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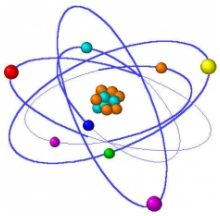
BIOGENIC S, P, D-BLOCK ELEMENTS, BIOLOGICAL ROLE, APPLICATION IN MEDICINE

Teaching and methodical manual

for foreign students of Zaporozhye State Medical University



Zaporozhye, 2015

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It is recommended by Methodic commission on chemical sciences as a textbook for students of medical faculty (Minutes №3, 27.11.2014).

Reviewers:

Aleksandrova E.V. PhD, Professor, head department of biochemistry and laboratory diagnostics of Zaporozhye State Medical University;

Priymenko B.A. PhD, Professor of organic and bioorganic chemistry department of Zaporozhye State Medical University.

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CONTENTS

PREFACE

Medicinal Chemistry is one of the most rapidly developing areas within the discipline of Chemistry, both globally and locally. It is the study of the design, biochemical effects, regulatory and ethical aspects of drugs for the treatment of disease.

The aim of this discipline is to produce graduates with an appropriate background in biology and pharmacology, built upon a strong chemistry foundation.

Methodical recommendation of Medicinal Chemistry is designed to equip students with strong grounding in biological and chemical technique which is relevant to the pharmaceutical world.

The discipline gives an in-depth coverage of the chemical techniques required and relates these to the relevant pharmacology, anatomy, biochemistry and molecular biology.

The whole course of Medical chemistry which consists of ten topics is studied by students-physicians during the first year. Lecturer staff of department has prepared an educational and methodical recommendation in which the theoretical material is stated in the concise and available form.

The distribution of material on each of ten topics that are studied is set according to training program, the thematic plan of lectures and practical training.

The material of each topic is stated in such way that performance of practical work and the solution of situational tasks are preceded by theoretical part in which questions of medicine and biological value and also connection with other disciplines (biological chemistry, normal physiology, pathophysiology and others) are included.

Offered laboratory works and situational tasks will give students the chance to understand theoretical material fully and to use this knowledge in practice.

The experience of teaching medical chemistry shows that it is not always possible to coordinate an order of laboratory works realization with sequence of lecture course statement. That is why students usually have to prepare for practical work performance independently before the lesson. Therefore the theoretical part (in which the necessary volume of knowledge for conscious performance of experiment is given) precedes to each section of these Methodical recommendations.

Increasing of level of seminar and laboratory works is reached by use of such forms of occupations which open and consolidate theoretical knowledge, train scientific thinking, develop creative initiative and impart skills of handling devices and chemicals, chemical ware.

The structures, figures and schemes are clear and easy to follow and color is used well, highlighting main points without being distracting.

Chapters are helpfully signposted throughout, informing the reader how topics are related, which is especially important in such a multidisciplinary subject.

Topics are also presented clearly and with a logical progression culminating in the main points, questions and reading sections at the beginning of each chapter.

An assortment of case studies is provided and the authors work through each one in great detail, giving an overall perspective on the science.

Finally, very useful and informative appendices and a glossary are provided together with a comprehensive index that is good enough to rival any search engine!

There are many books that describe medicinal chemistry and its uses, but these methodological recommendations present medicinal chemistry and its related topics in a clear, informative and interesting way that really demonstrates the application and impact of this fundamental subject in society.

INTRODUCTION

Purpose: to form the system of students' knowledge about physical-chemical and biological properties of s-, p-, d-block elements, their most important compounds which are used in medicine, as well as to develop logic and depth of thinking, ability to work with literature, chemical glassware and reagents.

Targets:

- To learn general characterization of s-, p-, d-block elements.

- To get an idea about atoms' structure and main properties of s-, p-, d-block elements and their connections.

- To learn biological role and application of most important connections of s-, p-, d-elements in medicine.

- To get practical skills in experimental work on the definition of biogenic elements.

- To learn test material

The student should know:

-Basic theoretical issues about biogenic s-, p-, d-block elements, namely atom structure, position in the Mendeleev's periodic table;

-biological properties of these elements and their compounds;

-the basic analytical methods of determination for biogenic elements;

The student should be able to do:

- to use the chemical glassware correctly;

- to use analytical reagents for qualitative analysis;

-to determine the cations of biogenic metals and anions of salts;

-to assess the received analytical results correctly.

CONCISE THEORETICAL MATERIAL

1 s-Elements. Biological role, application in medicine.

Elements of IA-group Li, Na, K, Rb, Cs, Fr, elements of IIA-group, Be, Mg, Ca, Sr, Ba, Ra as well as hydrogen and helium belong to the block of s-elements. The electronic formula of the external shell of IA-group elements and hydrogen is ns^1 and of the elements of IIA group and helium - ns^2, where "n" is the number of the period.

Chemical properties of s-elements of IA and IIA-groups are similar. s-Block elements easily give their valences-electrons, which means that they are strong reducers. Stable ions with an external electronic shell of the previous inert gas are formed by losing their s-electrons.

Radiuses of the ions increase in groups by growth of the atomic number of an element and decrease at transition from IA to IIA-group. The closeness of ionic radiuses of Li^+, K^+, Ba^{2+} plays an important role in the biochemistry of these metals.

S-Block elements are characterized by small ionization energy at big radiuses of atoms and ions. Mainly s-elements form compounds with ionic bonds, except of hydrogen, whose connections even with the elements with the greatest electronegavity is characterized by a covalent bond.

Hydrogen is the first element of the periodic table of elements. Fraction of total mass of Hydrogen in the Earth's crust is 1%-this is the 10th most prevalent element. However, its role in nature is not determined by the weight, but by the number of atoms, which amount among other elements is 17% (second place after oxygen-52%).So the importance of hydrogen in chemical processes occurring on the Earth is as great as the importance of Oxygen. Almost all hydrogen on Earth exists in the form of compounds and only very small number of hydrogen is contained in atmosphere in form of a simple substance (0.00005% in volume).

Hydrogen is a part of almost all organic substances and is present in all living cells. In living cells the number of atoms of hydrogen is nearly 50%.

Hydrogen is used in such industries as: chemical industry (production of ammonia, methanol, soap and plastic), food industry (registered as a food additive E949), and aviation industry.

Electron configuration of atoms of hydrogen is $1s^1$. Hydrogen similar to alkaline metals is univalent and has reducing properties. Hydrogen has three isotopes: protium ${}^1_1H$, deuterium ${}^2_1H$ and tritium ${}^3_1H$.

Hydrogen concentration in the human body is approximately 10%, that comparing to its content in the Earth's crust (1%) demonstrates its exceptional role in the human body. In human organism hydrogen exists in the form of different compounds, for example water.

Sodium, potassium.

Na^+ and K^+ ions are always togetherin the geosphere and their separation is a difficult process, on the contrary in the biosphere these ions are distributed on different sides of the cell membrane as they relate to the extracellular (sodium) and intracellular (potassium) cations.

These ions continuously move on ion channels in both directions, down a concentration gradient. This is the movement from a region of high substance density (prevalence) to a region of low density (prevalence).Such process can't proceed spontaneously, that is why the energy for it is reported by reaction of ATP hydrolysis. K^+penetrates into cells thanks to affinity to the protein membrane - phosphoprotein. ATP hydrolysis takes place in a cell with the formation of ADF (adenosine diphosphate acid), the released PO_4^{3-}-group phosphorylate phosphoprotein, and it "releases" K^+ ion into intracellular space. As a resultphosphorylated phosphoprotein has an increased affinity for Na^+ ion, it captures the ion and "goes" with it outside, where "releases" the ion into the extracellular space. This is one of the simplified work schemesof sodium-potassium pump, whose main task is to maintain the balance of potassium and sodium in all systems of the body. Firstly, this balance provides the maintenance of required osmotic pressure in bioliquids, which is the driving force of all absorption and excretion processes; Secondly, this balance keeps pH

values of each organ and tissue. Thirdly, sodium and potassium play a very important role in the transmission of nerve impulses.

By "ionophore" mechanism the K^+ ions fall into the central cavity of the lipid membrane, which is about 1 nm in diameter and contains hydrated K^+ ion. Polypeptide spiral, which forms this cavity, has an electrostatic charge which is able to keep suchnumber of K^+ ions, that corresponds to approximately 2 mol/l concentration. Then the central cavity is compressed and turns into a narrow channel-filter, which omits only already dehydrated K^+ ions. This filter has 4 places to link K^+thanks to peptide groups C=O, and the coordination number of K^+ is equal to 8.In the same conditions the Na^+ions are not associated, that provides the selectivity of cavity to K^+in 104 times.

It should be noted that the ions of Rb^+ and Cs^+can be linked by carbonyl groups in a membrane cavity that allows to use them as probes in the study of cell membrane channels. Whenlinking K^+ the internal charge of the cavity changes and it lets in and lets out K^+ ions from a cell.

It is possible to explain the action of sodium-potassium pump differently, considering ability of cellular membranes "to be turned inside out" at a change of an electrostatic charge on its surface.

Magnesium, calcium

Inside the cell the amount of Mg^{2+} is many times more, than in the extracellular space, whenCa^{2+} is predominantly extracellular cation. Mg^{2+}ion is a stronger complex former than Ca^{2+} ion. It serves as the center of some metal-enzymes, for example, catalyzes animportant hydrolysis of ATP. Magnesium complex with ATP is a part of substrate kinase enzyme responsible for the transfer of phosphate groups. Kinases are controlled by calmodulin and other proteins and are the basis of the signal system in higher organisms.

In the plant world Mg^{2+} is the part of coordination centre of two main enzymes that control such global process as photosynthesis, which is to make H_2O and CO_2 into carbohydrates and O_2 by the influence of light energy. In photosynthesis, which can occur in the dark (so-called "dark phase"),

magnesium is the center of the enzyme containing ribulose-1,5-diphosphate-carboxylate, which is called rubisko. This enzyme is very common in biosphere and controls the binding of atmospheric CO_2 (~ 1011 tons per year!). In the original form of enzyme the Mg^{2+}ion (with coordination number equal to 6)coordinates carboxyl groups of glutamic and aspartic acids, 3 molecules of water and the residue of lysine carbamate.

By the way carbamate is formed by the reaction of the original CO_2 portion with the terminal amino group of lysine, so already present CO_2 "runs" the mechanism of photosynthesis.

The content of Ca^{2+} in the body is ~1%, calcium- is the fifth element on prevalence after C, H, O, N. In mammals organism 95% of calcium is placed in solid tissues: bones and teeth, where it exists in the form of fluorapatite $Ca_5(PO_4)_3F$ and hydroxyapatite $Ca_5(PO_4)_3OH$; in birds and shellfish organisms it exists in the form of $CaCO_3$. In the blood vessels and arteries, calcium is present in the form of $CaCO_3$ or the complex with cholesterol.

Ca^{2+} ions form not very strong coordination compounds, have low values of formation constants and variable coordination number (6 and 8), have moving coordination sphere, as well as the high speed exchange of ligands. Therefore, calcium complexes are suitable for signal systems, regulate the reduction of muscle fibers, activate many enzymes, and define the process of blood clotting.

The concentration of Ca^{2+} in the body is regulated by parathyroid hormone - kalcitocin and its absorption is determined by the content of vitamin D in the body. The lack of this vitamin decreases the absorption of Ca and manifests itself in the form of the rickets disease. Ca is an extracellular element; its concentration in the cell is small: ~ 10-7 mol/l, and outside the cell~ 10-3 mol/l, a concentration gradient is maintained thanks to Ca-pump.

