# QUESTIONS FOR PART "C" OF EXAM FROM "MEDICAL CHEMISTRY"

## study branch - GENERAL MEDICINE

## winter semester 2022-2023

1. **Chemical bond** – definition of coordination bond, explanation of the term central atom, ligand and coordination number. Explanation of the term chelating ligand. Characteristics of tetrapyrrole ligands, their names and importance in biological system. Characteristics of hydrogen bond, the importance of hydrogen bond in biological systems (2 examples).
2. **Natrium, potassium and sulfur** – physiological functions of sodium and potassium. Hypo- and hypernatremia, hypo- and hyperkalemia (causes and consequences). Biologically important compounds containing sulfur – name at least 4 together with their biological functions.
3. **Calcium, magnesium and phosphorus** – physiological functions of calcium, compounds in which calcium is found in bones and teeth. Physiological functions of magnesium. Biologically important compounds containing phosphorus – name at least 4 together with their biological functions and write their formulas.
4. **Iron** – typical oxidation states, deficiency and excess of iron (causes and consequences). Functions of transferrin and ferritin. Description of heme, functions of hemoglobin. Write 2 examples of pathological derivatives of hemoglobin, explain their negative role in organism. Function of catalase (including corresponding reaction).
5. **Copper** – typical oxidation states, Wilson's disease, therapy of Wilson's disease – the name and formula of the compound used in the Wilson's disease treatment, its mode of binding to the copper. Functions of ceruloplasmin and cytochrome c oxidase. Function of Cu/Zn-SOD (including the summary reaction catalyzed by SOD and 2 steps in which it runs).
6. **Zinc, cobalt and manganese** – physiological functions of zinc in general. Functions of carbonic anhydrase and alcohol dehydrogenase (including corresponding reactions). Form of cobalt occurrence in the organism, functions. Functions of manganese.
7. **Toxic elements** – the factors influencing the toxicity of metal ions and the reasons of their toxicity (what is the metal ions toxicity based on). Chelation therapy – what are chelating agents from the chemical point of view, basic principles that define efficiency of chelating agents. Give 3 examples of therapeutic chelating agents.
8. **Dispersed systems (DS)** - definition of DS and phases, types of DS, classification of DS according to the size of dispersed particles, properties of DS, hydration, solvation, electrolytic dissociation, electrolytes and non-electrolytes - characteristics, dissolution process of polar and nonpolar substances, Tyndall effect.
9. **True solutions** - characteristics, properties, colligative properties of solutions - diffusion, osmosis, dialysis, definitions and formulas for calculation of osmolarity, osmotic pressure and ionic strength, saline, isotonic, hypotonic and hypertonic environment and erythrocyte´s behavior in these environments.
10. **Colloidal solutions** - their properties and types - sols, gels, foam, emulsions, emulsification process, biologically important emulsifiers and their role in the organism, classification of colloids according to the affinity of dispersed molecules with dispersion medium,

properties of individual groups, oncotic pressure, formation of edema, examples of colloids in the organism.

