MINISTRY OF HEALTH OF UKRAINE
Zaporizhzhya State Medical University
Analytical Chemistry Department

MEDICAL CHEMISTRY

Module 1

CHEMISTRY OF BIOGENIC ELEMENTS.
COMPLEXING IN BIOLOGICAL FLUIDS

(Abstract)

Topic module 1

Manual
for teachers and students
of the 1-st course of the Medical Faculty
speciality"GeneralMedicine"

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The Manual is **composed by**:

Doctor of pharmaceutical sciences, professor ***S. A. Vasyuk***;
Candidate of Pharmaceutical Sciences ***A. S. Korzhova.***
Candidate of Pharmaceutical Sciences ***Y. V. Monaykina***;
Candidate of Pharmaceutical Sciences ***B. A.Varynskyi.***

Reviewed by:

Doctor of Pharmaceutical Sciences, professor, head of the Department of Organic and Bioorganic Chemistry ***S. I. Kovalenko***;

Doctor of Pharmaceutical Sciences, professor, head of the Department of Inorganic Chemistry and Toxicology ***I. Panasenko.***

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PREFACE

Medical chemistry is studiedaccording to the approved standard of academic curriculum of 2005 yearfor students of the Universities of the III-IV levels of accreditationof Ukraine forspecialty 7.110101 "General medicine" field of study 1101 "Medicine" is established in accordance with the educational and skill characteristics (ESC) andeducationandprofessionalprograms (EPP) trainingapprovedbyorderoftheMinistryofEducationofUkrainefrom 16.04.03 № 239.

Organization of studying process is proceed according to the requirements ofEuropeanCreditTransferSystem (ECTS).

StudyofMedicalChemistryiscarriedoutduring 1 semesterof 1st yearoftraining according to theacademic curriculum.

Thecurriculumconsistsof a disciplinemodule, including 4 blocksoftopicmodules:

1. Chemistryofbiogenicelements. Complexformationinbiologicalfluids.

2. Acid – baseequilibriumsinbiologicalfluids.

3.Thermodynamic andkineticprocessesregularitiesandelectrokineticphenomenainbiologicalsystems.

4. Physicsandchemistryofsurfaceeffects. Lyophobicandlyophilicdispersesystems.

INTRODUCTION

MEDICAL CHEMISTRY

Medical chemistry studies chemical basis of processes of the life of a living organism which are corresponded to the basic chemical laws.

Most of the processes occurring in a living organism are explained on the basis of theoretical principles of inorganic, physical and colloid chemistry. For example, changes in the structure and function of blood cells in the blood substitute solution are explained by the laws of osmotic pressure; distribution of electrolyte ions between the cells and the external environment is explained according to the laws of Donnan membrane equilibrium. As a matter of a fact the mechanism of transmission of nerve impulses is explained by the theory of electrolytic dissociation; constant concentration of ions of H^+ in biological fluids (blood, lymph) largely depends on buffer systems. The doctrine of the redox potentials can explain the course of many reactions in the body due to the entering and expenditure of energy. Especially physics and chemistry of surface phenomena help interpret the mechanism of action of pharmaceuticals, explain the phenomena of phagocytosis and immunity.The laws of kinetics and catalysis are also important because they make it possible to understand the regularities of enzymatic and pharmacokinetic processes. Theoretical concepts of Colloid chemistry help to understand the role of sustainability of disperse systems of the body.

Medicinal chemistry studies the structure and reactivity of the most important biologically active molecules, theory of chemical bonding in complexes of biometals with bioligands and the role of biogenic elements in vital activity. It studies the processes occurring at the molecular and submolecular levels where the cause of the various forms of diseases and specific heredity should be sought.

Knowledge of chemistry laws allows the physician to influence the metabolism of clinically healthy and diseased organisms that is the key to improving of life quality.

TOPIC MODULE 1

CHEMISTRY OF BIOGENIC ELEMENTS.

COMPLEXING IN BIOLOGICAL FLUIDS

Tutorial # 1

1. THEME: Biogenic s- and p-elements, biological role, application in medicine.

2. PURPOSE: To study the properties of the compounds of s-and p-elements and their biomedical effects on human.

3. OBJECTIVIES:

3.1. To study general characteristics of s- and p-elements. To know important compounds of s- and p-elements and their properties.

