Medical Chemistry and Biochemistry
Exam Questions 2024/2025

I. Physical, inorganic and organic chemistry

1. Types of chemical bonds, weak interactions.
2. Water and its physical and chemical properties, significance in organism.
3. Dispersion systems, solubility of substances, true and colloid solutions, emulsion and suspension.
4. Diffusion, osmosis, osmotic and oncotic pressure, dialysis, examples from biochemistry.
5. Energetics of chemical reactions, Gibbs energy and entropy, application to metabolic processes.
6. Chemical equilibrium, Guldberg-Waage law. Kinetics and energetics of reversible reactions, application in enzymology.
7. Basic techniques for separation of macromolecules (electrophoresis, chromatography, salting out) and their usage in clinical practice.
8. Spectrophotometry, principle and use in clinical biochemistry.
9. Electrolytic dissociation, dissociation constant, strong and weak electrolytes, examples from biochemistry.
10. Brönsted-Lowry theory of acids and bases, equilibrium in protolytic reactions, examples from biochemistry.
11. Autoionization of water, pH and its significance in medicine.
12. Ampholytes, their properties, examples from biochemistry.
13. Buffers, calculation of buffer pH, significance in organism.
14. Oxidation and reduction, redox potential, dependence on concentration of reactants, examples from biochemistry. Coenzymes of oxidation-reduction reactions.
15. Precipitation reactions, solubility product, formation of complexes, coordination compounds, examples and significance in biochemistry and medicine.
16. Chemical properties of main biogenic elements.
17. Oxygen and its inorganic compounds, reactivity, properties.
18. Lipid peroxidation.
19. Toxicologically significant elements, mechanism of action of selected toxic compounds (CO, KCN, HCN, H_2S, heavy metals).
20. Biologic and metabolic significance of trace elements.
21. Structure of organic compounds, isomerism, examples from metabolic pathways.
22. Halogen- and nitroderivatives of hydrocarbons, examples of toxicologically and medically significant compounds.
23. Sulfur derivatives of hydrocarbons, examples of medically significant compounds.
24. Amines, significance in biochemistry.
25. Alcohols, phenols, aldehydes and ketones, roles in metabolism. Substances used as disinfectants, mechanism of their action.
26. Carboxylic acids, functional and substitution derivatives of carboxylic acids, use in biochemistry.
27. Nitrogen, oxygen and sulfur heterocycles, significance.
28. Structural features of amino acids, classification, reactions, significance.
29. Peptides, peptide bond, examples of biologically important peptides.
30. Proteins, primary, secondary, tertiary and quaternary structure. Suprasecondary structures (motifs), protein domains. Protein misfolding. Properties and functions of proteins.
31. Saccharides, classification, structure, stereochemistry, biological significance.
32. Reactions and derivatives of monosaccharides, disaccharides, O- and N- glycosidic bond, examples.
33. Homopolysaccharides and heteropolysaccharides, structure, occurrence and significance in the organism.
34. Proteoglycans, glycoproteins, structure, properties, examples.
35. Lipids – classification, structure, properties, function in the organism.
36. Fatty acids.
37. Phospholipids and sphingolipids, structure, properties and significance.
38. Sterols, bile acids and steroid hormones, structure, function and significance in the organism.

