Glucagon. The chemical nature, place of synthesis. Mechanism of signal transduction, effects on metabolism.
95. Insulin. The chemical nature, synthesis, insulin receptor structure. Mechanisms of signal transduction. Effects on carbohydrate, lipid, protein metabolism.
96. Diabetes mellitus. Types, causes. Disorders of carbohydrate, lipid, protein metabolism. Biochemical diagnosis of diabetes. Construction of sugar curves.
97. Diabetes mellitus: mechanism of ketonemia. Glucose metabolism in insulin-independent tissues. Glucose reduction pathway.
98. Iodine-containing thyroid hormones. The chemical nature, the synthesis of T3 and T4. Mechanism of signal transduction, effects on metabolism. Hypo- and hyperthyroidism.
99. Hormones of the adrenal cortex: glucocorticoids and mineralocorticoids. The chemical nature, structure of receptors. Mechanism of signal transduction, effects on metabolism. Cushing’s syndrome, Addison’s disease («Bronze disease»).
100. Functions of calcium. Vitamin D. Metabolism. Calcitriol. Mechanism action of calcitriol, effects on metabolism. Hypercalcemia. Hypocalcemia. Osteoporosis.
101. Parathyroid hormone. Biosynthesis of PH. Mechanism action of PH, effects on metabolism.
102. Calcitonin. Mechanism action of calcitonin, effects on metabolism.
103. Chemistry of vitamin A. Retinoic acid and retinal. Visual cycle. Deficiency of vitamin. Night blindness. Xerophthalmia. Keratomalacia. Hypervitaminosis A.
104. Functions of the water and distribution of water in the body. Electrolyte composition of body fluids. Regulation of electrolyte balance. Aldosterone. Metabolic effects. Hyperaldosteronism.
105. Vasopressin (ADH), chemical nature, hormonal signal transduction mechanism, effects. Diabetes insipidus.
106. Hormonal regulation of salt and water balance. Renin- angiotensin- aldosterone system. Metabolic effects of angiotensin II.
107. Atrial natriuretic peptide. Metabolic effects. Guanylate- cyclase system. Biological significance of NO.
108. **Functional biochemistry**

**Blood' biochemistry**

1. Hemoglobin (structure, molecular forms of hemoglobin, hemoglobin derivatives, abnormal forms of hemoglobin). Biological functions of Hb.
2. Features of metabolism in erythrocytes. Metabolism glucose. Reactive oxygen species and antioxidants. Free radicals scavenger systems in the erythrocytes.
3. The role of the liver in the pigment metabolism. Hemoprotein biosynthesis, regulation. The proteins containing heme as a prosthetic group, and their functions in the body. Porphyrias. Hemoglobinopathy. Thalassemias.
4. Degradation of hemoglobin. Metabolism of bile pigments. Jaundice. Causes, mechanisms of development. Laboratory diagnosis.
5. Chemical composition of plasma (physiological concentrations of the most important plasma components and their origin).
6. Respiratory function of the blood. Erythrocyte as a main participant of gas transport by the blood (the role of hemoglobin and carbanhydrase). Reversible binding of oxygen and carbon dioxide as a means of transport (mechanisms of binding CO2 and O2 to hemoglobin, co-operative interaction of hemoglobin subunits). Hypoxia, forms, mechanisms of development.
7. Blood plasma proteins. Main protein fractions: albumins, globulins, fibrinogen (content, functions); albumin-globulin ratio and its diagnostic value. Hypoproteinemias. Hyperproteinemias. Disproteinemias. Paraproteinemias.
8. Blood plasma enzymes (secretory, indicator, excretory). Diagnostic value of plasma enzymes activity determination.Proteins. Biological significance of albumins and globulins.

**Biochemistry of connective tissue**

1. Common characteristic and types of connective tissue (CT). Function of connective tissue (CT). Cellular component of CT. Common characteristic of fibers component. Common characteristic of extracellular matrix. Glycosaminoglycans (GAG) and proteoglycans (PG).
2. Common characteristic of collagen. Biosynthesis of collagen. Intracellular processing of collagen. Extracellular processing of collagen. Regulation biosynthesis of collagen. Degradation of collagen.

**Biochemistry of urine**

1. Normal characteristics of urine volume, density, color, transparency, pH. Inorganic and organic components of the urine.
2. Diagnostic significance of the urine pathologic components and their determination: a) Renal and extrarenal proteinuria; b) Glucosuria in diabetes mellitus, renal glucosuria; c) Renal and extrarenal hematuria; d) Ketonuria in fasting, diabetes.

**In exam each student should be able to:**

***1. Write formulas of amino acids and nucleotides.***

***2. Write reactions using chemical formulas of:***

‒ glucose anaerobic oxidation (glycolysis) and gluconeogenesis;

‒ oxidative decarboxylation of pyruvate;

‒ β-oxidation and synthesis of fatty acids;

‒ re-synthesis of lipids (triacylglycerols, phospholipids);

‒ ketone bodies synthesis and utilization;

‒ synthesis of mevalonic acid;

‒ lipid digestion (neutral fats and phospholipids);

‒ metabolism of amino acids (transamination, deamination, decarboxylation, reductive

amination);

‒ degradation of purine nucleotides.

***3. Write schemes of the next processes:***

‒ glycogen synthesis and degradation;

‒ citric acid cycle;

‒ urea synthesis;

‒ nucleotide de novo synthesis;

‒ electron transport chain.

***4. Write the schemes of hormonal signal transduction:***

‒ with participation of seconds messengers (cAMP, inositol triphosphate, diacylglycerol);

‒ via intracellular receptors.