3.2. Learning how to write electron configurations of atoms and ions.

3.3. Learning how to write the equation of chemical reactions, perform qualitative response to ions of s-and p-elements.

4. PLAN AND ORGANIZATIONAL STRUCTURE OF THE TUTORIAL:

4.1. Organizational part …….,,,,,,,,….....5 min

4.2. Goal-setting and motivation of the theme studying (opening address of the teacher)…….....…….....5 min

4.3. Determination of initial knowledge level …….....15 min

4.4. Correction of the initial knowledge level.…….....25 min

4.5. Organization of independent work of students (target teacher guidance, rules of accident prevention) ……...5 min

4.6. Laboratory work ……..…….45 min

4.7. Final comtrol: cheking of the laboratory work results and protocols ……...….....10 min

4.8. Concluding remarks of the teacher, guidance to the next lesson ……...……...…….....3 min

5. REFERENCE FOR SELF STUDY:

5.1. Questions for self-study

1. Introduction to the biogenic elements. The biosphere (the concept of Vernadsky), cycling of biogenic elements. biogeochemical provinces. Endemic diseases.
2. Macroelements, microelements, elements-organogens.
3. General characteristics of s-elements and their compounds according to the place in periodical system of elements of D.I. Mendeleev. Chemical properties of s-elements. Electron configuration of atoms and ions.
4. Biological role of sodium, potassium, calcium, magnesium, barium. Their level, localization and a role in the human body, medicines.
5. What is the mechanism of use of hypertonic NaC1 solutions in medicine?
6. Chemical similarity and biological antagonism (sodium - potassium, magnesium - calcium).
7. Why is not $NaHSO_3$ used as neutralization agent at hyperacid gastritis? But why are magnesium oxide and proteins (milk, egg yolk) used?
8. What are the elements of the teeth and bones?
9. Explain why the Ba^{2+} ion is toxic for the body.
10. General characteristics of p-elements and their compounds according to the position in the periodic table of D.I. Mendeleev. Chemical properties of p-elements. Electron configuration of atoms and ions.
11. Biological and medical significance of p-elements and their important compounds.
12. Which of the p-elements and their compounds are toxic? What are the rules of first aid at the poisoning by them?

13. What is called the chlorine water? Explain the mechanism of the bactericidal and bleaching action of chlorine water.

14. Quality reactions of K^+, Na^+, Ba^{2+}, Ca^{2+}, Mg^{2+}, SO_4^{2-}, CO_3^{2-}, $S_2O_3^{2-}$, Cl^-, Br^-, I^-, NO_2^-, NO_3^-.

5.2.Solve the tasks:

Task 1. Write the electron configurations of atoms and ions of potassium, calcium, magnesium, and barium.

Task 2. Write the equations of the reactions' chain:

$Na_2CO_3 \rightarrow NaHCO_3 \rightarrow Na_2CO_3 \rightarrow BaCO_3$

5.3. **Examples of the solved tasks:**

Task 1. Write the electron configuration of the atom and the sodium ion.

***Solution*:** $Na^0\ 1s^2 2s^2 2p^6 3s^1$

$Na^+\ 1s^2 2s^2 2p^6 3s^0$

Task 2. Write the equations of the reactions' chain:

Solution. $Ca \rightarrow CaO \rightarrow Ca(OH)_2 \rightarrow CaCO_3$

$$Ca + O_2 \rightarrow CaO$$

$$CaO + H_2O \rightarrow Ca(OH)_2$$

$$Ca(OH)_2 + CO_2 + H_2O \rightarrow CaCO_3$$

5.4.Studytests:

Tests for Tutorial # 1

1. Choose macroelements from the list below:

A. C, H, N, P, Co.

B. Fe, Cd, Cu, I, Br.

C. Na, K, Ca, Mg, S.*

Д. Ni, Cl, Pt, Hg, Cr.

2. Total phosphorus in the body is:

A. 21%.

B. 1%.*

C. 0,23%.

Д. 10%.

3. In medical practice, NH_4Cl is used as a diuretic. What oxidation state does nitrogen manifestate in the NH_4Cl:

A. +3.

B. –3.*

C. –1.

Д. +1.

