

**QUESTIONS FOR PART “C” OF EXAM FROM
“MEDICAL CHEMISTRY”
study branch - DENTISTRY
academic year 2023-2024**

1. Coordination and hydrogen bonds in biological systems

Definition of coordination bond, explanation of the term central atom, ligand, and coordination number. Give two examples of complexes with designation of the central atom and the ligands. Explanation of the term chelating ligand (give the names of 2 examples of chelating ligands). Characteristics of tetrapyrrole ligands, their names and importance in biological system. Characteristics of hydrogen bond, the importance of hydrogen bond in biological systems (give 3 examples).

2. Biological importance of Ca, Mg, and P

Write the group they belong to (according to their abundance in the organism). Physiological functions of calcium (at least 5 functions), compounds in which calcium is found in bones and teeth. Physiological functions of magnesium (at least 4 functions). Biologically important compounds containing phosphorus – name at least 4 together with their biological functions and write their formulas).

3. Biological importance of Fe

Write the group Fe belongs to (according to its abundance in the organism). Typical oxidation states of Fe and its amount in the organism. Absorption of Fe in the gastrointestinal tract and factors affecting it. Iron deficiency and excess (causes and consequences). Two examples of pathological derivatives of hemoglobin and their negative role in organism. Functions of transferrin and ferritin. Structure and functions of haemoglobin and description of the binding of iron in hemoglobin. Function of catalase (including corresponding reaction).

4. Biological importance of Cu and Zn

Write the group they belong to (according to their abundance in the organism) and their typical oxidation states. Transport of copper to the liver. 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). General functions of zinc in proteins. Functions of carbonic anhydrase and alcohol dehydrogenase (including corresponding reactions).

5. Toxicity of elements

Factors influencing the toxicity of metal ions in the organism. Write at least 4 examples of toxic elements. Reasons of metal ion toxicity in the organism. Chelation therapy, characteristics of chelating agents, properties determining their effectiveness. Give 3 examples of therapeutic chelating agents, write formula of one of them.

6. Disperse systems, true solutions

Definition of disperse systems. Classification of disperse systems based on the number of phases and particle size. Properties of true solutions, types of solvents and solutes, dissolution process. Colligative properties and processes based on them. Importance of dialysis in clinical practice. Definition and relationship for calculating osmotic pressure. Definition of isotonic, hypotonic, and hypertonic environments. Behaviour of erythrocytes in these environments. Expression of the composition of a physiological solution in three ways.

7. Oxidation-reduction reactions, biological oxidations

Definition of oxidation-reduction reactions. Oxidizing and reducing agents, four ways of oxidation in biological systems. Dismutation (provide an example). Driving force of oxidation-reduction reactions, its significance, and the relationship for its calculation. Definition of E° . Biological oxidations and their significance in metabolic processes. Give 4 examples of redox pairs, including 2 from the respiratory chain.

8. Reaction kinetics and equilibrium of chemical and biochemical reactions

Guldberg - Waage law. Factors affecting the rate of reaction and how they affect it. Graphical representation of the effect of a catalyst on the rate of reaction. Characteristics of chemical equilibrium, equilibrium constant, and its significance, give an example of calculating the equilibrium constant on a specific reaction. Le Chatelier's principle and a specific example of its application in physiology. Explain the effect of temperature on the equilibrium of exothermic and endothermic reactions.

9. Acids and bases theories, pH

The theories of acids and bases, conjugate pair - definition and examples; characteristics of ampholytes (give 2 examples). Acid ionization (dissociation) constant (explain and give an example for acetic acid). Characteristics of strong and weak acids and bases, give 2 examples of each. Ionic product of water (give also its value and valid units). pH scale and relationship between pH and pOH. Formulas for calculation of pH of strong and weak acid, strong and weak base. Write the equation of hydrolyses of sodium acetate and ammonium chloride, specify pH of these solutions. Write pH of gastric juice and physiological pH of blood.

