

Examination from Medical Chemistry - Autumn 2010

Examination from Medical chemistry is only written. The test consists from two parts.

The first part comprises 38 questions and is solved on computers in the computer room of Department of Biochemistry (time limit 50 min)

- 4-5 calculations (concentration, pH, buffers, osmotic pressure) – see seminars
- 16 simple questions (multiple choice or free answer)
- 5 structural formulas (essential organic and inorganic compounds)

Each correct answer counts for 1 point; in one question it is possible to obtain 3 points.

The maximal acquisition = 40 points.

The model test will be available during October 2010; students will be informed by e-mail.

Examples of simple questions from the first part

- ✓ Write the Latin name of the compound XY.
- ✓ Which period does the element X occur in?
- ✓ Write the valence electrons of the element Y.
- ✓ Which compound from the following hydrolyzes?
- ✓ Select weak electrolytes from the following compounds.
- ✓ Select conjugate pairs from the following species.
- ✓ Complete the reaction.
- ✓ Complete the structural formula.
- ✓ Give the name of compound which is formed by dehydrogenation / dehydration /...
- ✓ What heterocycle is contained in the compound X?
- ✓ Give the name of the organic compound.
- ✓ Structures of fatty acids, monosaccharides etc. – give the name or describe the structure.
- ✓ Structures of biopolymers – types of bonds, building units, non-covalent interactions etc.

The second part is written and is focused on the active knowledge of structural formulas of the most important compounds, expression of important biochemical reactions by chemical equations and the ability to formulate the basic physico-chemical relationships or to draw graphs. This part comprises 15 tasks; the maximal acquisition is 17 points (time limit 30 min).

Write and draw very clearly and legibly, illegible answers will not be assessed.

Tasks involved in the second part of the exam test:

Task	Point
Structure of amino acid ionized under certain pH value	1
Six structural formulas of (in)organic compounds: (di)carboxylic / inorganic acids and derivatives (amide, ester, anhydride, thioester, lactone), hydroxyl/oxo acids, amines (incl. biogenic ones – e.g. adrenaline, acetylcholine), alcohols, aldehydes, hemiacetals, acetals, thiols, sulfides etc.	6
Two chemical reactions (transamination, esterification of (in)organic acids, dehydrogenation, dehydration, citrate cycle reactions, hemiacetal formation, dehydrogenative deamination, decarboxylation)	4
Nucleoside, nucleotides incl. ADP, ATP, dinucleotide	1
Dipeptide or tripeptide	1
Monosaccharides (glucose, fructose, galactose, mannose, ribose), uronic / aldonic acids, lactones, aminosugars, N-acetylaminosugars, sugar alcohols), glycosides, disaccharides	1
Triacylglycerol, glycerophospholipid, sterane, cholesterol	1
Various curves: titration curves of weak and strong acid, kinetic curves	1
Writing chemical reaction or equation/relation - equilibrium constant, solubility product, Henderson-Hasselbalch eq., Nernst-Peters eq., $G \sim E$ relation, buffer reaction after adding strong acid/base etc.	1
Total sum	$\Sigma 17$

MEDICAL CHEMISTRY EXAMINATION TOPICS 2010

GENERAL MEDICINE

Some names of compounds are marked by an asterisk (*). It denotes that the complete presentation of the structural formula is not required. Nevertheless, the structural formula should be recognized as well as the proper names given to the important substructures.

- 1 Basic chemical terms: expression of amounts of substances, molar quantities.
- 2 Intermolecular forces, the resulting properties of matter. Similia similibus solvuntur – typical examples, the biological significance.
- 3 Energetics of chemical reactions: enthalpy, entropy, and Gibbs free energy changes, their relationship. The driving force of chemical reactions.
- 4 High-energy compounds, structures, energetic coupling of reactions, the biological significance.
- 5 Reaction rate. Kinetic equations, progress curves for the 1st order and the 0th order reactions, catalysts.
- 6 Chemical equilibrium, the equilibrium constant, the relationship between K and ΔG° . Factors influencing equilibrium.
- 7 Liquid dispersions, types and fundamental properties, expressing of concentration.
- 8 Colligative properties of solutions, osmotic pressure, osmolarity, isotonic solutions, the osmolality of blood plasma.
- 9 Liquid colloidal dispersions (hydrophilic colloidal solutions - molecular and micellar). Factors stabilizing and destabilizing liquid colloidal dispersions (ionic strength, electric charge, solvation shell, surfactants).
- 10 Adsorption, application of polar and non-polar adsorbents, adsorption chromatography.
- 11 Surfactants - structural types, formation of micelles, solubilizing and emulsifying effects.