The most studied Ca-containing enzyme is calmodulin. It activates a protein kinase, catalyzes the protein phosphorylation, activates Fe-containing enzyme NO-synthase. In calmodulin Ca^{2+} ion has a coordination number equal

to 6 and is surrounded by three monodentate carboxyls of asparagin acid, a bidentate fragment of glutamin acid and a water molecule.

2. P-block elements. Biological role, application in medicine.

30 elements of IIIA-VIIIA group of the periodic system belong top-elements; the p-elements enter into (II) and (III) short periods, as well as in the V-VI big periods. Elements of III-A group have one electron on the p-orbital. In other groups IVA-VIIIA there is a consecutive filling of the p-sublevel to 6 electrons.

Among p-elements there are elements that can be both cations and anions (A1, Ca, Ti, Se, Pb, PB, Sb, Bi) or only anions (B, C, Si, N, P, As, O, Te, P, CI, Br, I, At). All cations, except $A1^{3+}(1s^2 2s^2 2p^6)$have a structure of external electronic shell $(n-1)d^{10}ns^2$, where n is the number of period. Increased stability characterizes external electronic shell of elements of VI period because $6s^2$electrons are preceded by$4f^{14}5d^{10}$electrons, which shield the nucleus.

In the period from left to right atomic radiuses of p-elements decrease with the increase of nuclear charge andincrease with the increase of ionization energy(E_I) and electron affinity (E_a); electronegativity (EN) increases and oxidative activity of simple substances and non-metallic properties become stronger. In groups with the increase of sequence number the radius of atoms and ions also increases. Ionization energy in transition from 2p-elements to 6p-elements decreases. With an increase of number of p-element in the group the non-metallic properties become weaker, and metal properties become stronger. The properties of p-elements and their compounds are influenced both by the appearance of new sublevels in the external electronic shell and by the filling of sublevels of internal electronic shells. Properties of p-elements of the second period B, C, N, O, P differ from the properties of elements of other periods. So, starting with the p-elements of the third period, we receive free p-sublevel, on which electrons from 5s-sublevels can move to (when atoms are excited). Fully

filled 3p-sublevel of p-elements of the fourth period makes them distinctive from elements of the third period.

In the period from the left to the right the ability of p-elements to form positive ions with charge, corresponding to the number reduces, and ability to form negatively charged ions with a charge equal to the difference (8-group number)increases. Some p-elements form diatomic molecules $E_2$with varying resistance. The most stable diatomic molecules are molecules of the elements of the second period. When we move from IVA to IIIA and VA-groups the resistance of molecules increases, and then when we move to the VIIA-group the resistance decreases. In groups from top-to-bottom the strength of E-Ebond decreases.

P-elements of II period, namely nitrogen, oxygen and fluorine have shown a strong ability to participate in the formation of hydrogen bonds.

The elements of II and following periods loose this property. The similarity between p-elements of III period and p-elements of following periods consists mostly only of the outer shells structure and of valence states that appear from unpaired electrons in excited atoms. Boron, carbon and nitrogen in particular are very different from the rest of elements in its subgroups. When moving from p-elements of the II to III and following periods all link types, that characterize elements of the II period are saved and also more diverse types of chemical bonds appear. This increases both the ability of cells to form complex compounds and the value of coordination number. So if p-elements of the second period have the coordination number equal to 2, 3, 4, the p-elements of following periods may have coordination number equal to 5, 6, 7, 8 or even 12.In the group down wards the resistance of maximum positive oxidation states for p-elements increases and the resistance of lower degrees of oxidation decreases. So, for example, for carbon oxidation resistant is +4, +2 for the lead, +3 for aluminium, and -1 for thallium.

Physical properties of simple substances of p-elements differ significantly, in groups and periods the difference is not monotonic. The nature of these

changes is not always easy to associate with the structure of electronic shells of atoms, a type of chemical bond, coordination number.

So, the differences of the properties of p-elements both within the group and period are significantly bigger than of the s-elements. All p-elements and especially p-elements of II and III periods form numerous connections between s-, d-and f-elements. Most of known on earth connections are connections of p-elements.

Boron is an impurity microelement. It is known that boron is a part of teeth and bones, probably in the form of poorly soluble salts of boric acid. Excess of boron is harmful for the human. There are some facts that large excess of boron inhibits amylase, proteinase, reduces the activity of adrenaline. The decline of adrenalin activity, which is a derivative of polyphenol, is connected with its interaction with boric acid.

It was known long time ago that higher plants need boron, but data on its biological role is controversial. Studies in recent years have shown that boron is an essential element for some animals. It was found that boron is involved in carbohydrate-phosphate exchange and works with a number of biologically active compounds (carbohydrates, proteins, vitamins, hormones). However, consumption of foods with high content of boron violates the exchange of carbohydrates and proteins, which leads to endemic enteric diseases-enteritis.

Aluminium, same as boron, belongs to impurity microelements. Daily intake of aluminum for an adult is 47 mg. Aluminum affects the development of epithelial and connective tissues, bone regeneration, exchange of phosphorus, enzymatic processes. Al^{3+}mostly replaces the E^{2+}ions, which are enzyme-activators, such as Mg^{2+} and Ca^{2+}.

Such substitution is possible because of some properties similarity of Mg^{2+} and $A1^{3+}$, Ca^{2+} ions. For example, $Mg^{2+}$and $A1^{3+}$ ions have equal radii and similar coordination number equal to 6. The $A1^{3+}$ and Ca^{2+} ions have equal ionization energy (IE = 12.2 kJ/mol) and similar coordination number equal to 6.

An excess of aluminium in the body inhibits the synthesis of hemoglobin, because due to relatively high complexing ability aluminium blocks the active centers of enzymes involved in blood formation. There are reports that aluminum can catalyze the reaction of transamination. Aluminum salts of oxygen-containing acids are water-soluble, except aluminium phosphate $A1PO_4$.

The formation of slightly soluble phosphate plays an important role in the life of organisms. Assimilation of phosphorus becomes weaker in the presence of Al^{3+}cations due to slightly soluble aluminium phosphate formation in the gut. In living organisms aluminum forms chelate complex compounds with **bioligands**, such as hydroxy acids, polyphenols, carbohydrates, lipids. Usually links with organic ligands occur via oxygen atoms.

Carbonhas a tendency to long homochain creation. Molecules containing links between two carbon atoms can have linear, branched and cyclic structure. Various organic molecules, that contain connected carbon atoms with various radicals, form a huge number of biomolecules. Having intermediate electronegativity, carbon forms less-polar connections with such vital elements as hydrogen, oxygen, nitrogen, sulfur, etc. Other elements of this group form links predominantly through the oxygen atom, and the lead links through sulfur.

The ability of lead to form links with sulfur determines its toxic effect (blocking protein sulfhydryl groups).

Carbon monoxide (CO)-carbon monoxide is a product of incomplete oxidation of carbon. Human is one of the main sources of CO, as the body produces and releases carbon monoxide into environment approximately 10 ml per day. This is the so-called endogenous carbon (II) oxide, which is formed in the process of hematopoiesis.

Penetrating into lungs with air, CO quickly passes alveolar-capillary membrane, dissolves in blood plasma, diffuses into red blood cells and interacts in the opposite chemical reaction with both oxyhemoglobin HbO_2 and hemoglobin Hb:

$$HbO_2+CO=HbCO+O_2$$

$$Hb+CO=HbCO.$$

Formed carboxyhemoglobinis not able to attach oxygen;as a result transport of oxygen from the lungs to the tissues becomes unable. High chemical affinity of carbon (II) oxide with bivalence iron is a major reason of hemoglobin interaction with CO. It should be assumed that other bio-organic compounds containing Fe^{2+}ions must react with CO.

Since the reaction of carbon monoxide with oxyhemoglobin is partially reversed, so the increase of partial O_2 pressure will accelerate the dissociation of carboxyhemoglobin and CO excretion from the body (the equilibrium is shifted to the left by Le Chatelier's principle).

At the moment there are drugs that are used as antidotes in poisoning the body with CO. For example, the introduction of reduced iron shortly accelerates the CO removal from the body in the form of a carbonyl iron. The action of this drug is based on the ability to act as a ligand in complexes.

Carbon dioxide (CO_2) is constantly formed in the tissues of the body during metabolism and plays an important role in the regulation of respiration and blood circulation. CO_2 is a physiological stimulator of respiratory centre. Big concentrations of CO_2(more than 10%) cause severe acidosis (the lowering of blood pH), choking and paralysis of the respiratory centre. CO_2solution is the carbonic acid.Salts solutions of it are the result of hydrolysis and have alkaline medium (pH>7), for example:

$$Na_2CO_3+HOH=NaHCO_3+NaOH$$

$$CO_3^{2-}+HOH=HCO_3^-+OH^-$$

Carbonate buffer system (H_2CO_3 + HCO_3^-) is the main buffer system of blood plasma, which provides support for acid-base homeostasis.

Silicon (silicium) is an impurity microelement. As natural silicum (IV) oxide is poorly soluble in water, so silicon falls into the human body not through the digestive tract, but with air through the lungs in the form of powdered SiO_2. The inhalation of dust containing SiO_2 leads to silicosis. The

metabolic disorder of silicon leads to hypertension, rheumatism, ulcers and anemia. It was found that silicium is located in the skin, cartilage, mucopolysaccharides, where it strongly connected with essential hydroxide groups of carbohydrates.

Unlike carbon, silicon in the composition of biomolecules is only connected with the oxygen atoms (bond Si—O), because the energy of this bond is significantly higher than the energy of bonds Si—H, Si—C, Si—S etc.

Metabolism of silicon and germanium in living organisms has mutual influence, due to the similarity of chemical properties of these elements. Germanium is present in soy beans, tea, aloe, ginseng. It also contains in some medicinal plants, especially those that have been used in the East folk medicine for a long time. Therefore, it was assumed that there is a link between the content of germanium in plants and their pharmacological properties. A wide range of biological actions (such as neurotropic, anesthetic, hypotensive, bactericidal, antifungal, antiviral, antiradiacion and antitumorial) of compounds, that contain Germanium has been noted.

On content in the human body (10^{-4} %) **tin (stannum)** belongs to microelements. Information about its biological role is inconsistent. Stannum is ingested from acidic foods preserved in the can, covered with a layer of tin. Stannum dissolves in acidic environment and enters the bloodstream providing toxic effect:

$$Sn+2HA=SnA_2+H_2.$$

However, in experiments on rats it was found that in small quantities stannum provides stimulating effect on their growth. This suggests the need of this element for a human. Certainly, the biological role of this microelement requires further study.

Lead (plumbum) and its compounds, especially organic one, are very toxic. Plumbum ions form gelatinous albuminates reacting with cytoplasm of microbial cells and tissues. In small doses plumbum salts show astringent effect, causing jellification of proteins. Formation of jelly prevents the penetration of

germs into the cells and reduces the inflammatory response. The effect of stannum washes is based on this action. With an increase of Pb^{2+} ions concentration the formation of albuminates becomes irreversible, albuminates of proteins accumulate in superficial tissues:

$$Pb^{2+} + 2R\text{-}COOH = Pb(R\text{-}COO)_2 + 2H^+.$$

Therefore, medicines of plumbum (II) are designated exclusively for external use, in case of being absorbed in the gastrointestinal tract or the respiratory tract, they exhibit high toxicity. Compounds of plumbum affect the protein synthesis, the energy balance of cells and its genetic apparatus. It was found that plumbum is one of those elements whose presence in food affects the development of caries.