4. Deficite of Ca^{2+} in the body in calcium metabolism disorders leads to the development of:

A. Dysbiosis.

B. Diabetes.

C. Rikets.*

Д. Anemia.

5. Choose the microelements:

A. C, H, O, S, Ca.

B. Fe, Cr, I, Br, Co.*

C. Na, K, Ca, Mg, Cl.

Д. N, P, Cr, Ni, Al.

6. The total nitrogen content in the body is:

A. 10^{-12} %.

B. 3 %.*

C. 10 %.

Д. 10^{-5} %.

7. Exchange of this element is closely related to calcium metabolism. The daily need for it is 1.3 g. It is the basis of the humanand animal skeleton, teeth. It is contained in the chemical warfare agents. This element is:

A. N.

B. P.*

C. O.

Д. Cl.

8. The powder of the substance is applied externally in the form of ointments and powders, for treatment of skin diseases (seborrhea). It is contained in the amino acid cysteine:

A. N.

B. S.*

C. C.

Д. Zn.

9. Daily need of sodium is:

A. 4-7 g.

B. 1 g.*

C. 20g.

Д. 10 microgram.

10. The presence of nitrogen excess in the blood may cause:

A. Podagra.

B. Hepatitis (Botkin's disease).

C. Compressed air illness.*

Д. Basedow's disease.

11. Choose from the elements those that relate to the organogenic:

A. Mg, Cu, Ca, Na, K.

B. N, H, S, P, C, O.*

C. Si, Au, Ag, Ni, Se.

Д. Fe, Cd, Cu, I, Br.

12. The sodium level in the body is:

A. 10^{-7}-10^{-4} %.

B. 0,08 %.*

C. 21 %.

Д. 1 %.

13. The daily human body need for calcium:

A. 100 g.

B. 0,5-1,5 g.*

C. 0,01g.

Д. 100 mg.

14. The chlorine level in the body is:

A. 5,5 g.

B. 100 g.*

C. 2,8g.

Д. 55 g.

15. Nitric oxide N_2O in mixture with oxygen is used for anesthesia. What is the oxidation state of nitrogen in the compound?

A. +4.

B. +2.

C. –1.

Д. +1.*

16. Daily requirement for potassium::

A. 10 g.

B. 2-3 g.*

C. 0,1 g.

Д. 1 mg.

17. Ions of this element depending on the concentration block or allow the neuromuscular transmission. They inhibit the respiratory center and vasomotor center, thereby reducing blood pressure. This ion is:

A. $Co^{2+.}$

B. Mg^{2+}.*

C. P^{5+}.

Д. Na^{+}.

18. The concentration of this element in the body is about 10%, in the Earth's crust it is 1%. It is also a linking element between the chains of DNA and protein secondary structure:

A. S.

B. H.*

C. N.

Д. C.

19. Choosemicroelements from the list:

A. C, H, O, N, P, S.

B. Br, I, Cu, Co, Fe, Cr.*

C. Na, Cl, K, Mg, Ca.

Д. Na, Cd, K, Mg, Co.

20. Disease "Endemic goiter" is observed because of deficiency of the ion:

A. Br^-.

B. Cl^-.

C. I^-.*

Д. F^-.

21. Ion of which element is involved in the biosynthesis of sex hormones (testosterone) and regulates the function of gonads:

A. I^-.*

B. Cl^-.

C. Br^-.

Д. F^-.

22. The main extracellular cation involved in the maintenance of osmotic pressure:

A. Li^+.

B. Na^+.*

C. K^+.

Д. Ca^{2+}.

23. The main intracellular cation involved in the maintenance of osmotic pressure:

A. Li^+.

B. Na^+.

C. K^+.*

Д. Ca^{2+}.

24. What ions the most actively take part in the transmission of nerve impulses through the membrane:

A. K^{+}, Na^{+}, Cl^{-}.*

B. K^{+}, Fe^{2+}, Zn^{2+}.

C. Mg^{2+}, Ba^{2+}, I^{-}.

Д. Ca^{2+}, Cl^{-}, Cu^{2+}.

25. What halogens are in the form of simple hydrated ions in a living organism:

A. Br, Cl.*

B. F, Br.

C. Cl, F.

Д. I, F.

26. What halogen is in a bound state with other elements in a living organism:

A. F.*

B. Cl.

C. Br.

Д. All answers are correct.