10. Buffer systems and acid-base balance 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 organism. Physiological pH of the blood. Mechanism of action of bicarbonate buffer after addition of HCl (express by equation) and action after addition of KOH (express by equation). The formula for calculation of pH of buffer system (generally as well as for the certain buffer system). Acid-base balance, brief characteristics and the types of acid-base disorders. The main consequences of pH changes in the organism.

11. Organism as thermodynamic system, laws of thermodynamics, Gibbs free energy

The types of thermodynamic systems and their brief characteristics, organism as thermodynamic system. Definition and mathematical expression of the 1st law of thermodynamics (explain symbols). Hess law, enthalpy, internal energy. Reaction heat, exothermic and endothermic reactions. Definition and basic relationship for the 2nd law of thermodynamics, entropy as state function, 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 changes of entropy ΔS and ΔG of a thermodynamic system. The importance of ATP and its hydrolysis (write the formula of ATP and structurally the reaction of its hydrolysis, describe the types of bonds present in the ATP molecule).

12. Hydroxyderivatives of hydrocarbons and their biologically important reactions

Characteristics of the structure and properties of these derivatives, the difference between alcohols and phenols (structure, acidic properties). Classification of alcohols (give examples). Write in formulas 5 types of important reactions of alcohols and their specific biological importance. Biologically significant redox reaction of diphenols.

13. Oxo compounds - biochemically and toxicologically important structures and reactions

Characteristics of the structure, biochemically and toxicologically important oxo compounds and their reactions - redox properties of individual types of oxo compounds, reactions of hemiacetals and acetals formation, biological significance of the reaction. Aldol condensation - give specific example of reaction from metabolism. Schiff base formation reaction (structurally), specify in words the physiological and pathological examples. Biological significance of quinones.

14. Carboxylic acids

Basic characteristics of their structure, formation of carboxylic acids. Give at least 3 types of reactions provided by carboxylic acids. Formulas and trivial names of monocarboxylic acids with 1 to 4 carbon atoms. Formulas and trivial names of at least 2 dicarboxylic acids with 2 to 6 carbon atoms. Formulas and names of ionized forms of following acids: acetic acid, lactic acid, pyruvic acid. Names for higher carboxylic acids with shorthand

designation: C16:0, C:18:0, C18:2(9,12), C18:3(9,12,15), C20:4(5,8,11,14). Polyunsaturated carboxylic acids - characteristics of their structure and biological significance. Write the names, formulas and shorthand designations of essential higher carboxylic acids. Explain structurally formation of TAG as well as the different types of TAG hydrolysis (name products).

15. Carboxylic acids derivatives

Characteristics of functional derivatives of carboxylic acids from the viewpoint of their structure, the types of functional derivatives and for 3 of them give 1 biologically important example (write its name and formula). Write in formulas at least one reaction provided by functional derivatives of carboxylic acids. Functional derivatives of carboxylic acids in the structure of lipids - structure and meaning. Urea, its formula and importance. Characteristics of substitution derivatives of carboxylic acids from the viewpoint of their structure, the types of biologically important substitution derivatives, for each of them give example (write name and formula). Redox properties of lactic acid and biological significance of its formation. Ketone bodies in the organism - their names, reactions of their interconversions, physiological as well pathological meanings.

16. Organic compounds of nitrogen and sulfur

Characteristics of the structure of amines and thiols, biochemically important properties (reactions). Biologically important heterocyclic structures containing sulfur (names of 2 at least) and nitrogen (names and formulas of 2 at least). Give the names of at least 2 biologically important molecules including heterocycle containing sulfur or nitrogen in their structure and the names of those heterocycles. Energy rich compound derived from urea - name, formula and its 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 (name, formula importance). The names of biologically important organic compounds including sulfuric acid, name the type of bond by which sulfuric acid is bound in their structure.

17. Monosaccharides, their structure and reactions

Characteristics of saccharides structure and their classification from different viewpoints. The structure of aldohexoses and ketohexoses - Fischer, Tollens and Haworth formulas (explain for certain monosaccharides). Epimers, enantiomers and anomers - explain isomerism on glucose molecule. Biochemically important reactions of monosaccharides - oxidation of glucose and its biological importance, reduction of fructose and the meaning of formed products, esterification (reaction catalysed by hexokinase), formation of a glycosidic bond and its biological importance.