11. **Oxidation-reduction reactions -** oxidizing and reducing agents, 4 ways of oxidation in biological systems, dismutation (example), driving force of oxidation-reduction reactions, significance of redox potential and the formula for its calculation. Biological oxidations and their importance in metabolic processes, biologically important redox systems (2 examples).
12. **The concept of equilibrium of chemical and biochemical reactions.** Equilibrium constant and its meaning, give an example of calculating the equilibrium constant on a specific reaction and explain. The equlibrium law - Le Chatelier's principle - and its application in physiology (oxygen transport by hemoglobin from the lungs to tissues). Explain the effect of temperature change on the course of the exo- and endothermic reaction.
13. **Acid-base equilibrium in the organism** - Brönsted's theory of acids and bases, conjugate pair - definition and examples; characteristics of ampholytes (give an example). acid ionization (dissociation) constant (explain and give an example for acetic acid), ionic product of water, relationship between pH and pOH. pH scale and pH calculation. Formulas for calculating pH of strong and weak acid, strong and weak base (give at least 2 examples of each - weak acids, weak bases, strong acids, strong bases).
14. **Buffer systems and pH control in the organism** - general characteristics of buffer systems (composition, function). Names and compositions of the systems (buffer systems, organs) that maintain acid-base balance in the blood, physiological pH of the blood. Mechanism of action of bicarbonate buffer after addition of $HNO_3$ (express by equation) and action after addition of KOH (express by equation). Henderson-Hasselbalch equation. Brief characteristics of acidosis and alkalosis and their distribution.
15. **Organism as thermodynamic system** - characteristics of a biological system from thermodynamic point of view, definition and mathematical expression of the 1st law of thermodynamics. Hess law, enthalpy, internal energy. Reaction heat, exothermic and endothermic reactions.
16. **The 2$^{nd}$ law of thermodynamics -** definition and basic relation, characteristics of entropy of biological system, relation between information and entropy, relationship between entropy and spontaneity of biochemical processes. Characteristics of Gibbs free energy and standard Gibbs free energy, reaction spontaneity. Expression of the relationship between the entropy change $\Delta S$ and $\Delta G$ of a thermodynamic system.
17. **Gibbs free energy and the effect of reactant and product concentrations**. Coupling of exergonic and endergonic processes in biological systems. The importance of ATP and its hydrolysis, write the formula of ATP and its hydrolysis reaction, describe the types of bonds that are present in the ATP molecule. Name other energy rich compounds used by the body to allow a favorable course of metabolic reactions (two of them in formulas).
18. **Reactivity of organic compounds - reactive site in the molecule, factors influencing reactivity** - Induction effect (for which compound it is characteristic, what is its meaning in the molecule, what does it mean + I / -I, give an example of functional group of + I and –I effect). Mesomeric effect (for which compound it is characteristic, what is its meaning in the molecule, what does it mean + M / -M, give an example of functional group of + M and –M effect). Give examples of electrophilic and nucleophilic reagents. Chiral (asymmetric) carbon - characteristics - give an example (formula) of an organic compound with multiple chiral carbons (denote them in the formula).

19. **Halogen- and hydroxyderivatives of hydrocarbons** – biochemically and toxicologically significant structures and reactions. Physiological or pathophysiological importance of halogen derivatives of organic compounds (give examples). Explain the terms: primary, secondary, tertiary alcohol and monohydric, dihydric, trihydric alcohol. Characteristics of acidic and basic properties of alcohols. Reaction of complete oxidation of a particular primary and secondary alcohols. Reaction of alcohol with phosphoric acid, physiological significance of this reaction.
20. **Alcohols and phenols and their biologically important reactions** - the difference between alcohols and phenols (structure, acidic properties). Explain the terms monohydric, dihydric and trihydric alcohol. Reaction of alcohol with aldehyde, reaction product and biological significance of this reaction. Reaction between alcohol and organic acid, an example of a biologically important product. Reaction between two alcohol groups, examples of important products of such a reaction (glycoside bond). Biologically significant redox reaction of diphenols.
21. **Oxo compounds - biochemically and toxicologically important structures and reactions** - redox properties of aldehydes and ketones, reaction of hemiacetals and acetals formation, biological significance of the reaction. Aldol condensation of acetaldehyde with propanal. Biological significance of the reaction of activated glyceraldehyde with activated dihydroxyacetone. Schiff base formation reaction (give a specific example of the reaction), physiological and pathological example. Biological significance of quinones.
22. **Carboxylic acids - biochemically important structures, reactions and biological function.** Formation of carboxylic acids. List at least 3 types of reactions that carboxylic acids provide. Reaction of carboxylic acids in the formation of neutral lipids (TAG). Formulas and trivial names of monocarboxylic acids with 1 to 4 carbon atoms. Formulas and trivial names of dicarboxylic acids with 2 to 6 carbon atoms (at least 1 of each group). Formulas and names of ionized forms of following acids: acetic acid, lactic acid, pyruvic acid. Names for higher carboxylic acids: C16:0, C:18:0, C18:2, C18: 3, C20: 4. Unsaturated carboxylic acids - biological significance.
23. **Functional derivatives of carboxylic acids - biologically important structures and their reactions**. Types of functional derivatives of carboxylic acids, give at least 3 examples (also formulas) of biologically important derivatives. The difference between an amine and an amide, give examples of biologically important amides, illustrate the structure of at least one of them. Esters of carboxylic acids and alcohols, importance for lipids. Acyl- and its transfer in biochemical reactions in the body, an example of the most important acyl. Urea and its derivatives, briefly their biological significance.
24. **Substitution derivatives of carboxylic acids** - name types, give examples. Redox properties of lactic acid and biological significance of its formation. Ketone bodies in the body and their significance and reactions of their interconversions. Reaction of pyruvic acid with glutamic acid, biological significance of the reaction. Oxidative deamination of glutamic acid - write in formulas.
25. **Organic compounds of nitrogen and sulfur** (biologically important amines, thiols) - structure, biochemically important properties (reactions). Biologically important heterocyclic structures and their derivatives (write the formula of at least one). Nitrogen-containing energy rich compounds (creatine phosphate and carbamoyl phosphate), their biological significance. Reaction of the formation of biologically important amines from serine and their application in the synthesis of complex lipids. Amino acids with sulfur in the molecule, their importance. Sulfuric acid as a part of biologically important organic compounds.