There are numerous evidences that accumulation of plumbum in plants, in the tissues of animals and humans body is a result of environmental plumbum pollution. With food, water, air man daily absorbs up to 100 micrograms of plumbum. Plumbum deposited in skeleton (up to 90%) in the form of hard dissoluble phosphate $Rb_3(RO_4)_2$.

Mass fraction of plumbum in human body is 10^{-6}%. It's safe to intake 0.2 - 2 mg per a day.

Ions of Pb^{2+} are more active complexants comparing to other cations of 4th A group. They form stable complexes with bioligands. Pb^{2+} ions are able to interact with sulfideSH-groups of protein molecules of enzymes and block them:

$$R\text{-}SH + Pb^{2+} + SH\text{-}R = RS\text{-}Pb\text{-}SR + 2H^+$$

Ions of Pb^{2+} are involved in the synthesis of Porphyrins which control hemoglobin synthesis, and other biomolecules. Ions of Pb^{2+} may displace other cations Me^{2+}, inhibiting the metal-enzymes.

So, p-elements of the 4th group considerably differ from each other both on content in the human body and biological effect. Macroelement carbon plays central role in the life of organisms; microelement silicon, probably, is vital;

microelement germanium may perform physiological role in the body, while the stannum and, especially, plumbum are toxic elements.

Nitrogen belongs to macroelements. However, few organisms are able to absorb gaseous nitrogen.

Plants can use soluble nitrates as a source of nitrogen and animals need ammonia and amino acids. With the absorption of nitrogen by plants, soil depletion becomes a problem. Therefore, already at the beginning of the 20th century due to the need to amend the soil with nitrogenous fertilizers, measures have been taken to use air for nitrogen compounds, called nitrogen fixation.

The synthesis of ammonia from nitrogen and hydrogen is the main way to link atmospheric nitrogen. However, this method of nitrogen fixation is quite energy-intensive, therefore, it's expensive. That is why many scientists explore the possibility to link atmospheric nitrogen by using a variety of complex compounds.

It's interesting in the biological aspect, that one essential property of nitrogen is it's solubility in water, which is similar to oxygen. The presence of excess nitrogen in blood can cause the development of decompression sickness.

With the rapid rise of divers a rapid drop of blood pressure happens – so it decreases the solubility of nitrogen in blood (Henry's law), and the bubbles of nitrogen coming out of blood, occlude small blood vessels. This can lead to paralysis and death.

Together with oxygen, hydrogen, and carbon nitrogen forms a vital link - amino acids, which are bio-organic substances that serve as building blocks for the formation of proteins - the basics of life.

Ammonia itself in human body is one of the metabolism products of amino acids and proteins that income with food, or present in cells as a storage material. The reason of ammonia toxicity on the brain has not been already determined. In blood at pH = 7.4 ammonia is almost entirely present in form of ammonium ions. Ammonium ions, despite the fact that they are present in blood

in great excess, cannot pass through the cell membrane, while the neutral NH_3 molecules easily pass through the membranes and can affect the brain.

Some nitrogen compounds with oxygen are toxic. The production of nitric acid and some other substances produces nitrous gases which are a mixture of nitrogen oxides: NO, NO_2, N_2O_4, N_2O_3. These gases contacting with wet surface of lungs form nitrous and nitric acids that affect the lungs, leading to edema and other disorders. Nitrogenous poisoning of blood by gases also forms nitrates and nitrites.

Nitrites were recently added as conservants in sausages and other meat products. Although conservants are added in small amounts, there is a perception that they are dangerous for human. One of the reasons of poisonous properties of nitrous acid and nitrites is that they are deaminating agents, promoting the oxidation of amino groups of nucleic bases. Particularly strong impact is made by nitrous acid, which is formed from organic precursors, for example, nitrosamines and nitro compounds. This changes the structure of the nucleic DNA bases and their ability to form hydrogen bonds, so DNA damage is occurred.

Toxic effect of nitrite is manifested in the fact of transforming hemoglobin into methemoglobin, which is unable to bind and transport oxygen:

$$HbFe^{2+} + NO^{2-} + 2H^{+} = HbFe^{3+} + NO + H_2O$$

Methemoglobin is formed under the action of oxidants: oxides of nitrogen, nitrite, and aniline. Blood methemoglobin can also increase when some hemoglobinopathies associated with hereditary lack of reductase enzyme, which restores the methemoglobin to hemoglobin. In addition, methemoglobin is formed if to take high doses of certain drugs, for example, sulfonamides.

Up to the norm a small amount of methemoglobin can spontaneously form in erythrocytes, but the action of reductase restores it. Blood plasma and urine become brown in case of toxic methemoglobinemia.

Methemoglobinemia is treated by methylene blue or ascorbic acid that restore it into hemoglobin.

You can prevent death from lack of oxygen by the timely increasing of partial oxygen pressure that means inhalation of pure oxygen.

So, getting into the bloodstream, nitrites cause oxygen deficiency. However, in very small quantities, some inorganic nitrites (connection type R—O—N=O) and organic nitrates (R—O—NO_2) improve coronary circulation and are used to prevent coronary heart disease and to stop the strokes (glycerol trinitrate, etc.).

On content in human body **phosphorus** as nitrogen refers to macroelements and plays an important role in metabolism. Living organisms cannot live without phosphorus. The value of phosphorus is that monosaccharides and glycerol cannot be used by cells as a source of energy without prior phosphorylation.

Exchange of phosphorus in the body is closely linked to the exchange of calcium. This is confirmed by the decrease of inorganic phosphorus while the increase of calcium content in blood (antagonism). Human daily need for phosphorus is 1.3 g. Phosphorus is so common in food that its apparent failure (phosphate starvation) is virtually unknown. However, not all phosphorus contained in foods can be assimilated, as it depends on many factors: pH, the ratio of calcium and phosphorus in the diet, the content of fatty acids in food, but primarily from the vitamin D content.

From the biological point of view bioinorganic diphosphorus acid derivatives $H_4P_2O_7$ and uncommitted in a free form triphosphoric acid $H_5P_3O_{10}$ are extremely important. These are adenosine diphosphate acid (ADP) and adenosine triphosphate acid (ATP). At pH 7.4 ATP and ADP exist almost as ATF^{4-} and ADP^{3-}anions, which means that their phosphate groups are fully ionized. Many biosynthesis reactions occur due to the transfer of phosphate groups from high-energy to a low-energy acceptor.

Similar to polyphosphoric acids anions ATP $^{4-}$ and ADP^{3-} can be hydrolyzed. As a result of interaction with one water molecule ATP^{4-}anion hydrolyses into ADP^{3-} and hydrophosphate HPO_4^{2-}ion. ADP and ATP form

complex salts with cations of metals. Thus, in intracellular fluid ADP and ATP are present mainly in the form of magnesium complexes: $MgATP^{2-}$ and MgADP. In enzymatic reactions of phosphorylation, in which ATF participates as a donor of phosphate group, the complex of $MgATF^{2-}$ is an ATP active form.

Phosphate buffer system is one of the main buffer systems of the blood (HPO_4^{2-}+ $H_2PO_4^-$). It should be noted, that certain organophosphorus compounds containing the C-P bond, are strong poisons, that comprise into chemical warfare agents. Used as pesticides. White phosphorus is toxic due to its high solubility in fats, and thus the ability to penetrate through the cell membrane, as well as its highly reactive activity. The rest of the allotropic modifications of phosphorus due to their insolubility are non-toxic.

Arsenic is toxic in the extent of oxidation +5, unlike the phosphorus, which is toxic only in phosphorus (III) compounds. This is caused by the fact that human body easily recovers arsenic (V) to arsenic (III). Mechanism of arsenic toxic effects is explained by its ability to block sulfhydryl groups of enzymes and other biologically active compounds.

In addition, arsenic replaces iodine, selenium, phosphorus. Breaking the biochemical processes of metabolism in the body, it is the antimetabolite of these elements. The lethal dose for human is about 0.1-0.3g of arsenic. In the acute poisoning by arsenic (III) oxideAs_2O_3 death occurs in approximately 70 hours.

Arsenic is accumulated in bones and hair for several years and doesn't output to the end. This feature is used in forensics to determine the issue of poisoning by arsenic compounds. Determination of arsenic in biological material is carried out by the Marsh's reaction. Marsh's reaction is very sensitive and allows to define 7×10^{-7}g of arsenic.

Arsenic compounds not only kill, but also help. As_2O_3 is used externally to treat skin diseases. In dental practice $As_2O_3$is applied for necrosis of soft tissues of the tooth. In addition, this drug is prescribed in microdoses (0.001g per reception) for the treatment ofanemia, exhaustion, nervousness. It's an

interesting fact that, the body can get used to As_2O_3 if its introduced gradually, increasing the dose. In clinical practice, other arsenic compounds, such as Na_2HAsO_4 are also used.

The physiological role of **antimony (stibium)**, obviously, is similar to arsenic. Arsenic As^{3+} ions, antimony Sb^{3+}ions, and in lesser extent Bi^{3+}ions are synergistic. So, it is known that in biogeochemical provinces with the excess of arsenic, there is an increase of not only arsenic, but also antimony in the organism. While both elements are accumulated in the thyroid gland, they inhibit its function and cause goiter.

Synergism of arsenic and antimony is determined by their ability to form compounds with sulfur ligands. Water-soluble compounds of antimony, falling into the body, show toxic effect, which is similar to the action of arsenic compounds. Bismuth reacts more with ligands, thatcontain NH_2 group. Thus, bismuth compounds inhibit enzymes of amino- and carboxypolipeptidaze. Water-soluble compounds of bismuth are toxic. For example, for dogs lethal dose is 6 mg per 1 kg of mass. However, getting into digestive tract, most compounds of antimony and bismuth practically do not show toxic actions. The reason of this is the fact that Sb(III) and Bi (III) salts in the digestive tract are subjected to hydrolysis with the creation of soluble products which are not absorbed through the tunicof gastrointestinal tract.

Comparing biochemical properties of elements of VA group, we can make following conclusions. Nitrogen compounds with carbon and hydrogen in biomolecules; phosphorus is linked via oxygen; arsenic, antimony and bismuth-through oxygen and sulfur. This leads to the lack of mutual substitution of nitrogen and phosphorus, as well as the lack these elements substitution of by arsenic, antimony and bismuth. Nitrogen and phosphorus are essential elements for all living organisms. Perhaps arsenic can be an indispensable element, at the same time the necessity ofantimony and bismuth for living organisms is unknown. Arsenic, antimony and bismuth are synergistic, they block sulfhydryl groups of bioligands, and in large doses they are very toxic. At the same time

positive biological role of arsenic micro amount suggests that antimony and bismuth may be in one or another way useful for living organisms.

Oxygen refers to macroelements. It is an indispensable element and is one of the most important elements that form the basis of living systems. Oxygen is a part of all vital organic substances: proteins, fats, carbohydrates. Many essential life processes are impossible without oxygen, for example, respiration, the oxidation of amino acids, fats, carbohydrates. Only few microorganisms, called anaerobic, can live without oxygen. In the organism of higher animals, oxygen enters the bloodstream, connects with hemoglobin, forming oxyhemoglobin, which is easily dissociated. With the blood, this compound goes into the capillaries of various organs. Here oxygen rifts from hemoglobin and diffuses into tissues through tunicas capillaries. The link between hemoglobin and oxygen is unstable and is carried out by donor-acceptor interaction with Fe^{2+} ion.