18. Glycosides

Definition of glycosides, types of glycosidic bond. General reaction of glycosidic bond formation. Characteristics of disaccharides and homopolysaccharides (homoglycans). Characteristics of three important disaccharides and write 2 of them in formula. Explain

the term reducing and non-reducing disaccharide, give examples. Give example of an important animal homoglycan, its structure, types of bonds, biological importance. Characteristics of cellulose and its digestibility in humans.

19. Heteropolysaccharides (heteroglycans) and glycoconjugates

Characteristics of the structure of heteropolysaccharides and the difference in comparison to homopolysaccharides. General reaction of formation of the bond between the building units in heteropolysaccharides. Basic building units in heteropolysaccharides (verbal characteristics and at least 2 types in formulas). The importance of hyaluronic acid and heparin in organism and its use in medicine. General characteristics of the structure of glycoconjugates and their classification. Proteoglycans, their composition, occurrence in the organism and function. Glycoproteins, their composition and in words at least 6 examples of glycoproteins and their functions.

20. Lipids

Characteristics of lipids, their functions (at least 6), and classification according to the chemical structure. Hydrolysable simple lipids - structure and meaning. For each type, give at least 2 examples, and write one of them also in formula. Chemical properties of TAG, the general reactions of formation and hydrolysis of TAG. Saponification.

21. Complex lipids

Classification of complex lipids according to the basic alcohol and the nature of the non-lipid component - biological function of individual groups and explain their amphiphilic character. Lecithins and cerebrosides - general formula, types of bonds. Formulas of alcohols bound to phosphatidic acid. Structure (fluid mosaic model) and composition of cell membranes.

22. Lipoproteins

Basic characteristics of the structure of the lipoprotein particle, classification of lipoproteins according to the density. Sites of formation and biological functions of individual classes of lipoproteins. General formulas of lipids transported in the core of the lipoprotein particle. The classes of apoproteins, their biological function, and relative representation in individual groups of lipoproteins.

23. Derived lipids

The basic structural unit of terpenes (formula and name) and their classification. Basic structure of steroids (formula and name). Classification of steroids according to the number of carbons - names of basic saturated hydrocarbons from which steroids are derived, provide examples in each group of steroids and their functions.

24. Classification and biochemically important reactions of amino acids

Characteristics of the structure and biological function of amino acids, classification of amino acids. Formulas of acidic and basic amino acids. In formulas write at least 4 types of chemical reactions provided by amino acids (give also names of products, enzymes and coenzymes). The formation of peptide bond, describe character of peptide bond. Glutathione - description of structure and biological function. Peptide hormones - description of the structure and biological function of two peptide hormones in the organism.

25. Proteins

The basic characteristics of proteins, types of their structures, bonds or interactions that stabilize these structures (mention the functional groups in amino acid chains that can facilitate their formation). Heteroproteins - classification into groups, characteristics of individual groups and examples of proteins belonging to these groups. Hemoglobin - characteristics of structure and function.

26. Nucleic acids

Characteristics, structure of building units, tautomeric forms, and their application in the transfer of genetic information. Complementarity of nitrogenous heterocyclic bases and their application in the process of gene expression. Formulas of heterocyclic bases bound in DNA and RNA. Definition and general formulas of nucleoside and nucleotide, and types of bonds by which their components are bound.

27. DNA and RNA

Characteristics, primary and secondary structure of DNA and RNA (including types of bonds), Chargaff's rules, DNA forms. Formulas of dTTP and dGDP. Types of RNA, place of origin and biological functions. The formula of the nucleotide to which the amino acid binds in the formation of aminoacyl-tRNA in the process of proteosynthesis, site and type of bond.

28. Vitamins

Vitamins - definition, classification according to their solubility (listing vitamins in individual groups), and diseases caused by avitaminosis (5 examples). Trivial names of B-group vitamins, names of their coenzyme forms, and their participation in biochemical reactions. Structural formulas of all forms of vitamins B₃ and B₆.