- 12 Weak electrolytes, the ionization constant K and percent ionization α_c . Strong electrolytes, concentration versus activity of ions, ionic strength.
- 13 Acids and bases, conjugate pairs, weak acids and bases, pK_A and pK_B . The pH values of aqueous solutions of strong and weak acids and bases.
- 14 Titration curves, differences between titration curves of strong and weak acids.
- 15 Hydrolysis of ions.
- 16 Buffer solutions, the action of buffers. The relation between the buffer composition and pH value, buffer capacity, its relation to the titration curve.
- 17 Buffer systems in the human body.
- 18 Precipitation, solubility product constant K_S , soluble and insoluble carbonates and phosphates.
- 19 Coordination compounds (structure, stability, examples and nomenclature), chelation.
- 20 Oxidation and reduction, oxidizing and reducing agents, electrode potential of the half-cell E° and E . Decisions about the direction of a redox reaction considering the ΔE . The relationship between ΔE and ΔG .
- 21 Redox pairs of biological significance (substrates, coenzymes of dehydrogenases, ascorbic acid).
- 22 Elements in the human body (essential macroelements and microelements).
- 23 English chemical nomenclature of inorganic compounds; Latin nomenclature of pharmaceuticals (oxides, hydroxides, inorganic and organic acids and salts).
- 24 Oxygen, composition of air, ozone, reactive oxygen species, hydrogen peroxide, water.
- 25 Halogens, biological significance of halides, blood plasma chloride.
- 26 Sulfur compounds, selenium - biological significance.
- 27 Nitrogen, inorganic nitrogen compounds in nature (the nitrogen cycle), biological importance.
- 28 Phosphorus as biogenic element (phosphates, diphosphates, phosphate esters important in metabolism).
- 29 Biological significance of carbon compounds (oxides, carbonates, cyanides), nutrients, carbon cycle in the nature.
- 30 Si, B, Al - compounds applicable in medicine (antacids, boric acid and borax).
- 31 Magnesium, alkaline earth metals, biological role of Ca^{2+} and Mg^{2+} ions, significant compounds, water containing $Ca+Mg$ ions, insoluble calcium compounds.
- 32 Na, K – human intake of these minerals, biological role of Na^+ and K^+ ions, blood plasma concentration, significant sodium and potassium compounds.
- 33 Fe - biochemical significance, forms of iron occurrence in the body, some important iron compounds.
- 34 Toxic inorganic compounds (ozone, SO_2 , nitrites, HCN, CO, As, Pb, Ba, Cd, Hg, asbestos).
- 35 Constitution of organic compounds, structural isomerism (examples). Tautomerism (types, examples). Conformation of alkanes and cycloalkanes (cyclohexane, decaline, sterane).
- 36 Stereoisomerism (*cis-trans* isomerism, optical isomerism). Notation of chiral molecules configuration (Fischer projection formulas, *R/S* convention), enantiomers, racemates, diastereomers.
- 37 Important and useful arenes (benzene, toluene, styrene), biotransformation of arenes, polycyclic aromatic hydrocarbons.
- 38 Alcohols - types, general properties, reactions, ethanol and methanol.
- 39 Polyhydric alcohols (glycols, glycerol, alditols, inositol), enols.
- 40 Phenols, general properties. Quinones (*ubiquinone, 1,4-naphthoquinone). Ethers.
- 41 Esters of inorganic acids, biological significance (nitrates, sulfates, phosphates, organophosphates).
- 42 Organic compounds of sulfur (thiols, alkyl sulfides, sulfonic acids).
- 43 Reactions of carbonyl compounds, biologically important aldehydes and ketones (acetone, pyridoxal, malondialdehyde, allysine, *retinal, the biochemical term "ketone bodies").