27. Which of the ions causes inhibition of the central nervous system:

A. I-.

B. F-.

C. Br-.*

Д. Ca^{2+}

28. H_2S is toxic to living organisms because:

A. It blocks the transfer of electrons in the respiratory chain.*

B. It forms acid salts.

C. Most sulfides are insoluble in water.

Д. When interacting with oxygen forms sulfur.

29. Nitrogen forms several oxides. One of them has a vasodilatory effect and the second is used for anesthesia. Choose these oxides:

A. N_2O_3, NO.

B. NO_2, NO.

C. NO, N_2O.*

Д. N_2O_5, NO_2.

30. Which ion increases the strength of the teeth enamel?

A. F^-.*

B. Cl^-.

C. Br^-.

Д. I^-.

31. What sublevels of the elements of main group of the 1st and 2nd groups are filled with electrons?

A. p.

B. s.*

C. d.

Д. f.

32. Potassium and bromine are located in 4th period of the periodic table of the elements. This is due to:

A. The same chemical properties.

B. The same number of energy levels.*

C. A positive valence.

Д. Nuclear charge.

33. Which element has the highest affinity to an electron?

A. Sulfur.

B. Selenum.

C. Oxygen.*

Д. Nitrogen.

34. Which element has the highest electronegativity?

A. Magnesium.

B. Oxygen.*

C. Nitrogen.

Д. Carbon.

35. What is the maximum number of electrons in the p-sublevel?

A. 1.

B. 4.

C. 6.*

Д. 8.

E. 18.

36. Biogenic elements:

A. They are permanently the part of the body and perform specific biological functions.*

B. They are present in the biosphere and effect on vitality.

C. They are present in industrial emissions and have a negative impact on living organisms.

Д. All variants.

37. Elements-organogens are:

A. The base of the biological important molecules and macromolecules such as proteins, fats, carbohydrates, etc.*

B. The part of the biologically active substances such as enzymes, hormones and vitamins.

C. Provide basic vital processes in the body such as to maintain constant pH, osmotic pressure, etc

38. Biotic dose is:

A. The level of the element in the body.

B. The dose of the element corresponding to the biological needs of the organism.*

C. The dose of the element which has toxic effects.

39. Endemic diseases related to:

A. Living in the definite area.*

B. Metabolic disorders.

C. Microelements deficiency in the body.

Д. Vitamin deficiency.

40. Synergism of elements is:

A. Independent action in the body.

B. Enhancing of action of one element by another element when they uptaken together.*

C. The weakening of an action of one element by another.

41. Antagonism of elements is:

A. Mutual enhancing of their activities.

B. Mutual weakening of their activities.*

C. Appiarance of new properties of an element at the presence of another element.

42. Calcium is antagonist of magnesium in the body:

A. It enhances the biological activity of magnesium.

B. It reduces its activity. *

C. Their activities are added.

43. The process of blood clotting can be enhanced by the introduction into the body of:

A. Copper salts.

B. Calcium salts.*

C. Sodium salts.

Д. Iron salts.

44. Plaster bandages are consisted of:

A. Calcium sulfate.*

B. Calcium carbonate.

C. Magnesium sulfate.

Д. Calcium chloride.

45. The concentration of NaCl physiological (isotonic) solution is:

A. 0,7 %.

B. 0,9 %.*

C. 2 %.

Д. 9 %.

46. What is the X-ray contrast agent for the diagnosis of gastric ulcer?

A. Suspension of $BaSO_4$.*

B. 0,9 % solution of $BaCl_2$.

C. 0,9 % solution of NaCl.

Д. 10 % solution of $CaCl_2$.

47. What disease is caused by deficit of fluorine?

A. Caries.*

B. Fluorosis.

C. Anemia.

Д. Endemic goiter.

48. What disease is caused by deficit of iodine?

A. Fluorosis.

B. Endemic goiter.*

C. Chronic hepatitis.

Д. Anemia..

49. Which of the nitrogen oxides is used as a component for inhalation anesthesia?

A. N_2O.*

B. NO.

C. N_2O_3.

Д. NO_2.

E. N_2O_5.

50. Where is the major amount of the body phosphorus located?

A. In the blood.

B. In the liver.

C. In bone tissue.*

Д. In the tissues of the brain.