Thanks to donor-acceptor interaction with ions of Fe^{2+}, Cu^{2+} oxygen forms such complexes as $Hb(Fe^{2+})O_2$, $He(Cu^{2+})O_2$, where Hb -hemoglobin, He - hemocyanin. Having two unseparated pairs of electrons, oxygen acts in these coordination compounds as a donor.

At rest person inhales roughly $0.5m^3$ of air per hour, but only 1/5 of inhaled oxygen is contained in the body. However, the excess of oxygen (4/5) is required to create high concentrations in blood, which provides sufficient oxygen diffusion rate through the tunic of capillaries. Thus, a person actually takes about $0.1m^3$ of oxygen per a day. Oxygen is used for oxidation of various substances in the tissues. These reactions eventually lead to the formation of the main products of metabolism: carbon (IV) dioxide, water and energy (-2888 kJ/mol).

Phagocytic (protective) functions of the body are also associated with the presence of oxygen. The reduction of oxygen content in the body decreases its protective properties. In phagocytes (cells that can capture and digest foreign particles) O_2 is restored to superoxide anion radical O_2^-:

$$O_2+e^-= O_2^-.$$

O_2 initiates the radical-chain oxidation processes of foreign organic substances RH, captured by phagocytes:

$$O_2^- +HOH=HO_2 + OH^-$$

$$HO_2^- + RH=R\text{-}O\text{-}O^* +H_2$$

With a lack of oxygen, these processes are slowed down; as a resulted resistance of organism to infections is decreased.

Oxygen is used for inhalation in conditions involving oxygen deficiency (hypoxia), diseases of respiratory system, cardiovascular system, carbon (II) monoxide and hydrocyanic acid poisoning.

Ozone O_3 is an allotropic modification of oxygen. A small impurity of it in the air creates a feeling of pleasant freshness and beneficial effect on human, particularly pulmonary patients. Applying oxygen O_2 and ozone O_3we should take into account their toxicity due to the intensification of oxidation processes in the body.

Oxidative effect of ozone on organic substances is associated with the formation of radicals:

$$RH + O_3 =RO_2 +HO^*$$

RO_2radicals and HO initiate radical-chain reactions with bioorganic molecules, such as lipids, proteins, and DNA. Such reactions lead to the damage and cell death. Ozone kills microorganisms in air and water. This is the base of ozone usage in sterilizing drinking water and water of swimming pools.

The most common oxide on the Earth is oxide of hydrogen (water). Over 70 years of life a person drinks about 25000 kg of water. Thanks to the unique structure of molecules water has its own properties. It is the solvent of organic and inorganic compounds involved in the ionization of molecules of dissolved substances in a living organism. Water is not only the environment for biochemical reactions, but it is also intensely involved in hydrolytic processes.

Sulfur is a macroelement. It is vital element, like oxygen. A daily requirement of sulfur for an adult is 4-5g. Sulfur is included in many

biomolecules: proteins, amino acids (cysteine, cystine, methionine, etc.), hormones (insulin), vitamins (B). A lot of Sulfur is contained in hair, bones, nervous tissue.

A number of proteins containing cysteine and an important coenzyme A (which includes the p-aminoetanol) have sulfide (thiol) group-SH and behave like bioorganic derivatives of hydrogen sulfide. Some photosynthetic bacteria, for example green sulfur bacteria, use hydrogen sulfide as a source of hydrogen donor:

$$2H_2S+CO_2 = CH_2O + HOH + 2S$$

(This reaction is occurred in the light with the help of enzymes)

These bacteria emit sulfur, which is the oxidation product of H_2S. Hydrogen sulfide is a toxic substance, because it is an inhibitor of the enzyme cytochrome oxidase, which transfers electrons to the respiratory chain. H_2S inhibits the transfer of electrons with cytochrome oxidase on oxygen.

Sulfur oxides (IV, VI) also apply to toxic substances.

Oxide SO_2 primarily effect on the higher animals as an irritant of mucous membrane of the respiratory tract. This gas is toxic for plants. SO_2 compounds in the atmosphere in the industrial areas, where coal containing large amounts of sulfur is burned. Dissolving in water, which is on the leaves of plants, SO_2 forms a solution of sulphurous acid, which in it turn is oxidized to sulfuric acid H_2SO_4.

Atmospheric moisture with dissolved SO_2 and H_2SO_4 falls as acid rain, leading to the death of plants.

Selenium is a microelement. Selenium deficiency causes a decrease in the concentration of the Glutathione peroxidase enzyme which causes the oxidation of lipids and sulfur-containing amino acids. The active centre of Glutathione peroxidase contains the remainder of amino acids selencysteine. This enzyme together with the glutathione tripeptide protects cells from the ravages of organic peroxides ROOH and hydrogen peroxide H_2O_2. There is evidence that

selenium deficiency in the body prevent tissue necrosis by adding sodium gypsum $Na_2SeO_3$to the diet of rats.

On the content of human body chlorine (0.15%) refers to micronutrients and the other halogens are microelements (content 10-5%). Halogens in various forms of compounds are included in the human and animal tissue.

In human body **fluoride** weight is about 7 mg (5-10%). The shortage of fluoride in the organism causes tooth's decay. Mineral base of dental tissues - dentin – consists of hydroxylapatite $Ca_5(PO_4)_3(OH)$, chlorapatite $Ca_5(PO_4)_3C1$ and fluorapatite $Ca_5(PO_4)_3P$. Formation of hydroxylapatite can be expressed by scheme:

$5Ca^{2+} + 3HPO^{2-} + HOH = Ca_5(OH)(PO_4)_3 + 4H^+$.

Fluoride-ion replaces hydroxide-ion easily in hydroxylapatite, forming a protective layer of enamel of more solid fluorapatite:

$Ca_5 (PO_4)_3(OH) + F = Ca_5(PO_4)_3F + O^-$.

Moreover, fluoride ions facilitate the deposition of calcium phosphate, expediting the process of remineralization (crystal formation):

$10Ca^{2+} + 6PO_4^{3-} + 2F^- = 3Ca_3(PO_4)_2 + CaF_2$.

Caries begins with the formation of damaged area of enamel on tooth surface in the form of the spot. Under the action of the acids produced by bacterias, hydroxylapatite component of enamel dissolves:

$Ca_5(PO_4)_3(OH) + 7H^+ = 5Ca^{2+} + 3H_2PO_4^- + H_2O$.

Enrichment of drinking water with fluoride (water fluoridation) in order to transmit fluoride content to normal (1 mg/l), results in a significant decrease of the caries incidence, but an excess of fluoride is also harmful.

With increased content of fluoride in water tooth enamel becomes fragile and destroyed. A disease that occurs in this case is called fluorosis. In many biochemical processes fluoride act as inhibitor, blocking active centers of enzymes that contain Ca^{2+}, Mg^{2+} and other metal ions.

The human body contains about 100g of chlorine (0.15%). Gaseous Cl_2, which is a strong oxidant, is a poisonous substance which causes irritation of

the mucous membranes of eyes, nose, larynx and lung affection. Maximum allowable concentration of chlorine gas in the air is 0.001 mg/l. As for the biological role of the chloride ions, they activate some enzymes that create an favorable conditions for the action of proteolytic enzymes of gastric juice, involve in maintaining osmotic balance.

Cl^- is present in the body in macroscopic quantities. Hydrochloric acid is an essential component of the gastric juice; its mass fraction is about 0.3%. For derivation of hydrochloric acid in the stomach NaCl must be present (table salt). Hydrochloric acid forms as follows:

$$H_2CO_3 \text{ (blood)} + Cl^- = HCO_3 \text{ (blood)} + HC1 \text{ (stomach)}.$$

Hydrochloric acid of the gastric juice with pepsin is necessary for transfer of the inactive enzyme pepsinogen into the active form-pepsin. Pepsin provides digestion of proteins by hydrolytic cleavage of the peptide bonds.

Hypochloric acid is a strong oxidizing agent, germicidal and bleaching effects of chlorinated water are explained by its content. Atomic oxygen, which is produced by the decomposition of HC1O, discolors paints and kills germs. Hypochloric acid reacts with organic compounds RH:

RH + HClO = ROH + HCl;

RH + HClO = RCl + H2O

E.g. as oxidizer and as chlorinating substance HClO breaks down proteins, which are micro-organisms.

Mass of **bromine** in the human body is about 7 mg (5-10%). There is evidence, that bromine connections inhibit thyroid function and increased adrenocortical activity.

Central nervous system is most sensitive to the action of Br ions. The insertion of bromide ions into the body restores the disturbed balance between the processes of excitation and inhibition. They are easily absorbed in the gastrointestinal tract. Their toxicity is low, however, due to the slow removal from the body (30-60 days) they can accumulate that leads to the development of chronically poisoning, which is called "bromism".

Iodine is an essential element, and its compounds play an important role in the process of metabolism. Iodine affects the synthesis of some proteins, lipids, thyroid hormones and thyroxine. Iodine, in the same way as chlorine, replaces hydrogenous atoms at the nitrogen atoms in the proteins molecules of microorganisms, which leads to their death:

$$R\text{-}CO\text{-}NH\text{-}R_1 + I_2 = R\text{-}CO\text{-}NI\text{-}R_1 + HI$$

The human body contains about 25 mg (4-10%) of iodine. More than half of it belongs to the thyroid gland secretes hormones - thyroxine and triiodothyronine. Decreased activity of the thyroid gland (hypothyroidism) can be due to reducing its ability to accumulate iodide ions, as well as the lack of iodine in foods (goiter).

Analysis of the biochemical properties of halogens shows that bromine and chlorine are usually found in the body in the form of hydrated ions Br^-, Cl^- , fluorine and iodine in the related condition: iodine forms a connection with link C—I, and fluorine binds to metals (Ca, Mg, Fe).

On the physical-chemical characteristics and propensity for coordination with biogenic elements fluoride differs significantly from other halogens: it almost does not participate in replacement of ions of chloride, bromide and iodide. CI, Br, I are close in properties, and replace each other in the body, while exercising synergy and antagonism.

So, most of the elements of the p-block arenonmetals. They all can be a part of organic molecules and can participate in the creation of living tissue. The six elements (C, K, O, P, S, Cl) are found in the organism in big quantities, five (P, Sì. As, Se, I) are vital for human beings, Borium is essential for higher plants.

Bromine value to human is not fully understood. Metals that block elements are vital. Bismuth compounds are applied in medicine. However, most p-block metals have excessive toxicity. The most dangerous for human are plumbum compounds which are common in industry; they disrupt the normal

synthesis of porphyrin, which is necessary for further synthesis of hemoglobin and other hemoproteins.

3. d-Block elements. Biological role, application in medicine.

D-elements belong to the microelements. Metal microelements have certain common characteristics:

1) they are quite common, so are available for absorption from the soil;

2) they have high comprehensive ability in relation to various donor atoms, have different stable oxidation states and easily move from one stage of oxidation to other.

These macroelements are involved in the most important processes, that take place in cells:

1) enzymatic catalysis of reactions of synthesis and reactions of cellular energy;

2) transfer of electrons, ions, molecules and molecular enzymes;

3) regulate the activity of cell mechanisms and systems.

Free ions of d-metals don't exist in the body, most commonly in biochemical reactions d-elements take part in the form of bioinorganic complexes of metals.

Essential elements Zn, Cu, Fe, Mn, Co, Mo are called vitals metals.

Copper is an essential macroelement of plant and animal organisms. Currently, there are about 25 copper-containing proteins and enzymes.

The part of enzymes catalyzes oxygen interaction with the substrate. They are a part of a so-called oxygenase group.