26. **Monosaccharides, their structure and properties** - the structures of aldohexoses by Fischer, Tollens and Haworth formulas (e.g. for glucose or galactose molecule); the structures of ketohexoses by Fischer, Tollens and Haworth formulas (e.g. for fructose molecule). Epimers, enantiomers and anomers - explain isomerism on glucose molecule. Phosphate esters of monosaccharides, their meaning and structure. Biochemically important reactions of monosaccharides - write the types and write at least one fructose reaction in formulas (give also name of products).
27. **Reactions of monosaccharides** - oxidation (in formulas glucose oxidation, name of products), reduction (in formulas fructose reduction, name of products), esterification (reaction of glucose with ATP in glycolysis), formation of a glycosidic bond and its biological importance. Reaction of glucose with proteins and its importance. The formation of glucuronic acid (in formulas) and its biological significance.
28. **Glycosides** - express structurally the formation of a glycosidic bond. Characterize disaccharides, homopolysaccharides (homoglycans). Examples of important disaccharides (structure, significance, source for the organism, formula of at least one disaccharide). Explain the term reducing and non-reducing disaccharide, give examples. An example of an important animal homoglycan, its structure, types of bonds, biological significance. Cellulose, its digestibility in humans, cellulose monosaccharide units, bond between them.
29. **Heteropolysaccharides (heteroglycans)** - difference between homopolysaccharides and heteropolysaccharides, basic saccharide units in heteropolysaccharides, classification of heteropolysaccharides, localization in tissues. Hyaluronic acid, basic units, localization and the role in tissues. Heparin, basic units, the role of heparin in the body and in medicine. Write the formula and name of at least one monosaccharide derivative that occurs in the heparin molecule.
30. **Glycoconjugates -** proteoglycans, their composition and function, occurrence in the body, glycoproteins, their composition and function. Function of carbohydrate component in proteoglycans, binding of carbohydrate component to protein in proteoglycans, type of bonds. Functions of the carbohydrate component in glycoproteins. Write the formula and name of at least one monosaccharide derivative that occurs in the proteoglycan molecule.
31. **Lipids** - functions and division according to chemical structure. Simple lipids - non-hydrolyzable and hydrolyzable. Structure, properties and meaning. For each type, give at least 2 examples and write one of them with a formula.
32. **Phospholipids** - classification according to the basic alcohol and the nature of the non-lipid component, structure and biological function. Lecithins - general formula, types of bonds, amphiphilic character. Formulas of alcohols bound to phosphatidic acid and their mutual transformations. Specificity and catalytic effect of phospholipases.
33. **Glycolipids** - division according to the basic alcohol (write formulas) and the nature of the non-lipid component, structure and biological function. Neutral and acid glycolipids - examples of acidic functional groups.
34. **Biomembranes** - structure, asymmetry of cell membranes, lipid rafts and biological function. Division and importance of cell membrane proteins. Formulas of at least three lipid components of membranes and a description of the property that determines the formation of the membrane.
35. **Lipoproteins** - basic characteristics of the structure of a lipoprotein particle, names of classes of lipoproteins according to the density of their particles and their biological functions. General formulas of lipids transferred in the core of a lipoprotein particle. Names of proteins and their relative representation in individual groups of lipoproteins.