- 44 Carboxylic acids - general properties. The most important saturated and unsaturated aliphatic and aromatic acids (mono- and dicarboxylic), the trivial and systematic names of those acids, ibuprofen.
- 45 Carboxylic acid derivatives (acid anhydrides, mixed anhydrides, esters, thioesters, amides).
- 46 Derivatives of carbonic acid (carbamates, urea, guanidine, creatine, phosphocreatine, creatinine, arginine).
- 47 Aliphatic and aromatic hydroxy acids (structures and names, products of oxidation, lactones).
- 48 Oxo carboxylic acids of biochemical importance, the term "ketone bodies".
- 49 *p*-Aminobenzoic acid, the relation of PABA to folic acid. The principle of sulfonamides action.
- 50 Biochemically significant interconversions of some aliphatic mono- and dicarboxylic acids (saturated acids to unsaturated and to hydroxy carboxylic and oxo carboxylic acids, transamination of amino acids).
- 51 Amines - general properties, basicity, reaction with aldehydes and ketones, origins of amides, oxidative deamination of amines.
- 52 Biogenic amines, catecholamines, phenethylamines.
- 53 Quaternary ammonium salts exhibiting biological significance (choline, *myorelaxants, carnitine, cationic surfactants).
- 54 Halogenated organic compounds (solvents, PCBs, chlorofluorocarbons, herbicides, dioxins), halogenated anesthetics. Nitro compounds.
- 55 Derivatives of pyrrole, pyrrolidine, indole (porphyrin, *porphyrins, haem, *corrin, proline, tryptophan and derivatives of it).
- 56 Imidazole, thiazole, and their derivatives (histidine and histamine, *biotin, *thiamine, the *skeleton of penicillins).
- 57 Derivatives of pyridine and chroman (pyridoxal phosphate, nicotinic acid, nicotinamide, *tocopherol, *coumarin).
- 58 Pyrimidine derivatives (bases in nucleosides, *thiamine, cytostatic analogs of pyrimidine bases).
- 59 Purine and its derivatives (purine bases, uric acid, allopurinol, methylxanthines).
- 60 Pteridine, isoalloxazine and derivatives (*biopterin, *folic acid, *riboflavin).
- 61 General characteristic of alkaloids. Examples of important alkaloids.
- 62 Toxic organic chemicals.
- 63 Monosaccharides - definition, chirality in monosaccharides (expressing the configuration by Fischer projection), epimers, trivial names and the configurations of the most important monosaccharides.
- 64 Cyclic forms of monosaccharides (anomers, Haworth projection formulas, conformation formulas of pyranoses).
- 65 Reactions of monosaccharides (tests for reducing properties, products of oxidation and/or reduction of monosaccharides). Alditols and acids derived from monosaccharides (general structures, group names, significance - esp. of glucuronic acid and of *neuraminic acid).
- 66 Formation of glycosidic bonds, glycoside types (O-, N-, and ester glycosidic bonds).
- 67 Amino sugars (general structure, nomenclature, N-acetylation, importance for heteropolysaccharides, *neuraminic acid and *sialic acids) and deoxy sugars (general structure, D-deoxyribose as a constituent of nucleosides).
- 68 Disaccharides (reducing, non-reducing, structures, properties).
- 69 Homopolysaccharides (starch, glycogen, cellulose, inulin, dietary fibre).
- 70 Heteropolysaccharides (constituents, common types of *glycosaminoglycans).
- 71 Proteoglycans – structure, significance, examples.
- 72 Nucleosides - structures, nomenclature.
- 73 Nucleotides - structural types (nucleoside triphosphates, cAMP, NAD⁺, FAD, coenzyme A).

- 74 Characterization of deoxyribonucleic acid structure (polarity of strands and bonds, B-form of the DNA double-helix, base pairing, denaturation and hybridization).
- 75 Higher order DNA structures
- 76 Human genom – the basic terms and information (exons, introns, repetitive DNA and its types)
- 77 Prokaryotic and mitochondrial DNA
- 78 Main classes of RNA molecules, characteristics of the structures and of the functions (stems and loops, description of the *tRNA).
- 79 Fatty acids (saturated, unsaturated, essential acids). Eicosanoids.
- 80 Triacylglycerols, properties, structure, products of hydrolysis, fats and oils in the nutrition.
- 81 Glycerophospholipids, structural classes, differences in polarity, significance.
- 82 Sphingophospholipids, glycolipids (neutral and acidic types, components, group names).
- 83 Terpenes, major classes with examples (*menthane, *phytol, squalene, *carotenes).
- 84 Steroids, the basic structure, numbering of carbon atoms, stereochemistry; cholesterol, bile acids, significance.
- 85 Steroid hormones: corticosteroids (cortisol, aldosterone), gestagens, androgens, estrogens (structural differences, sites of secretion, notion about their functions).
- 86 Twenty standard amino acids, classification based on chemical structure and polarity of a side chain.
- 87 Standard amino acids, ionization and the pH value, isoelectric point.
- 88 Peptides, groups of peptides possessing biological activity (glutathione, examples of hormones, antibiotics, toxins).
- 89 Proteins, qualitative differences between peptides and proteins, levels for characterization of the structures, three main classes of proteins (globular, fibrous, and membrane proteins).
- 90 Primary and secondary structures of proteins (definition of the terms, types of bonds).
- 91 Tertiary and quaternary structures of proteins (definition, stabilizing bonds, super-secondary motifs and domains, stability versus flexibility of the native protein conformations, protein denaturation).
- 92 Properties of proteins - solubility, ionization, salting out, denaturation, precipitation.
- 93 Glycoproteins – types of structures, significance, different types of glycosidic linkages to proteins in glycoproteins.
- 94 Hydrophilic vitamins.
- 95 Lipophilic vitamins.