There is a large group of copper-containing proteins catalyzing redox reactions with transfer of protons or electrons from the substance,which are oxidized to molecular oxygen (these are so-called oxidases). They are characterized by high affinity to oxygen, as well as the high value of redox potentials. Most important respiratory enzyme cytochrome oxidase (CHO), which catalyzes the final step of tissue respiration concerns to oxidases.

Ceruloplasmin (CP) ("blue" oxidase) is a very important cooper containing plasma protein of the blood of mammals. Performing the transport function the CP controls the balance of copper and copper excess excretion from the body.

There are known copper-bearing proteins, for example, superoxide dismutase (SOD), which accelerates the decomposition reaction of superoxide O_2^- ion. This ion enters into interaction with organic components of cells and destroys it:

$[SOD \bullet Cu^{2+}] + O_2^- = [SOD \bullet Cu^+] + O_2$;

$[SOD \bullet Cu^+] + O_2^- + 2H^+ = [SOD \bullet Cu^{2+}] + H_2O_2$.

Thus, the SOD translates the superoxide ion O_2 to hydrogen peroxide, which is relatively mild oxidant and decomposes rapidly in the body under the action of the enzyme catalase.

Copper with ferrum takes part in blood formation. At copper deficiency in the body iron exchange between blood plasma and erythrocytes is disturbed that can lead to the destruction of red blood cells. In experiments on animals it is shown that copper deficiency leads to severe changes in metabolism: copper anemia, exotic ataxy, etc. The human need for copper (2-3 mg/day) is totally ensured by food.

Wilson-Konovalov disease is associated with excess content of copper in the body. It’s believed that cooper excess forms as a result of the violation of the synthesis of ceruloplasmin and excess excretion of copper is not supplied with food.

In high concentrations, soluble copper salts are toxic. Copper (II) sulfate up to 2 g causes severe poisoning with possible fatal consequences. This is because copper forms an insoluble bioinorganic chelate-albumins with the protein, e.g. coagulate proteins.

Zinc is included in composition of more than 40 metal-enzymes, catalyzing the hydrolysis of peptides, proteins, certain esters and aldehydes. Permanent oxidation state defines its role in the reactions of non-electron transport hydrolysis.

One of the most studied is the zinc containing enzyme - carbonic anhydrase. This enzyme in erythrocytes and blood occurs in three forms, which differ in activity. The enzyme consists of about 260 amino acid residues and is a bioinorganic complex in which the coordination number of zinc is 4 (three coordinating places are taken by amino acid residues; the fourth one binds water (or OH group).

The availability of zinc in enzyme is a necessary condition of catalytic activity of carbonic anhydrase, which provides the hydration of CO_2:

$CO_2 + H_2O = H_2CO_3 = H^+ + HCO_3^-$.

Consensus on the mechanism of action of enzyme is not present. According to other sources zinc coordinates hydroxyl group, which is involved in the process of hydration (the mechanism of "zinc - hydroxide"):

$OH^- + CO_2 = HCO_3^-$

The other zinc containing enzyme - carboxypeptidase (CPD) exists in several forms, which vary in the number of amino-acid residues and molar mass. Carboxypeptidase is involved in reactions of peptide bonds hydrolysis. The mechanism of action of the CPD has also not been elucidated yet.

There are zinc enzymes involved in the hydrolysis of dipeptide, they are called dispeptidase. Zinc is a part of the hormone insulin, which affects blood sugar. The richeston zinc are meat, liver, milk, eggs.

Manganese is necessary for normal processes in animal and plant organisms. In the body manganese make complexes with proteins, nucleic acids (RNA and DNA) and amino acids. These complexes are a part of metal-enzymes (arginase, cholinesterase, etc.).

It is proved, that participating in biochemical processes, manganese, as a rule, does not change its oxidation state. This is likely due to the fact that there are no strong oxidants in the body, and ligands (thanks to the expense of the chelate effect) and ligands fields, stabilize the status of manganese (II).

Manganese is a participant in the synthesis of vitamins C and B, the synthesis of chlorophyll. It is known that an agent and a battery of chemical

energy in the body is a system of ATP-ADP. There are following enzyme reactions, in which MnATF2complex performs the role of the donor of phosphate groups. So, manganese is involved in such vital process as accumulation and transfer of energy in the body. The daily requirement of manganese is 5-7 mg, we get it by the food. A lot of manganese containsin tea, beets, carrots, liver, potatoes.

Permanganates are poisons for the body.

Big part of **iron (ferrum)** is concentrated in blood hemoglobin (70%). Iron is a part of many enzymes. In a related form iron is found in some proteins, which act as vectors of iron.

One of the most important chelate natural compounds of iron is hemoglobin. This is a complex protein that contains nonprotein (prosthetic) group - the gem, mass fraction of which is 4%. Prosthetic group is a bio-complex with iron (II) polycyclic organic matter - porfirin. This group is known as the gem (from Greek "Gemma"-blood). Gem has a flat structure. At gem ion of iron (II) forms the four nitrogen atoms of donor groups in the plane of the porphyrin rings. The fifth iron ion forms a link with the nitrogen atom of the imidazole group of histidine. Iron (II) ion in the gem also has the sixth orbital, which is used in the hemoglobin oxygen binding. This orbital is involved in bond formation with carbon monoxide (II). The physiological function of hemoglobin is the ability to bind oxygen back and transfer it from the lungs to the tissues. Hemoglobin, which attached oxygen, is called oxyhemoglobin and hemoglobin which gave his oxygen - dezoxyhemoglobin.

$[Hb \bullet Fe^{2+}] + O_2 = [HbFe^{2+} \bullet O_2]$.

Hemoglobin has a structure which is characterized by the lowest electron affinity, in its iron atoms protrude above the plane of the porphyrin ring. At the same time, oxyhemoglobin iron atoms are in the plane of the porphyrin ring.

The hemoglobin reacts with carbon monoxide and forms the macrocyclic complex - carbonylhemoglobin:

$[Hb \bullet Fe^{2+}] + CO = [HbFe^{2+} \bullet CO]$.

When carbon monoxide (II) is inhaled most of the hemoglobin becomes carboxyhemoglobin, which disrupts the transport of oxygen from the lungs to the tissues and causes poisoning of the body.

There is a group of iron-containing enzymes that catalyze electron transfer process in the mitochondria, so-called cytochromes (CCh). In total more than 50 cytochromes are known. The most studied cytochrome is C. The transfer of electrons in a redox chain involving this enzyme is carried out by changing the state of iron:

$CChFe^{3+} + e^{-} => CCh\text{-}Fe^{2+}$.

The enzyme peroxidase accelerates the oxidation of organic substances by hydrogen peroxide.

In organs and tissues so called deposited iron is placed, which is used in iron deficiency. It is deposited by the help of ferritin protein with a molecular weight of 460000, which is bioclaster. The lack of iron and cobalt in the body leads to the hemoglobin synthesis. This causes a disease of blood called anaemia.

The iron in the body can be transported in the form of amino acid complexes. Formation of bioinorganic complexes allows the passage of iron ions through the cell membrane.

Cobalt as a microelement performs a variety of functions, as it forms the catalytically active centers of enzymes necessary for DNA synthesis and the metabolism of amino acids. Some of its complexes with proteins are the trasfers of molecular oxygen.

Cobalt in the body exists in the form of vitamin B12. The composition of vitaminB_{12}($C_{63}H_{90}N_{14}O_{14}PCo$) - bioinorganic complex compound, in which complexing compound is Co^{3+}. In a molecule of vitamin B12 cobalt has a coordination number equal to 6. There are enzymatic systems, in which vitamin B_{12} acts not in free state but in so-called B_{12}—coenzymes. Cofactor is an active part of enzyme, which is easily separated. The inactive protein part that is left, is called aloenzyme. As aloenzyme B_{12} participates in two processes:

1) transfers propellant CH_3-groups (methylation reactions)

2) transfers hydrogen ions.

Cobalt affects carbohydrate, mineral, protein, lipid metabolism, and participates in the process of hematopoiesis. The radioactive cobalt isotope has found application in the treatment of malignant tumors, and the complex of cobalt with nicotinic acid (koamid) - in the treatment of anemia.

It is known that enzymes that contain **molybdenum** are involved in the reactions associated with the transition of oxygen groups. This is possible thanks to the ability of molybdenum to form solid oxygen complex. Molybdenum does not form stable cations at low degrees of oxidation in biological systems. In the body it exists only in the form of complexes in which oxidation state of Mo is +5 and +6. In the complexes molybdenum is associated usually with an oxygen atom.

Molybdenum is a part of enzymes catalyzing redox reactions in plant and animal organisms. These include xanthine oxidase, xanthine dehydrogenase, aldehyde oxidase. These enzymes catalyze the reactions associated with transfer of oxygen. Xanthine oxidase catalyzes the oxidation of xanthine to uric acid by oxygen.

Molybdenum has an important role in the process of soft air nitrogen fixation. Enzymes that contain molybdenum catalyze processes of transformation of molecular nitrogen into ammonia and other products containing nitrogen. Therefore, molybdenum is important for plant organisms.

Vanadiumconsists of one of the most important enzymes of nitrogen-fixing microorganisms of the soil, which restores the molecular nitrogen to ammonia- vanadium nitrogenase.

A microelement **chromium** is not enough studied, but it has essential nutrient role in plant and animal organisms.It is a part of some enzymes involved in redox reactions in the cells. Chrome is also a part of pepsin, which splits proteins in the digestive tract of animals and involves in the regulation of glucose absorption. Chrome, which is contained in leaps and bounds as a

complex with nicotinic acid and aliphatic amino-acids, is considered as "impaired glucose tolerance factor". It is necessary for normal carbohydrate metabolism in human body. Its effect consists in strengthen the insulin hypoglycemic actions.

Metal parts that contain chromium, do not show significant toxicity, but metal dust irritates lung tissue, which can lead to infection. It is known that chromium (VI) compounds are significantly more toxic than chromium (III) compounds. All chromium compounds cause irritation of skin that in its turn causes dermatitis. There is also evidence that chromium (VI) derivatives cause carcinogenic effect.

Nickel, comparing with iron and cobalt plays a more modest role in the body. However, there is evidence that nickel, like cobalt is involved in blood formation, effecting carbohydrate metabolism. Ni^{2+} has complexes with amino acids, carboxylic acids and other biologically active compounds that are donors of N-or O-groups. Obviously, due to many complexes formation nickel stimulates the synthesis of amino acids in the cell, accelerates the regeneration of blood plasma proteins, and normalizes the content of hemoglobin in the blood.

Argentum is an impurity microelement of plant and animal organisms. Like most of heavy metals, this element is not as important, but, like all heavy metals entering the body exhibits a toxicity effect.

Connecting with proteins containing sulfur, Argentum inactivates enzymes, coagulates and destroys proteins, forming insoluble albuminates. The same property to form albuminates causes bactericidal properties of Argentum and its compounds. The Argentum content of 10^{-8} mmol/l in water already has bactericidal action. All medicines of Argentum used in medicine are the drugs of external use, which is based on the binding, cauterizing and bactericidal properties. Among inorganic compounds Argentum nitrate is widely used for this purpose.

Argentum bioinorganic complexes with proteins - proteinates are colloidal solutions. Argentum colloidal drugs do not cause precipitation of tissue proteins and are used for the treatment of conjunctivitis, infectious diseases of the mucous membranes, venereal diseases and skin diseases.