36. **Arachidonic acid** (formula), scheme of eicosanoid formation, their biological significance and practical use. Structure and biological function of prostaglandins. Structure and name of an important drug that inhibits cyclooxygenase.
37. **Terpenes** - basic structural unit - formula and name. Division of terpenes according to the number of basic structural units and an example of compounds belonging to individual groups. Their biological function and relationship to lipophilic vitamins. **Steroids** - basic structure and functions. The names of the basic saturated hydrocarbons of steroids, the number of carbon atoms in their molecule and the names of the steroid substances which are derived from these hydrocarbons.
38. **Biochemically important amino acid reactions** - decarboxylation, deamination - desaturation (histidine deamination reaction), oxidative (glutamic acid deamination reaction), transamination (alanine aminotransferase catalyzed reaction), peptide bond formation.
39. **Peptides** - biological function. Characteristics and examples of dipeptides and pentapeptides. Glutathione - structure and biological function. Peptide hormones - description of the structure and biological function of at least three peptide hormones in the body.
40. **Proteins**, basic characteristics and structure (primary, secondary, tertiary, quaternary). Bonds or interactions stabilizing the tertiary structure of proteins; for each type, indicate the functional groups of the amino acid side chains that may form them. Classification and biological function of proteins, influence of denaturation on protein function. Denaturing agents.
41. **Heteroproteins**, division into groups. Characteristics of individual groups (at least 5) of heteroproteins, examples of proteins belonging to these groups and their function.
42. **Hemoproteins** - classification, characteristics and biological function. Hemoglobin, myoglobin, cytochromes. Plasma proteins. Immunoglobulins, basic structure, classes of immunoglobulins and their biological function.
43. **Nucleic acids** - characteristics, structure of building blocks, tautomeric forms and their application in the transfer of heredity. Complementarity of pyrimidine and purine bases Formulas of heterocyclic bases bound in DNA and RNA. Minority principles. Definition of nucleoside and nucleotide and types of bonds by which the components are bound.
44. **DNA** - characteristics, primary and secondary structure of DNA, Chargaff's rules, types of DNA, basic characteristics of individual types and their biological function.
45. **Chemical modification of nucleotides**. Chemical and physical mutagenic agents. Genotoxicity of nitrous acid and hydroxylamine, impact on base complementarity in DNA.
46. **RNA** - structure, types of RNA (m-RNA, r-RNA, t-RNA), their biological functions. Influence of the presence of minority bases on the secondary structure. The nucleotide formula to which the amino acid binds in proteosynthesis, site and type of binding.
47. **Vitamins** - classification according to their solubility - individual names of vitamins, and the most important biological functions of water-soluble vitamins and their coenzyme forms. Diseases caused by avitaminosis $B_1$, $B_3$, $B_{12}$, C, A, D, K. Vitamin $B_3$ formula. Antivitamins - their classification according effect, examples of individual groups.
48. **Vitamins A and D** – their individual names, toxicity, names of their provitamin forms and places of their occurrence. Mechanism of vision, biological functions of vitamin A (at least 3), diseases caused by vitamin A deficiency (at least two), sources of vitamin A and its precursor. Structural formula of the molecule from which vitamin D is derived, places of

vitamin D activation and the most important functions, consequences of hypovitaminosis and hypervitaminosis of vitamin.D

49. **Vitamins E and K** – their specific names, names of three groups of vitamins K and the formula of their ring (without side chains), main functions of vitamins E and K, vitamin K cycle, consequences of vitamin K hypovitaminosis, anticoagulants in medicine - mechanism of dicoumarol action.
50. **B complex vitamins ($B_1$, $B_2$, $B_6$, $B_7$) -** individual names, biochemical and physiological significance of individual vitamins, names of their coenzyme forms, names of molecules transported by the given coenzymes in metabolic reactions, structural formulas of all forms of vitamin $B_6$, description of the structure of the coenzyme derived from the vitamin $B_2$ (only verbally) and the type of reactions in which the coenzyme is involved, vitamin $B_1$ avitaminosis.
51. **B complex vitamins ($B_3$, $B_5$, $B_9$)-** their specific names, biochemical and physiological significance, their coenzyme forms, mechanism of their action, reaction of ethanol oxidation (enzyme, coenzyme), diseases caused by avitaminosis $B_3$ and $B_9$, symptoms of the diseases, formula of the compound which may be a precursor of vitamin $B_3$
52. **Vitamins C and $B_{12}$** - specific names, biochemical and physiological significance, structural formulas of two forms of vitamin C, cooperation of vitamin C with vitamin E. Element (and its oxidation number) located in the central part of the vitamin $B_{12}$ molecule, scheme of vitamin $B_{12}$ transport from food to cells. Consequences of hypovitaminosis C and $B_{12}$.
53. **Coenzymes $NAD^+$ / NADH, $NADP^+$ / NADPH -** their structures, mechanism of action during ethanol oxidation, name of the class of enzymes using these coenzymes. Coenzyme Q, the structure of its ring without side chains and the mechanism of its action. Coenzyme Q intracellular location.
54. **Coenzymes transferring groups of atoms** - adenosine phosphates as coenzymes not derived from vitamins (ATP, ADP, AMP), their structures, the reaction of cAMP formation. The name of enzymes using these coenzymes. Lipoic acid, biochemical and physiological significance.
55. **Enzymes - mechanism and kinetics of enzyme reactions –** enzymes´ function, simple enzymes and holoenzymes, classification of cofactors according to the type of transferred group - examples, mechanism of enzyme reactions, stages of enzyme reactions, kinetics of enzyme reactions - equation to calculate the reaction rate according to Michaelis – Menten, definition and graphical evaluation of $K_M$ constant according to Michael-Menten and Lineweaver - Burke. Enzyme active site, types of substrate binding to the active sit of the enzyme, theories of enzyme-substrate binding.
56. **Enzymes, their specificity, isoenzymes** - types of enzyme specificity, parts of enzyme molecule responsible for certain type of specificity, classification of enzymes according to their specificity. Isoenzymes - biological significance, lactate dehydrogenase - its isoenzyme forms, the catalyzed reaction (with a coenzyme).
57. **Regulation of enzyme activities** - units of enzyme activity and their mutual conversion, scheme of classification of regulation of enzyme activities with / without the change in the number of enzyme molecules. Physico-chemical factors influencing enzyme activity, their description and graphs of the dependence of the reaction rate on the given factor.
58. **Enzymes inhibitions** – principle of inhibitions, classification of enzyme inhibitions, inhibition by diisopropyl fluorophosphate and iodoacetamide (formulas, functional groups of the enzymes with which they react), the importance.

