Examination from Medical Chemistry - autumn 2009

Examination from Medical chemistry is <u>only written</u>. The test consists from two parts.

<u>The first part</u> comprises 25 questions and is solved on computers in the computer room of Department of Biochemistry (time limit 45 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 is possible to obtain 3 points. The maximal acquisition = 27 points.

The model test will be available during October 2009; 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?
- ✓ Draw the ionic structure of amino acid at pH ....
- ✓ Give the name of the 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.

<u>The second part</u> (time limit 45 min) comprises 3 × 5 problems, as active answers, from the three blocks (general + inorganic chemistry, organic chemistry, bioorganic chemistry). One block contains five parts (a-e), each part a-e is donated by 2 points. Maximal acquisition = 30 points (3 × 5 × 2).

Answers have to be very explicit. Write very legibly, illegible answers will not be assessed.

Example of the second part

I. Halogens

a) Give the names and the symbols of halogens ....

Put them in the order according to decreasing electronegativity ....

Write the configuration of valence electrons of chlorine atom .... and chloride ion ....

Complete the reaction $Cl_2 + 2\,X^- \rightarrow$ ……......... + ……..………, where X^- is a halogenide ion.

Which halogenides X^- can react this way? ……………..

2 p.

b) Complete the table:

Compound	Practical usage in everyday life and/or human medicine
Lugol's solution	
Sodium chloride	
Sodium iodate	
Potassium fluoride	

2 p.

c) What is the concentration of chlorides in blood plasma? ………………..............................mmol/l

What is the function of chlorides in blood plasma? ………………………………………………......

The loss of chlorides from the body will cause the elevated plasma concentration of ....

What is the concentration of NaCl solution isotonic with blood plasma? ....mmol/l

2 p.

d) Complete the table:

Halogen	Compounds in human body (at least one)	The consequences of halogen deficit
Fluorine		
Iodine		

2 p.

e) Give at least **two** best food sources of **three** halogenides. Select from the following foodstuffs:

tea, milk, coffee, cocoa, coconut, sea products, tomatoes, beef, butter, potatoes, tap water, Vincentka, poppy seed, bacon, cheese, table salt, sugar, vinegar, legumes, spinach, liver, mushrooms, mineral waters, chocolate, mustard.

Halogenide	Food source

2 p.

II. Amines

a) Draw structural formulas and determine the type of compound (primary, secondary, tertiary amine, quaternary ammonium salt, amide).

	Cyclohexylamine	**Benzylamine**	**Ethylenediamine**	**Urea**
Formula				
Type of compound				

2 p.

b) Give a general reaction of an amine with water: ....

Explain acid-base properties of amines ....……………………........

Write the reaction of methylamine with HCl ....…………………………………….

Give the name of the product …………………………………...

2 p.

c) Complete the table, encircle the correct possibility:

Feature	**Amines**	**Amides**
General formula		
Basicity	YES / NO	YES / NO
Salt formation	YES / NO	YES / NO
The pH of aqueous solutions	acidic / neutral / alkaline	acidic / neutral / alkaline

2 p.

d) Complete the sentence: Biogenic amines are formed by ……………………………. ....

Give the formulas and the names of **three** biogenic amines:

2 p.

e) Give the names of **all** compounds called catecholamines: …………………………………….....................

Complete: Decarboxylation of DOPA provides ………………………...

Write this reaction in structural formulas:

2 p.

III. Monosaccharides

a) Draw D-glucose in acyclic form.

Show the groups which react to make pyranose.

What general type of product is formed in such reaction?

2 p.

b) Draw Haworth formula of β-D-glucopyranose.

Show the anomeric carbon atom.

What is the relation between α- and β-anomer of glucose? Encircle the best answer from the following:

enantiomer, epimer, diastereomer, tautomer.

What type of conformation prevails in pyranoses?

2 p.

c) In Haworth projection, draw the formula of product formed by the C-6 oxygenation of D-glucose.

Give the name.

This compound binds e.g. to bilirubin, catecholamines. What is this reaction good for in human body?

Great amount of this compound occurs in proteoglycans. What is the general name of saccharide component?

2 p.

d) What is the product of the hydrogenation of ribose? Give the name and draw the structural formula.

Which vitamin contains this compound?

2 p.

e) Complete the table:

Disaccharide	**Monosaccharide units**
Sucrose	
Maltose	
Lactose	

Cellobiose	

2 p.

MEDICAL CHEMISTRY EXAMINATION TOPICS 2009

DENTAL 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 1^{st} order and the 0^{th} order reactions, catalysts.

6 Chemical equilibrium, the equilibrium constant, the relationship between K and $\Delta G°$.

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_c. Strong electrolytes.

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 Hydrolysis of ions.

15 Buffer solutions, the action of buffers. The relation between the buffer composition and pH value, buffer capacity, its relation to the titration curve.

16 Buffer systems in the human body.

17 Precipitation, solubility product constant K_S, soluble and insoluble carbonates and phosphates.

18 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.

19 Redox pairs of biological significance (substrates, coenzymes of dehydrogenases, ascorbic acid).

20 Elements in the human body (essential macroelements and microelements).

21 Latin nomenclature of pharmaceuticals (oxides, hydroxides, inorganic and organic acids and salts).

22 Oxygen, composition of air, ozone, reactive oxygen species, hydrogen peroxide, antioxidants.

23 Halogens, biological significance of halides, blood plasma chloride.

24 Sulfur compounds, selenium - biological significance.

25 Nitrogen, inorganic nitrogen compounds in nature (the nitrogen cycle), biological importance.

26 Phosphorus as biogenic element (phosphates, diphosphates, phosphate esters important in metabolism).

27 Biological significance of carbon compounds (oxides, carbonates, nutrients, carbon cycle in the nature).

28 Magnesium, alkaline earth metals, biological role of Ca^{2+} and Mg^{2+} ions, significant compounds, water containing Ca+Mg ions, insoluble calcium compounds.