The most famous colloidal medicines of Argentum is Protargolum (protein complex of Argentum) and colloid silver (colloidal Argentum). In small amounts it is applied to produce alloys (copper, argentum, stanum), which are used in dentistry.

The review of biochemical properties of d-elements allows us to note that both the biogenic (d) elements, and (d)-metals, whose role in living organisms, not yet determined, are widely used in medical practice in the form of various compounds. Lack of them in the body, as well as excess, leads to a number of pathologies.

The application of transition element compounds as medicinal products is based on their acid-base and redox properties and the ability to form complex compounds that are involved in various biochemical reactions.

QUESTIONS FOR SELF-TRAINING

1. General characteristics of s-elements (the features of the structure of atoms, atomic radii, change the ionization energy);
2. Common patterns of changing nature of oxides and hydroxides of s-elements I and II periods (acid-base properties).
3. The biological role of s-elements (Na, K, Ca, Mg) and the use of their compounds in medicine.
4. The p-elements in the periodic system, the features of the structure of atoms.
5. Change of the redox properties of p-elements depending on the oxidation number.
6. Change the acid-base properties of oxides and hydroxides of elements into groups.
7. The biological role of p elements (P, N, halogens) compounds and their application in medicine.
8. General characteristics of p-elements (O, N, P, halogens), their biological role and use of compounds in medicine.
9. Write the equation of the chemical reaction of sodium peroxide interaction with carbon (IV) oxide. Make an electronic balance and indicate what practical purpose of this reaction.
10. Write the equation of the chemical reactions of potassium hydride with water. Make an electronic balance and specify the oxidizer and reducing agent.
11. Calculate the mass fraction alkali in a solution obtained at interaction of 20 g sodium and 100 ml of water.
12. What mass of calcium is dissolved in 150 ml of water to obtain a solution with 10%?

TASKS

Task 1.

Write electronic configuration for chlorine and strontium and their ions – Cl^- and Sr^{2+}.

Task 2.

Present comparative analysis of sulfur and chromium on the ground of their electronic configuration.

Task 3.

Specify which one of the following hydroxides: $Sn(OH)_2$ or $Pb(OH)_2$ is the stronger base according to position of elements in Periodic table.

Task 4.

Write electronic configuration of element №21 and element №51. Specify electronic family for every element.

Task 5.

Present comparative analysis of bromine and aluminium.

THE STANDARD ANSWERS

Example # 1.

Write electronic configuration of element №20 and element №50. Specify electronic family for every element.

Standard sums.

Element №20 of the periodic table is calcium, element №50 is tin. Atomic number of element is equal to number of its electrons and nucleus charge. Electronic position of atoms according to the element's position on the periodic table:

Ca: $1s^2 2s^2 2p^6 4s^2$ s-element

Sn: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^2$ p-element

Example # 2.

Present comparative analysis of chlorine and manganese.

Standard sums.

Chlorine and manganese are characterized the same number of group – group VII. So they have seven valence electrons in the outermost level. The highest oxidation state for these elements is +7, that's why they are known by higher oxides – Cl_2O_7 and Mn_2O_7. They are acidic oxides which form strong oxoacids – $HClO_4$ and $HMnO_4$.

Chlorine is in group VIIa so it has s- and p- valence electrons. Its electronic configuration is only one electron short of the stable octet. That's why chlorine is typical non-metall and powerful oxidant.

But manganese is in group VIIb. It is transition metal and d-element. Manganese has 5 unpaired electrons in 3d-level and 2 electrons in 4s-level, so it is typical metal and reducing agent.

Lower oxides of these elements differ by their property. MnO is a base oxide which form a basic hydroxide $Mn(OH)_2$. Cl_2O – acidic oxide, anhydride of weak hypochlorous acid.

EXPERIMENTAL PART

Experiment 1.

Determination of K^+-ion using the reagent of sodium hexanitrocobaltate (III) $Na_3[Co(NO_2)_6]$.

The method principle: is based on the reaction of sodium hexanitrocobaltate (III) with potassium ions in a neutral medium with the formation of the yellow crystalline precipitate of hexanitrocobaltate (III) potassium and sodium.

Equipment: test tubes, pipettes, solution of potassium chloride, solution of sodium hexanitrocobaltate (III).

Sequence of procedures:

1. Put 4 drops of potassium chloride salt on the bottom of a dry test tube.
2. Add 3 drops of sodium hexanitrocobaltate (III) solution.
3. Leave the mixture for 2-3 minutes.
4. Dfeine the color of the obtaining sediment.
5. Write the equation of the corresponding reaction in the molecular and ionic form.
6. Make a conclusion concerning to the usage of this reaction for the precipitation of K^+ ions in the blood serum at permanganatometric determining K^+ ions content in the blood.

Experiment 2.

Determination of Ca^{2+} ion using the reagent of ammonium oxalate $(NH_4)_2C_2O_4$

The method principle: is based on the reaction of calcium with ammonium oxalate, which resulted in a white, crystalline precipitate of calcium oxalate CaC2O4, insoluble in acetic acid, but soluble in nitric and hydrochloric acids.

Equipment: test tubes, pipettes, calcium chloride solution, a solution of ammonium oxalate $(NH_4)_2C_2O_4$, acetic acid, nitric acid, hydrochloric acid solution.

Sequence of procedures:

1. Pup 6 drops of calcium chloride solution on the bottom of a dry test tube.

2. Add 6 drops of ammonium oxalate $(NH_4)C_2O_4$ reagent.

3. Define the color of the obtaining sediment of calcium oxalate.

4. Divide the precipitate into 3 tubes equally.

5. Add to the first tube an excess of acetic acid solution.

6. Add to the second tube an excess of nitric acid solution.

7. Add to the third test tube an excess of hydrochloric acid solution. 12

8. Make the conclusion according to the solubility of calcium oxalate precipitate in acids.

9. Write the equation of the corresponding reaction in the molecular and ionic form.

10. Note possibility of using this analytical reaction for the precipitation of calcium ions in the urine and blood by permanganatometric method.

Experiment 3.

Determination of Mg^{2+} ion with sodium hydrogen phosphate Na2HPO4 reagent.

The method principle: is based on the reaction between sodium hydrogen phosphate Na_2HPO_4 and magnesium ions in the presence of ammonium hydroxide and ammonium chloride, which resulted in a white, crystalline precipitate of magnesium ammonium phosphate.

Equipment: test tubes, pipettes, sodium hydrogen phosphate solution Na_2HPO_4, ammonium chloride solution, 2M solution of ammonium hydroxide, magnesium chloride solution.

Sequence of procedures:

1. Pour 3 drops of magnesium chloride solution on the bottom of a dry test tube.

2. Add by 2 drops of ammonium chloride and 2M ammonium hydroxide solutions.

3. Add into the tube 2 drops of sodium hydrogen phosphate solution.

4. Define the color of the resulting sediment.

5. Write the equation of the corresponding reaction in the molecular and ionic form.

6. Make a conclusion about possibility of the application of this reaction for the determination of magnesium ions in the blood.

Experiment 4.

Alkali action on aluminum salts and determination of the Al^{3+} ion.

The method principle: is based on precipitation reactions by caustic alkalis NaOH and KOH from solution of aluminum salts (a white gelatinous precipitate of aluminum hydroxide is soluble as in acids as in alkalis).

Equipment: test tubes, pipettes, a solution of aluminum chloride, sodium hydroxide NaOH, a solution of hydrochloric acid HCl, ammonium chloride crystals, a gas burner.

Sequence of procedures:

1. Put into the tube 7 drops of aluminum chloride solution.

2. Add drop by drop sodium hydroxide solution until a sediment is formed.

3. Divide sediment into 2 tubes.

4. Add to the first test-tube a few drops of hydrochloric acid HCl solution.

5. Add to the second tube a few drops of sodium hydroxide NaOH solution.

6. Observe dissolving of the sediment in both tubes.

7. Add to the second tube with aluminate, a few crystals of ammonium chloride.

8. Boil this mixture until odor of ammonia will disappear. 13

9. Define the formation of aluminum hydroxide precipitate.

10. Write the equations of the reactions at the molecular and ionic forms.

11. Make a conclusion about an application of this analytical reaction for detection of aluminum cations.

Experiment 5.

The action of potassium iodide solution to the lead salts.

The method principle : is based on the reaction of potassium iodide solution with lead ions, Pb^{2+}, which resulted in a yellow precipitate of iodide of lead.

Equipment: test tubes, pipettes, solution of lead acetate, a solution of potassium iodide.

Sequence of procedures:

1. Put into a test tube 5 drops of lead acetate $Pb(CH_3COO)_2$ solution.

2. Add drop-wise a solution of potassium iodide to formation of precipitate.

3. Write the equation of the corresponding reaction in the molecular and ionic form.

4. Make a conclusion regarding the application of this reaction for the detection of lead ions Pb^{2+}.

Experiment 6.

The action of diphenylamine on the nitrate ion NO^{3-}.

The method principle: is based on the oxidation of diphenylamine $(C_6H_5)_2NH$ with NO^{3-} ions to a product with a dark blue color.

Equipment: hour glass, a solution of diphenylamine, a solution of concentrated sulfuric acid, sodium nitrate solution.

Sequence of procedures:

1. Put on a watch glass 4 drops of diphenylamine solution.

2. Add 6 drops of concentrated sulfuric acid H_2SO_4.

3. Add to the solution of 2 drops of sodium nitrate solution.

4. Observe the appearance of an intense blue color.

5. Make a conclusion about possibility of using this reaction to identify the nitrate ions in a solution.

Experiment 7.

The action of barium chloride on tetraborate anion $B_4O_7^{2-}$.

The method principle: is based on the reaction of precipitation with barium chloride $BaCl_2$ in concentrated solutions of borax, a white precipitate of barium metaborate $Ba(BO_2)_2$, which is soluble in dilute hydrochloric and nitric acids.

Equipment: test tubes, pipettes, solution of barium chloride, a solution of sodium tetraborate $Na_2B_4O_7$, a solution of dilute hydrochloric acid, dilute nitric acid solution.

Sequence of procedures:

1. Put into test tube 5 drops of borax solution $Na_2B_4O_7$.

2. Add 6 drops of barium chloride solution.

3. Define the formation of a white precipitate of barium metaborate Ba(BO2)2.

4. Divide the precipitate into 2 tubes. 14

5. Add to the first tube excess of dilute hydrochloric acid HCl solution.

6. Add to the second tube an excess of dilute nitric acid HNO_3 solution.

7. Observe dissolution of barium metaborate precipitate in dilute hydrochloric and nitric acids.

8. Write the equation of the corresponding reaction in the molecular and ionic form.

9. Make a conclusion about possibility of applying this reaction to identify the tetraborate anion.

Experiment 8.

The action of potassium permanganate on the oxalate ion $C_2O_4^{2-}$.

The method principle: is based on oxidation of oxalate ions $C_2O_4^{2-}$ by potassium permanganate $KMnO_4$ in presence of sulfuric acid.

Equipment: test tubes, pipettes, solution of ammonium oxalate $(NH_4)_2C_2O_4$, sulfuric acid, potassium permanganate solution $KMnO_4$, a gas burner.

Sequence of procedures:

1. Put into test tube 5 drops of ammonium oxalate solution.

2. Add 6 drops of sulfuric acid.

3. The mixture should be slightly heated.

4. Add to the obtained solution drop by drop potassium permanganate solution.

5. Observe decoloration of the solution.

6. Write the equation of oxidation-reduction reaction.

7. Balance the redox reaction using half-reaction method.

8. Make a conclusion regarding the application of this reaction for to prove the presence of oxalates in analyzable solution.