59. **Enzyme inhibitions -** competitive, non-competitive, uncompetitive inhibitions - principle, graphic representation according to Michaelis-Menten and Lineweaver Burke, $K_M$ and $v_{max}$ values. The principle of using ethanol as an antidote for methanol and ethylene glycol poisoning - metabolic reactions of methanol, ethanol and ethylene glycol.
60. **Enzymes- allosteric regulation of enzyme activity -** allosteric enzymes - graphical representation of the relationship between the substrate concentration and reaction rate, cooperative and sequential model of allosteric enzyme activation, feedback regulation and feed-forward activation. Reaction of isocitrate to α-ketoglutarate conversion - name of enzyme, coenzyme, activators and inhibitors of enzyme.
61. **Covalent modifications of enzyme activity** - various types, phosphorylation, dephosphorylation - principle and their advantages, regulation of glycogen synthesis / degradation by phosphorylation / dephosphorylation. Limited proteolysis - examples and its importance for protein metabolism.
62. **Inhibitors in medicine** - succinate dehydrogenase catalysed reaction, name and structure of two competitive enzyme inhibitors, , reaction catalyzed by xanthine oxidase, name of its competitive inhibitor and its importance in medicine. Mechanism of aspirin action during fever and inflammation, aspirin structure.
63. **Regulation of enzyme activity with the change in the number of enzyme molecules**. Inductive and constitutive enzymes, induction, repression. Regulated protein degradation - endopeptidases, exopeptidases, lysosomes, proteasome - structure, function, mechanism of action. Classification of proteases according to the optimal pH and according to the amino acid in the active site of the enzyme, specificity of proteases.
64. **Enzymes classes and nomenclature** – types of enzyme nomenclature, 6 classes of enzymes, examples of reactions catalyzed by individual classes of enzymes.
65. **Enzyme multisubstrate reactions and enzyme disorders** – types of mechanisms of multisubstrate reactions, example for individual mechanisms. Enzyme disorders - lactose and sucrose intolerance. Classification of enzymes according to their location - intracellular and extracellular, description of individual groups, example.
66. **Physico-chemical analytical methods.** Basic classification and general principles of individual groups of methods. Principle of spectrophotometry, basic law (its name and formula with explanation of symbols), definition of molar absorption coefficient. Definition of absorption spectrum and analytical curve. Application of spectrophotometry in biochemistry. The principle of sedimentation and centrifugation, relative centrifugal force. The principle of potentiometry and an example of its application. Principle of gel permeation and thin layer chromatographies, definition of retention factor.
67. **Oxidative stress - definition, reactive metabolites of oxygen and nitrogen, antioxidant systems, markers of oxidative damage to important biomolecules**. Definition of free radicals, examples of radical and non-radical reactive metabolites derived from oxygen and nitrogen. The ways of free radicals formation, Fenton reaction, Haber-Weiss reaction. Antioxidants, definition, mechanism of action, classification and examples of three antioxidants of each group. Oxidative stress and its importance for the organism.