II. Metabolism

1. Structure of enzymes (simple and conjugated; apoenzyme and holoenzyme; cofactors: coenzymes, prosthetic groups, coactivators; oligomeric structure); multiple enzyme forms and isoenzymes. Classification of enzymes. Examples, significance.
2. Enzyme activity and its measurement, physico-chemical influences, regulation (expression, covalent modifications, allosteric effects). Use of enzymology in medicine.
3. Energetics of enzyme catalysis. Kinetics of monomeric and oligomeric enzymes, examples. K_m, k_{cat}, catalytic efficiency of enzymes.
4. Inhibition of enzymes: competitive, non-competitive, covalent, allosteric. Use of enzyme inhibitors in medicine.
5. The respiratory chain. Oxidative phosphorylation. Substrate shuttles for transport of electrons across mitochondrial membranes.
6. "Macroergic" compounds, substrate level phosphorylation; driving endergonic reactions.
7. Citric acid cycle, amphibolic character, course, regulation.
8. General mechanisms of amino acid conversions, deamination, transamination, decarboxylation. Nitrogen balance.
9. Metabolism of one-carbon residues. Sources and utilization of one-carbon residues, cofactors.
10. Production of ammonia, its detoxication, ureosynthetic cycle and its regulation, hyperammonemia.
11. Metabolism of amino acids of the pyruvate and oxaloacetate groups, participation of these amino acids in metabolic processes.
12. Metabolism of carbon skeleton of amino acids of the 2-oxoglutarate group and branched-chain amino acids, participation of these amino acids in metabolic processes.
13. Catabolism of aromatic amino acids, disorders.
14. Metabolism of sulfur amino acids.
15. Biosynthesis, biodegradation and function of the most significant biogenic amines.
16. Conversion of amino acids to specialized products: creatine, S-adenosylmethionine, carnitine, taurine, their significance.
17. Glycolysis, energetic yield, utilization by various body organs at different physiological conditions, regulations, oxidation of pyruvate, pyruvate dehydrogenase complex.
18. Gluconeogenesis, significance, regulation.
19. Synthesis and degradation of glycogen, significance, regulation, disorders.
20. Pentose phosphate cycle, regulation.
21. Metabolism of galactose and fructose, disorders.
22. Metabolism of glucuronic acid and its significance in the organism.
23. Biosynthesis of fatty acids.
24. Formation of ketone bodies from acetyl-CoA, metabolic causes, significance.
25. Oxidation of fatty acids, energetic yield, carnitine system.
26. Triacylglycerols, biosynthesis, degradation.
27. Biosynthesis and degradation of phospholipids (glycerophospholipids and sphingolipids).
28. Biosynthesis of prostaglandins, thromboxanes and leukotrienes.
29. Biosynthesis of cholesterol and its regulation, role of HMG-CoA reductase and SREBP protein.
30. Conversion and excretion of cholesterol, biosynthesis of bile acids and its regulation.
31. Biosynthesis and degradation of steroid hormones.
32. Transport of lipids, roles of lipoproteins, structure of lipoprotein particles. Electrophoresis of lipoproteins.
33. Transport of endogenous and exogenous cholesterol (origin, conversion and role of chylomicrons, VLDL, LDL and HDL lipoproteins).
34. Biosynthesis of tetrapyrroles – heme, and its disorders. Incorporation of heme into apoproteins and its function.
35. Degradation of tetrapyrroles – heme, and its disorders. Intravascular and extravascular decomposition of erythrocytes.
36. Metabolism of purine nucleotides, regulation, inhibitors, disorders.
37. Metabolism of pyrimidine nucleotides, regulation, inhibitors, disorders.
38. Reactive oxygen species, origin and significance, antioxidants.

III. Biochemistry of organs and functions

1. Biochemical interrelationships between metabolism of saccharides and other nutrients.
2. Glycemia, regulation, diagnostics (oGTT, glycated hemoglobin).
3. Metabolism of adipose tissue.
4. Regulation of heme biosynthesis, differences between hepatocyte and erythroid cell, metabolism of iron.
5. Mechanism of action of hormones regulating water and mineral metabolism.
6. Hormonal regulation of energetic metabolism.
7. Biochemical processes in digestion of saccharides, lipids and proteins.
8. Biochemical functions of the hepatocyte and liver, possibilities of biochemical diagnostics of hepatocyte damage and liver functions.
9. Biotransformation of endogenous and exogenous substances, types of biotransformation processes, toxic and cancerogenic substances in the environment.
10. Buffering systems in the organism, function and significance for acid-base balance.
11. Metabolism of erythrocytes.
12. Important proteins of blood plasma, importance in the organism (albumin, Ig, acute phase proteins, transport proteins).
13. Blood coagulation, cascade of coagulation factors, initiation, amplification and propagation, tenase and prothrombinase complexes. Role of thrombocytes and vitamin K.
14. Fibrin, fibrinolysis. Mechanism of action of anticoagulants.
15. Urine – physiological and pathological components.
16. Extracellular matrix, extracellular polysaccharides and proteins (collagen, elastin) – structure, properties, function. Metabolism of collagen.
17. Biochemistry of connective tissue (cartilage, bone).
18. Biochemistry of the skin (barrier function, vitamin D, cytokeratins, cell junctions, biosynthesis of melanin).
19. Contractile apparatus, control of smooth muscle and striated muscle contraction.
20. Markers of muscle damage, significance, determination.
21. Biochemistry of vision, Wald cycle, transducin cycle.
22. Biochemistry of senses (taste, smell).
23. Biochemistry of nervous synapses, neurotransmitters.
24. Catecholamines – biosynthesis, biodegradation.
25. Steroid hormones – structure of receptors for steroid hormones, mechanism of action, functions.
26. Peptidic hormones – mechanisms of action, functions.
27. Local mediators (cytokines, growth factors, chemokines) – functions, mechanism of action.
28. Hormones of the thyroid gland and their function in regulatory processes.
29. Structure and function of the individual parts of the immunoglobulin molecules. Classes of immunoglobulins, properties and function. Monoclonal antibodies – preparation and use.
30. Molecular basis of immunoglobulin diversity in the primary and secondary antibody response, somatic recombination, isotype switching.
31. Molecular foundations of cellular immunity – pathogen recognition by cells of specific and innate immunity, effector mechanisms. MHC molecules – structure, function, mechanisms of antigen presentation to T_c and T_H lymphocytes.
32. Basic immunochemical techniques. Immunoturbidimetry, ELISA, RIA.
33. Biochemical significance of fat-soluble vitamins.
34. Biochemical significance of water-soluble vitamins, cofactors derived from these vitamins.
35. Structure, composition and properties of cellular membranes.
36. Transport of substances across membranes.
37. Cytoskeleton.
38. Compartmentation of biochemical processes at the subcellular level.