TESTS

What cations with hydrochloric acid form precipitate, dissoluble in hot water?

A. *β
B. Barium.
C. Zinc.
D. Silver.
E. Cadmium.

What cations with sodium hydroxide not form precipitate but at heating up make the gas with sharp odour?

A. Mercury (I).
B. *Ammonium.
C. Bismuth.
D. Aluminium.
E. Arsenic

What cations are in solution, if at heating up with gypsum water a bit later solution become turbid?

A. Calcium.
B. *Stroncium.
C. Barium.
D. Lead.

Solution in the reaction with potassium dichromate gives colorized precipitate. What cations are in a problem?

A. Stroncium.
B. *Barium.
C. Mercury (I).
D. Calcium.

E. Silver.

What cations with sulfuric acid form precipitate, indissoluble in inorganic acids?

A. Calcium, silver.

B. Barium, mercury (I).

C. *Barium, stroncium, calcium.

D. Stroncium, calcium.

E. Silver, barium.

What cations at heating up with formaldehide in presence of ammonia form mirror scurf on walls of a test tube?

A. Mercury (I).

B. Mercury (II).

C. *Silver.

D. Lead.

What cations with Nessler's reagent give red - brown precipitate?

A. Mercury (I).

B. *Ammonium.

C. Silver.

D. Cobalt.

E. Iron (III).

What cations are in a problem, wich colourized a colorless flame of the burner in yellow color, and by consideration of colouring through an indigotic prism - violet color?

A. Sodium and calcium.

B. Sodium and stroncium.

C. Potassium and calcium.

D. Sodium and barium.

E. *Sodium and potassium.

About what availability of cations it is possible to make the concluding, if the filter paper, impregnated solution of cobaltous nitrate and investigated solution, after incineration gives ashes of cyan color?

A. Zinc.

B. Chromium(III).

C. *Aluminum.

D. Nickel.

E. Antimony.

What cations contained in solution, if at attachment of dithizon
at the presence of alkali the pink colouring aqueous and chloroformium layer we can see?

A. Tin (II).

B. Cadmium.

C. *Zinc.

D. Lead.

E. Copper.

What cations with hydrogen sulphide in presence hydrochloric acid form brown precipitate?

A. Manganese.

B. Arsenic (III).

C. Antimony (V).

D. *Tin (II).

E. Antimony (III).

In the reaction with sodium diaethyldithyocarbaminate form red - brown precipitate, dissoluble in chloroformium. What cations contained the solution?

A. Nickel.
B. Cadmium.
C. Cobalt.
D. *Copper.
E. Iron (II).

What cations with diacethyldioxym at pH 5-10 form scarlet - red precipitate?

A. Iron (II).
B. Iron (III).
C. *Nickel.
D. Cobalt.
E. Copper.

What cations form white precipitate with sodium sulphide?

A. Manganese.
B. Antimony (III).
C. Arsenic (III).
D. *Zinc.
E. Arsenic (V).

What cations at heating up at presence of excess of alkali and hydrogen peroxide of a precipitate not form, but the solution become yellow?

A. Tin (II).
B. *Chromium (III).
C. Tin (IV).
D. Cobalt.
E. Arsenic (III).

What cation are in a problem, if at dilution its by water we can observ turbid solution which is not become transparent at presence of a tartaric acid?

A. *Bismuth.
B. Antimony (V).
C. Tin (II).
D. Tin (IV).
E. Antimony (III).

What cations with solution of 8-oxyquinoline at the presence of solution of ammonia and chloride of ammonium (pH=9) form yellow-green precipitate?

A. Aluminium.
B. *Magnesium.
C. Manganese.
D. Zinc.
E. Bismuth.

What cations with solution of potassium iodide form red - orange precipitate, dissoluble in excess of reagent with formation of colorless solution?

A. Bismuth.
B. Mercury (I).
C. *Mercury (II).
D. Antimony (V).
E. Lead.

What cations contained in the solution, wich in the reaction with potassium thiocyanate form blood-red colouring of solution, and at presence of sodium fluoride and amyl alcohol the cyan colouring of an organic layer you can observ?

A. Iron (III).
B. Cobalt.

C. Chromium and cobalt.

D. *Cobalt and Iron (III).

E. Cobalt and Iron (II).

F. Iron (III) and nickel.

What cations present in the task, if the filter paper, wich use for the reaction between solution of cobalt nitrate and investigated solution, after incineration gives ashes of green color?

A. Aluminium.

B. *Zinc.

C. Nickel.

D. Chromium (III).

E. Bismuth

What cations can is in solution, if at heating up with ammonium persulfate at the presence of silver nitrate the solution become crimson?

A. Iron (III).

B. *Manganese.

C. Cobalt.

D. Bismuth.

E. Magnesium.

What cations with potassium hexacyanoferrate(III) form cyan precipitate?

A. *Iron (II).

B. Iron (III).

C. Copper.

D. Zinc.

E. Antimony (III).

What cations with a-nitrozo-b-naphthol form red - brown precipitate?

A. Cadmium.

B. *Cobalt.

C. Iron (III).

D. Nickel.

E. Mercury (II).

What cations with potassium hexacyanoferrate (II) form red - brown precipitate?

A. Iron (II).

B. Iron (III).

C. *Copper.

D. Nickel.

E. Cadmium.

What cations give a positive reaction with alizarin in presence of potassium hexacyanoferrate (II)?

A. Magnesium.

B. *Aluminum.

C. Nickel.

D. Bismuth.

E. Antimony (V).

What cations with solution of potassium iodide give black precipitate, dissoluble in excess of reagent with formation of solution of orange color?

A. Mercury (I).

B. Mercury (II).

C. Lead.

D. *Bismuth.

E. Silver.

Solution in the reaction with alcalis form white precipitate, which one on air become brown. What cations were in solution?

A. Iron (II).
B. Iron (III).
C. *Manganese.
D. Tin (II).
E. Cobalt.

What cation is presence in solution, if in the reaction with alkalis red - brown precipitate is formed, indissoluble in excess of alkalis?

A. Manganese.
B. Cobalt
C. *Iron (III).
D. Iron (II).
E. Copper.

What ions after reaction of solution with hydrogen nitrate form colorless gas which is not having of odour?

A. Thiosulphate - ions.
B. Sulphide - ions.
C. Acetate - ions.
D. *Carbonate - ions.
E. Thiocyanate-ions.

What anions at heating up with aluminium in an alcaline condition make the gas, change colour of red litmus paper into cyan?

A. Nitrite - ions.
B. *Nitrate - ions.
C. Acetate - ions.
D. Carbonate - ions.

E. Thiosulphate - ions.

What anions at presence of iron (III)chloride, hydrochloric acid and chloroformium give violet colouring layer of chloroformium?

A. Bromate - ions.
B. Bromide - ions.
C. Thiocyanate-ions.
D. *Iodide - ions.
E. Benzoate - ions.

What anions in the reaction with salts of cadmium form yellow precipitate?

A. Bromide-ions.
B. Salicylate - ions.
C. Tartrate - ions.
D. Citrate - ions.
E. *Sulphide - ions

What anions at presence of the sulfuric acids and ethanol form product burning by green flame?

A. Bromate - ions.
B. Phosphate - ions.
C. *Pyroborate - ions.
D. Acetate - ions.
E. Citrate - ions.

What anions at presence of acid make the gas, having color and odour?

A. *Nitrites - ions.
B. Nitrates - ions.
C. Thiosulphates - ions.
D. Sulphides - ions.

E. Sulphites - ions.

What anions with silver nitrate in neutral environment form precipitate of chocolate color?

A. Phosphate - ions.

B. *Arsenate - ions.

C. Arsenite - ions.

D. Thiosulphate - ions.

E. Sulphide - ions.

What anions at presence of acid with chlorine give orange colouring of layer of organic solvent?

A. Iodide - ions.

B. *Bromide - ions.

C. Bromate - ions.

D. Thiocyanide - ions.

E. Chloride - ions.

What colors of precipitate in the reaction of cation of manganese (II) with sulphides - ions?

A. White.

B. Orange.

C. Yellow.

D. *Colour of human body.

E. Brown.

What cations contained the investigated solution, wich form black cubical crystals in the reaction with sodium - lead hexanitrocuprate (II)?

A. Ammonium.

B. Sodium.

C. Barium.

D. *Potassium.

E. Calcium.

What cations contained the investigated solution, wich form precipitate of yellow colour in the reaction with sodium hexanitrocobaltate(III)?

A. Sodium.

B. *Potassium.

C. Calcium.

D. Ammonium.

E. Stroncium.

What cations contained in the investigated solution, wich form white crystalline precipitate with a tartaric acid?

A. Stroncium.

B. Barium.

C. Lead.

D. *Potassium.

E. Sodium.

At what value of pH it is necessary to do reaction of cations of magnesium with 8-oxyquinoline?

A. pH=3.

B. pH=5.

C. pH=7.

D. *pH=9.

E. pH=11.

What cations with solution of ammonia at first give of blue precipitates, and then at presence of excess of reagent - intensive - cyan solution?

A. Nickel.

B. Cobalt.

C. *Copper.

D. Chromium (III).

E. Iron (II).

The investigated ion with solution of salt of lead form yellow precipitate, which one is diluted at heating up in water and again precipitate 俣golden rain· What ions contained in solution?

A. Chloride - ions.

B. Phosphate - ions.

C. *Iodide - ions

D. Arsenate - ions.

E. Thiocyanide - ions.

In the reaction of ions of a cobalt (II) with ammonium thiocyanate, ions of iron (III) eliminate:

A. *Masking in a complex with sodium fluoride.

B. At presence of excess of ammonium thiocyanate.

C. At presence of solution of isoamyl alcohol with an ether.

D. Reduction of ions iron (III) up to ions iron (II).

E. At presence of acetic acid.

The investigated solution with solution of barium chloride form white precipitate indissoluble neither in acids, nor in alkalis. What composition of precipitate?