51. What type of elements are usually microelements?

A. d-elements.*

B. s- elements.

C. p- elements.

Д. f- elements.

52. Where is the majority of microelements at maximal concentration located?

A. Blood

B. Liver.*

C. Brain.

Д. Kydney.

53. Indicate the average iodine, copper, arsenic, fluorine, bromine, and cobalt in the living matter (V. I.Vernadsky)

A.Higher 10^{-2} %.

B.From 10^{-3} till 10^{-5} %.*

C. Lower 10^{-5} %.

54. How many times does the potassium ion concentration exceed the concentration of sodium ions in the cell?

A. 2.

B. 4.

C. 8.

Д. 16.*

E. 32.

55. How many times does the concentration of magnesium ions exceed the concentration of calcium ions in the cell?

A. 5.

B. 9.

C. 13.

Д. 19.*

E. 25.

56. What is the cause of toxic effects of barium ions Ba^{2+}?

A. The same size of $Ba^{2+}$and K^{+}.

B. Competing of $Ba^{2+}$and K^{+} ions in biochemical processes.

C. Formation of very durable and poorly soluble barium phosphate in bone, nerve cells and brain.

Д. All answers are correct.*

57. What is the color of the precipitate formed in the interaction of potassium ions with sodium hexanitrocobaltate?

A. White.

B. Yellow.*

C. Black.

Д. Blue.

E. Green.

58. What is the precipitate formed in the interaction of magnesium ions with sodium phosphate buffer in ammonia?

A. $Mg_3(PO_4)_2$.

B. $MgHPO_4$.

C. $MgNH_4PO_4$.*

59. What is the color of the precipitate formed in the interaction of sodium ions with sodium hexahydroxostibate?

A. White.*

B. Yellow.

C. Black.

Д. Blue.

E. Green..

60. What is the precipitate formed in the interaction of calcium ions with ammonium oxalate?

A. $Ca(HC_2O_4)_2$.

B. $(CaOH)_2C_2O_4$.

C. CaC_2O_4.*

Д. $[Ca(NH_3)_4]C_2O_4$.

61. Which element ions may be substituted for calcium ions in the bone?

A. Mg.

B. Sr.*

C. Be.

62. What process in the human body is due to theheterogeneous equilibrium with the participation of the cationCa2+?

A. The formation of bone and muscle tissue.*

B. Formation of nerve tissue.

C. The formation of kidney stones and deposits $CaCO_3$ in sclerotic plaques in the case of pathology.*

63. Why is barium sulfate applicable in X-ray practice?

A. Because of its low solubility.*

B. Because of its high density.

C. Because of optimal conditions for mass transfer.

Д. Because of its high tendency to X-rays absorbtion.*

64. Water hardness is caused by the presence of Ca^{2+} and Mg^{2+} ions. What drinking water is beneficial?

A. Hard.*

B. Soft.

C. Does not matter.

Literature

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6. LABORATORY WORK

Each student during his laboratory work individually performs all the reactions on the ions. The conditions of the reactions shold be provided accurately. The properties of the reaction products (color of the solution or precipitate, precipitate dissolution, stability of the reaction products, the form of crystals, etc.) must be stied as well.

Determination of K^+-ions

Reaction withsodium hexanitrocobaltate(III)

Put 2-3 drops of potassium salt solution (K^+-ions) into a test tube, add 1-2 drops of $Na_3[Co(NO_2)_6]$ solution. Yellow sediment should be observed.

Determination of Na^+- ions

Reaction withpotassium hexahydroxyantimonate(V

Put 3-4 drops of sodium salt solution (Na^+-ions) into a test tube, add 2-3 drops of fresh solution of hexahydroxyantimonate (V) potassium. Cool the tube and isrub its internal wall by a glass stick. White sediment should be observed.

Determination of Ba^{2+}- ions

Reaction with potassium dichromate.

Put 3-4 drops of barium salt solution (Ba2+-ions) into a test tube, add 3-4 drops of acetate buffer solution and 3-4 drops of potassium dichromate. Yellow sediment should be observed.

Determination of Ca^{2+}- ions

Reaction with ammonium oxalate

Put 3-4 drops of calcium salt solution (Ca^{2+}-ions) into a test tube, add 1-2 drops of 2 M CH_3COOH solution, 3-4 drops of ammonium oxalate solution. Heat the test tube. White sediment should be observed.