29. Vitamins A and D

Vitamin A - trivial name, provitamin forms, and sources of vitamin A and its provitamins. Mechanism of vision, biological functions of vitamin A (at least 3), and diseases caused by its deficiency. Vitamin D - trivial name, provitamin forms, sources. Structural formula of the molecule vitamin D is derived from, the name of its most active form, the ways of its

activation and its location in the organism, most important functions, consequences of hypovitaminosis and hypervitaminosis.

30. Vitamin E and K

Trivial names, main functions, and sources of vitamins E and K. The formula of vitamin K core (without side chains). Causes and consequences of hypovitaminosis of vitamin K. Anticoagulant effect of dicoumarol (mechanism of action). Antivitamins - definition, classification by their effect, examples of individual groups.

31. Coenzymes

Classification of coenzymes, mention 2 examples from each group (full name and abbreviation), at least 1 example from each group with a formula. Functions of at least 6 coenzymes in biochemical reactions - type of substance transferred and examples of enzymes using a given coenzyme. Vitamin C - trivial name, coenzyme form, its functions in the organism, structural formula of two forms of vitamin C, avitaminosis of vitamin C and its manifestations.

32. Enzymes - mechanism of action and kinetics of enzyme reactions

Structure, function of enzymes, classification based on their structure, and names of individual components. Active site of the enzyme, types of binding of the substrate to the enzyme's active site. Theories of substrate binding by the enzyme. Mechanism and stages of enzyme reaction. Kinetics of single-substrate enzymatic reactions - formula for the calculation and graphical expressions of the dependence of reaction rate on substrate concentration. Definition of the K_M constant and its graphical representation.

33. Enzymes - their specificity, isoenzymes

Structure and function of enzymes in the organism. Enzyme specificity - definition, classification, examples of enzymes that belong to individual classes, and reactions they catalyse. Isoenzymes - definition, characterization and biological significance. Lactate dehydrogenase - its structure and isoenzyme forms, location, and the catalyzed reaction.

34. Enzymes - regulation of enzyme activities

Structure and function of enzymes in the organism. Classification scheme of regulation of enzyme activities with a change and without a change in the number of enzyme molecules. Physico-chemical factors affecting the activity of enzymes, their description, and graphs of the dependence of reaction rate on the given factor. Units of enzymatic activity, their definition and mutual conversion.

35. Enzymes - regulation of enzyme activities

Principle of enzyme inhibitions and their classification. Structure of allosteric enzymes and the principle of allosteric effector action. Graphical representation of the relationship between substrate concentration and the rate of a reaction catalysed by allosteric enzyme

in the presence of effectors. "Feed-back" and "feed-forward" regulations. Two models of activation of allosteric enzymes. The reaction of conversion of isocitrate to α -ketoglutarate - name of the enzyme, coenzyme, activators and inhibitors of the enzyme.

36. Reversible inhibition of enzyme activities

Classification of reversible inhibitions, their principles, graphical representation of K_M and v_{max} according to Michaelis and Menten, and according to Lineweaver and Burk. The principle of using ethanol as an antidote for methanol and ethylene glycol poisonings. Metabolic reactions of methanol, ethanol, and ethylene glycol (reactions in formulas, names of products, enzymes and coenzymes).

37. Covalent modifications of enzymes, limited proteolysis

Definition and types of covalent modifications, principle and advantages of the most common covalent modification in the cell, names of enzymes participating in the given modification. Regulation of glycogen synthesis/degradation. Limited proteolysis - description of the process, examples and its significance.

38. Oxidative stress, reactive metabolites and antioxidant systems

Definition of oxidative stress and its impact on the organism. Definition of free radicals, examples of radical and non-radical reactive metabolites derived from oxygen and nitrogen. The ways of free radicals formation in the organism under physiological and pathological conditions. Markers of oxidative damage to biomolecules. Antioxidants, definition, mechanism of action, classification according to molecular weight, 3 examples of antioxidants of each group. Physiological role of reactive metabolites in the organism.