A. Barium carbonate.

B. Barium sulphite .

C. *Barium sulphate.

D. Barium oxalate.

E. Barium phosphate.

For discovery of an arsine at the determination of arsenic, apply:

A. Mercury chloride (I).

B. *Mercury chloride (II).

C. Lead acetate.

D. Molybdenic fluid.

E. Magnesian mixture.

Choose main places of localization of cobalt

A. Some departments of brain

B. Adrenal gland

C. Glands - pancreatic, hypophysis, sexual, milk

D. *Liver, thyroid gland, microflora of stomach-intestinal tract

Choose main places of localization of manganese

A. Some departments of brain

B. Adrenal gland

C. Glands - pancreatic, hypophysis, sexual, milk

D. *Liver, thyroid gland

Choose main places of localization of copper

A. *Liver, some departments of brain

B. Adrenal gland

C. Glands - pancreatic, hypophysis, sexual, milk

D. Thyroid gland, microflora of stomach-intestinal tract

Choose main places of localization of zinc

A. Some departments of brain

B. Adrenal gland

C. *Liver, glands - pancreatic, hypophysis, sexual, milk

D. Thyroid gland, microflora of stomach-intestinal tract

Choose biological impotance of copper

A. Increase the level of adrenalin

B. *Maintenance of thyroxin in blood

C. *Promotes hormonal activity of front stake of hypophysis

D. *Promotes activity of insulin

E. *Reduces the level of adrenalin

Choose biological impotance of manganese

A. Paticipate in transport of oxygen.

B. Increases activity of thyroid gland

C. Maintenance of thyroxin in blood

D. *Strengthens the action of hormones: front stake of hypophysis, sexual, insulin

Choose biological impotance of iron

A. Increases activity of thyroid gland

B. Promotes hormonal activity of front stake of hypophysis

C. Formation of teeth

D. *Paticipate in transport of oxygen.

Choose biological impotance of cobalt

A. Promotes hormonal activity of front stake of hypophysis

B. Formation of teeth

C. Paticipate in transport of oxygen.

D. *Increases activity of thyroid gland

Choose toxical effect of exess of cobalt

A. Sideros
B. Vomiting
C. Nervouse desfunctions
D. *Encrease number of erytrocytes
E. *Supress activity of SH-groups in enzymes

Choose toxical effect of exess of copper

A. Sideros
B. *Mental disfunctions
C. Encrease number of erytrocytes
D. Supress activity of SH-groups in enzymes

Choose toxical effect of exess of iron

A. *Sideros
B. Mental disfunctions
C. Encrease number of erytrocytes
D. Supress activity of SH-groups in enzymes

Choose macroelements:

a) Co
b) Zn
c) *P
d) *I
e) Fe

Choose macroelements:

a) Cu
b) *C
c) Mn

d) Mo
e) *S

Choose macroelements:

a) *Na
b) Bi
c) Te
d) Cs
e) *H

Choose macroelements:

a) Hg
b) Mo
c) Sb
d) *O
e) Au

Point range of content of macroelements:

a) 10 -3 – 10 -12%
b) *> 10 -2%
c) <10 -12<./sup>%

Point range of content of microelements:

a) < 10-12<./sup>%
b) *10 -3 – 10 -12%
c) 10-2%

Point range of content of ultramicroelements:

a) 10-2%
b) *< 10-12<./sup>%

c) 10 -3 – 10 -12%

Choose factors influenced to content in human organism:

a) *Deseases
b) *Sex
c) *Age
d) *Conditions of labour
e) *Season of the year

Point content of Li in the human body:

a) *10-4 %
b) 10-5 -10-6 %
c) 0,1%
d) 10%
e) 1%

What do you know about biological function of Li?

a) Have an influence upon the transport of Fe-ions in nervous and muscle cells
b) Have an influence upon the transport of Cl-ions in nervous and muscle cells
c) *Have an influence upon the transport of Na-ions in nervous and muscle cells
d) Have an influence upon the transport of Ca-ions in nervous and muscle cells
e) Have an influence upon the transport of Mg-ions in nervous and muscle cells

Choose application in medicine of Li-salts:

a) Antiallergic

b) Anticonvulsant
c) Antiacidic
d) Effective laxative
e) *Suspension of pathological emotional lability and exitation

How many percent of Na content in human body?

a) *0,25%
b) 10-4%
c) 10-5-10-6%
d) 0,1%
e) 5%

Choose primary location of Na in human body:

a) Intracellular
b) *Extracellular

How many gram of Na for 24 hours necessary for human life ?

a) 1 g
b) 100 g
c) *4-7 g
d) 20 g

Point biological importance of salts of Na:

a) *Takes part in a regulation of water exchange
b) React with SH-groups of albumins
c) Depress the center of breathing
d) *Maintains an acid-base equilibrium (pH) in an organism
e) *Ensure of an osmotic pressure of blood

Choose application in the medicine of 0,9% solution of NaCl:

a) *At Vomiting
b) *At Shock
c) *At Bleeding
d) *At Choler
e) *At Poisoning

Choose application in the medicine of Na_2SO_4:

a) Anticeptic
b) Antiarhythmic
c) Anticonvulsant
d) Antiallergic
e) *Purgative

Choose application in the medicine of $NaHCO_3$:

a) Antiarhythmic
b) Anticeptic
c) Anticonvulsant
d) *Antiacidic
e) Purgative

What total mass part of K in the organism?

a) 10-2%
b) 5%
c) 10%
d) 0,1%
e) *0,22 %

Choose primary location of K in human body:

a) *Intracellular
b) Extracellular

What biological importance of K in human organism?

a) React with SH-groups of albumins
b) Depress the center of breathing
c) *Influence to activity of enzymes
d) *Take part in albumen synthesis
e) *Influence to membrane potential of cell

Application in the medicine of KCl:

a) Cure diseases of thyroid gland
b) Cure stomach ulcer
c) Cure hyperacidic gastritis
d) *Cure disturbance of heart rhythm
e) *Cure muscle dystrophy

Where primary situated Mg in human organism?

a) Extracellular
b) *Intracellular

Choose total mass part of Mg in human organism:

a) 0,1%
b) 10-4%
c) 10%
d) 1%
e) *0,04%

Choose types of existing of different elements in human organism:

a) Combines with fats
b) Simple substances
c) *Combines with nucleic acids

d) *Combines with proteins
e) *Free station of ions

Choose functions of Mg in human organism:

a) Takes part in a regulation of water exchange
b) Can react with SH-groups of albumins
c) *Can depress a vasmoving center
d) *Can depress the center of breathing
e) *Can blockade and can ensure a nerve-muscle transmission

Choose functions of Mg in human organism:

a) Mg-ions are the antagonists of Fe-ions
b) Mg-ions are the antagonists of Na-ions
c) Mg-ions are the antagonists of K-ions
d) *Mg-ions are the antagonists of Ca-ions
e) *Stimulate the cholesterol secrete out of the organism

Choose application in the medicine of $MgSO_4$:

a) Cure stomach ulcer
b) Cure hyperacidic gastritis
c) *Has purgative effect
d) *Cure hypertensive diseases
e) *Cure convulsions

Choose application in the medicine of MgS_2O_3:

a) Cure disturbance of heart rhythm
b) Cure muscle dystrophy
c) Has purgative effect
d) *Cure atherosclerosis
e) *Cure hypertensive diseases

How to use magnesium hydroxide?

a) *Cure hyperacidic gastritis
b) *Has slight purgative effect
c) Cure hypertensive diseases
d) Cure convulsions
e) *Cure the stomach ulcer

How to use magnesium carbonate basic?

a) *Cure hyperacidic gastritis
b) *Has slight purgative effect
c) Cure hypertensive diseases
d) Cure convulsions
e) *Cure the stomach ulcer

What total mass percentage of Ca in human body?

a) 0.1%
b) 10-4%
c) 20%
d) 10%
e) *1.4%

What needing for human organism of Ca for 24 hours?

a) 50 g
b) 0,1 g
c) 10 g
d) 5 g
e) *0,8-0,9 g

Where primary situated Ca in human organism?

a) Pancreatic gland
b) Kidneys
c) Lungs
d) Liver
e) *Osseous tissues and teeth

Choose biological importance of Ca:

a) Can depress a vasomoving center
b) Can depress the center of breathing
c) *Coagulation of blood
d) *Regulation of the work of heart
e) *Take part in the transmission of nervous impulse

Choose application in medicine of $CaCl_2$:

a) Antihyperthensive
b) Antiacidic
c) *Antiinflamatory
d) Anticonvulsant
e) *Antiallergic

What total mass percentage ofSr in human body?

a) 0,1%
b) 10-4%
c) *10-3%
d) 1,4%
e) 10%

Choose biological impotanceof Sr:

a) Regulation of the work of heart
b) Coagulation of blood

c) Take part in the transmission of nervous impulse

d) *Bones formation

e) *Teeth enamel formation

Where is Ba concentrated in human body?

a) In stomach juice

b) In heart

c) In bones

d) In liver

e) *In eyes

How to use $BaSO_4$?

a) Cure stomach ulcer

b) Cure hyperacidic gastritis

c) Cure disturbance of heart rhythm

d) Cure muscle dystrophy

e) *For X-ray photography

How many percent content of Boron in the human body?

a) 0,1%

b) 10-3%

c) 10%

d) *10-5%

e) 1%

Choose primary location of boron in the human organism:

a) Osseous tissues and teeth

b) *Spleen, brain

c) Kidneys, pancreatic gland

d) Muscles, liver

e) *Lungs, thyroid gland

Choose application in the medicineof boric acid:

a) Antihyperthensive
b) Antiacidic
c) Antiallergic
d) Anticonvulsant
e) *Anticeptic

Choose application in the medicine of sodium tetraborate:

a) Antihyperthensive
b) Antiacidic
c) Antiallergic
d) Anticonvulsant
e) *Anticeptic

What mass part of Al is in human body?

a) 10-3%
b) 10%
c) 1%
d) *10-5%
e) 0,1%

Choose application in the medcine of "Almagel":

a) Antihyperthensive
b) Antiallergic
c) Anticonvulsant
d) *Protective of stomach
e) *Antiacidic

Choose application in the medicine of potassium-aluminum sulfate $KAl(SO_4)_2*12H_2O$:

a) Antihyperthensive
b) Anticonvulsant
c) *Anticeptic
d) *Anti-inflammatory
e) *Astringent

What mass part of C in human body?

a) 10-3%
b) *21,15%
c) 1%
d) 10-5%
e) 0,1%

Point biological importance of carbon:

a) Constituent of some cells
b) Constituent of some tissues
c) *Constituent of all the tissues and cells

Choose medical application of sodium hydrocarbonate:

a) *Antiacidic
b) Anticonvulsant
c) Anticeptic
d) Antiinflammatory
e) Astringent

How many percent content of silicon in human body?

a) *10-3%
b) 21,15%

c) 1%
d) 10-5%
e) 0,1%

Choose biological importance of the Si:

a) Influence the formation and functioning of the lymph
b) Influence the formation and functioning of the osseous tissues
c) Influence the formation and functioning of the nervous tissues
d) Influence the formation and functioning of the blood
e) *Influence the formation and functioning of the epithelial and connecting tissues

What diagnostic test use at infection hepatitis?

a) Determination of Ca
b) Determination of Mo
c) Determination of B
d) *Determination of Si
e) Determination of Fe

Choose nitrogen content in human body:

a) 10-5%
b) 10-3%
c) 1%
d) 10%
e) *3,1%

Point biological importance of nitrogen:

a) Constituent of some cells
b) Constituent of some tissues
c) *Constituent of all the tissues and cells

What natural compounds content Nitrogen?

a) *Alkaloids
b) *Nucleic acids
c) Carbohydrates
d) Fats
e) *Proteins

How to use nitrogen oxide?

a) Antiacidic
b) Antiinflammatory
c) Anticonvulsant
d) *For inhalation narcosis
e) Diuretic

How to use ammonia chloride?

a) Antihypertensive
b) Anticeptic
c) Hepatoprotector
d) Spasmolytic
e) *Diuretic

Choose percentage of phosphorus in human organism:

a) 5%
b) 10-3%
c) 1%
d) *0,25%
e) 10%

Choose daily need of phosphorus:

a) 0,01 g
b) 0,1 g
c) 50 g
d) 10 g
e) *1,3 g

Point biological importance of Phosphorus compounds:

a) Can depress the center of breathing
b) Takes part in a regulation of water exchange
c) Coagulation of blood
d) *Part of cellular membranes
e) *Energetic exchange and deposition of energy

How to use in medicine phosphororganic compounds?

a) Purgative
b) Diuretic
c) Anticonvulsant
d) Antacidic
e) *Antitumor

Choose biological role of As:

a) Coagulation of blood
b) Takes part in a regulation of water exchange
c) Energetic exchange and deposition of energy
d) *In large amounts strong poison
e) *It takes part in processes of blood forming

Choose percentage of As in the human organism:

a) 10-5%
b) 0,1%

c) 10%

d) 1%

e) *10-3%

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