29 Na, K – human intake of these minerals, biological role of Na^{+} and K^{+} ions, blood plasma concentration, significant sodium and potassium compounds.

30 Fe - biochemical significance, forms of iron occurrence in the body, some important iron compounds.

31 Toxic inorganic compounds (ozone, SO_2, nitrites, HCN, CO, As, Pb, Ba, Cd, Hg, asbestos).

32 Constitution of organic compounds, structural isomerism (examples). Tautomerism (types, examples). The term conformation.

33 Stereoisomerism (*cis-trans* isomerism, optical isomerism). Notation of chiral molecules configuration (Fischer projection formulas).

34 Alcohols - types, general properties, reactions, ethanol and methanol.

35 Polyhydric alcohols (glycols, glycerol, alditols, inositol), enols.

36 Phenols, general properties. Quinones (*ubiquinone,).

37 Esters of inorganic acids, biological significance (nitrates, sulfates, phosphates, organophosphates).

38 Organic compounds of sulfur (thiols, alkyl sulfides, sulfonic acids).

39 Reactions of carbonyl compounds, biologically important aldehydes and ketones (acetone, pyridoxal, malondialdehyde, allysine, *retinal, the biochemical term "ketone bodies").

40 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.

41 Carboxylic acid derivatives (acid anhydrides, mixed anhydrides, esters, thioesters, amides).

42 Derivatives of carbonic acid (carbamates, urea, guanidine, creatine, phosphocreatine, creatinine, arginine).

43 Aliphatic and aromatic hydroxy acids (structures and names, products of oxidation, lactones).

44 Oxo carboxylic acids of biochemical importance, the term ”ketone bodies“.

45 *p*-Aminobenzoic acid, the relation of PABA to folic acid. The principle of sulfonamides action.

46 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).

47 Amines - general properties, basicity, reaction with aldehydes and ketones, origins of amides, oxidative deamination of amines.

48 Biogenic amines, catecholamines, phenethylamines.

49 Quaternary ammonium salts exhibiting biological significance (choline, *myorelaxants, carnitine, cationic surfactants).

50 Derivatives of pyrrole, pyrrolidine, indole (porphin, *porphyrins, haem, proline, tryptophan and derivatives of it).

51 Imidazole, thiazole, and their derivatives (histidine and histamine, *biotin, *thiamine)

52 Derivatives of pyridine (pyridoxal phosphate, nicotinic acid, nicotinamide).

53 Pyrimidine derivatives (bases in nucleosides, *thiamine,).

54 Purine and its derivatives (purine bases, uric acid, allopurinol, methylxanthines).

55 Pteridine, isoalloxazine and derivatives (*biopterin, *folic acid, *riboflavin).

56 Monosaccharides - definition, chirality in monosaccharides (expressing the configuration by Fischer projection), epimers, trivial names and the configurations of the most important monosaccharides.

57 Cyclic forms of monosaccharides (anomers, Haworth projection formulas, conformation formulas of pyranoses).

58 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).

59 Formation of glycosidic bonds, glycoside types (O-, N-, and ester glycosidic bonds).

60 Amino sugars (general structure, nomenclature, N-acetylation, importance for heteropolysaccharides, and deoxy sugars (general structure, D-deoxyribose as a constituent of nucleosides).

61 Disaccharides (reducing, non-reducing, structures, properties).

62 Homopolysaccharides (starch, glycogen, cellulose, inulin, dietary fibre).

63 Heteropolysaccharides (constituents, common types of *glycosaminoglycans).

64 Nucleosides - structures, nomenclature.

65 Nucleotides - structural types (nucleoside triphosphates, cAMP, NAD^+, FAD, coenzyme A).

66 Characterization of deoxyribonucleic acid structure (polarity of strands and bonds, B-form of the DNA double-helix, base pairing, denaturation and hybridization).

67 Main classes of RNA molecules, characteristics of the structures and of the functions (stems and loops, description of the *tRNA).

68 Fatty acids (saturated, unsaturated, essential acids). Eicosanoids.

69 Triacylglycerols, properties, structure, products of hydrolysis, fats and oils in the nutrition.

70 Glycerophospholipids, structural classes, differences in polarity, significance.

71 Sphingophospholipids, glycolipids (neutral and acidic types, components, group names).

72 Steroids, the basic structure, numbering of carbon atoms, stereochemistry; cholesterol, bile acids, steroid hormones.

73 Twenty standard amino acids, classification based on chemical structure and polarity of a side chain. Ionization and the pH value, isoelectric point.

74 Proteins, qualitative differences between peptides and proteins, levels for characterization of the structures, three main classes of proteins (globular, fibrous, and membrane proteins).

75 Primary and secondary structures of proteins (definition of the terms, types of bonds).

76 Tertiary and quaternary structures of proteins (definition, stabilizing bonds, super-secondary motifs and domains, stability versus flexibility of the native protein conformations, protein denaturation).

77 Properties of proteins - solubility, ionization, salting out, denaturation, precipitation.

78 Hydrophilic vitamins.

79 Lipophilic vitamins.

80 Ceramic materials, metals and their melts in dental medicine – see lecture

81 Macromolecular compounds a plastic materials in dental medicine – see lecture