IV. Cellular and molecular biology

1. Principles, mechanisms and significance of intercellular communication and intracellular signal transduction cascades.
2. Types of membrane receptors, their ligands, biological significance, examples.
3. Intracellular receptors, heat-shock proteins, interactions of receptors with DNA.
4. Amplification, integration and cross-talk of signaling pathways.
5. G-proteins – structure, activation, function.
6. Types and role of second messengers in signal transduction.
7. Mechanism and significance of reversible phosphorylation in signal transduction.
8. Signaling stimulated by growth factors (MAPK, PKB/AKT) and cytokines (JAK-STAT).
9. Signaling pathways dependent on regulated proteolysis, examples. Signaling role of HIF in response to hypoxia.
10. Signaling of NO, medical significance.
11. Structure and function of DNA.
12. Structure and function of RNA.
13. Organization of prokaryotic, eukaryotic and mitochondrial genome.
14. Techniques of DNA sequencing (Sanger, NGS, human genome sequencing).
15. Classification of human genomic DNA according to repetitiveness and according to function, pseudogenes, transposons.
16. Replication of eukaryotic DNA, replication machinery and its regulation.
17. DNA repair – BER, NER, MMR, direct repair of modified bases.
18. DNA repair – HR, NHEJ.
19. Transcription of prokaryotic and eukaryotic genomic DNA. Transcription factors, interaction DNA-protein.
20. Structure of mRNA, post-transcriptional modification (capping, poly(A), splicing).
21. RNA interference, types and functions of non-coding RNA.
22. Regulation of gene expression at the transcription level.
23. Genetic code and its properties.
24. Eukaryotic and prokaryotic translation. Regulation of translation.
25. Protein sorting and targeting. Post-translational protein modifications.
26. Biosynthesis of glycoproteins, their significance.
27. Vesicular transport. Endocytosis and exocytosis.
28. Restriction enzymes and other tools of genetic engineering, construction of recombinant molecules of DNA and proteins. DNA cloning.
29. Methods of cell fractionation, electrophoresis of nucleic acids and proteins.
30. Polymerase chain reaction, use of PCR in clinical diagnostics, RT-PCR and use of this technique.
31. Nature of gene mutations, inherited and acquired mutations, polymorphisms, mini- and microsatellite sequences and their uses.
32. DNA and RNA viruses – structure and replication.
33. Proto-oncogenes.
34. Tumor suppressor genes.
35. Cell cycle, role of cyclins and cdk (cyclin-dependent kinase) complexes.
36. Lysosomal and proteosomal degradation of cellular proteins. Ubiquitination of proteins.
37. Biochemistry of apoptosis, examples of pro- and anti-apoptotic genes/proteins. Caspases. Role of mitochondria in cell death.
38. Epigenetics, modification of histones, DNA methylation, significance.