Determination of Mg^{2+}- ions

Reaction with sodium hydrogen phosphate

Put 2-3 drops of magnesium salt solution (Mg^{2+}-ions) into a test tube, add 1-2 drops of solutions of NH_4Cl, NH_3 and Na_2HPO_4. White sediment should be observed.

Determination of SO_4^{2-}- ions

Reaction with barium chloride

Put 3-4 drops of the studied ion solution into a test tube, add 1-2 drops of $BaCl_2$ solution. White sediment should be observed. Study its solubility in the solutions of HCl and CH_3COOH.

Determination of CO_3^{2-}- ions

Reaction with barium chloride

Put 3-4 drops of the studied ion solution into a test tube, add 1-2 drops of $BaCl_2$ solution. White sediment should be observed. Study its solubility in the solutions of HCl and CH_3COOH.

Determination of $S_2O_3^{2-}$- ions

Reaction with mineral acids

Put 6-7 drops of $S_2O_3^{2-}$-ions solution and the same amount of 2 M HCl solution into a test tube. Turbidity of the solution and formation of gas with a specific odor should be observed.

Determination of Cl^-- ions, Br^-- ions, I-- ions
Reaction of silver nitrate in the 2 mol/l nitric acidsolution.

Put 3-4 drops of the studied ion solution into each of three test tubes, add 2-3 drops of silver nitrate solution, 2-3 drops of 2 M solution of nitric acid. White caseous sediment of silver chloride, pale yellow sediment of silver bromide, yellow sediment of silver iodide should be observed. Study their solubility in the solution of NH_3.

Determination *of NO_2^-- ions and NO_3^-- ions*
in case of their simultaneous presence in solution.

Put 2-3 drops of NO_2^--ions and NO_3^--ions into a porcelain cup, add 5-6 drops of 5% solution of antipyrin. Add 1 drop of concentrated sulfuric acid in the center of the cup. Green color of nitrosoantipyrin appears (determination of NO_2^--ions). Then add 5 more drops of concentrated sulfuric acid. Red color of nitroantipyrin appears (determination of NO_3^--ions).

7. TRAINING AND CONTROL MEANS:

– cards for determination of initial level of knowledge and skills;

– control questions;

– tests.

Tutorial # 2

1. THEME: Biogenic d- elements, biological role, application in medicine

2. PURPOSE: To study the properties of the compounds of d-elements and their biomedical effects on human organism

3. OBJECTIVIES:

3.1. To study the general characteristics of d-elements. Know the most important compounds of d-elements and their properties.

3.2. Learning how to write electronic configuration of atoms and ions.

3.3. Learning how to write the equation of chemical reactions, perform qualitative reactions of d-elements ions.

4. PLAN AND ORGANIZATIONAL STRUCTURE OF THE TUTORIAL:

4.1. Organizational part ……,,,,,,,,….....5 min

4.2. Goal-setting and motivation of the theme studying (opening address of the teacher)…….....…….....5 min

4.3. Determination of initial knowledge level …….....15 min

4.4. Correction of the initial knowledge level.…….....25 min

4.5. Organization of independent work of students (target teacher guidance, rules of accident prevention) ……...5 min

4.6. Laboratory work ……..…….45 min

4.7. Final comtrol: cheking of the laboratory work results and protocols ……...….....10 min

4.8. Concluding remarks of the teacher, guidance to the next lesson ……...……...…….....3 min

5. REFERENCE FOR SELF-STUDY:

5.1. Questions for self-study

1. General characteristics of d-elements and their compounds according to the place in the periodic table of Mendeleev. Their chemical properties. Electronic configuration of atoms and ions.
2. The biological role of zinc, manganese, iron, chromium, copper, molybdenum, cobalt, mercury. Their level, localization and function in the human body, medicines.
3. The toxic effect of d-elements and their compounds.
4. Quality reactions of Zn^{2+}, Fe^{2+}, Fe^{3+}, Cu^{2+}, MnO_4^{2-}.

5.2. Solve the tasks:

Task 1. Write the electron configurations of atoms and ions of zinc, manganese, iron, chromium, molybdenum, cobalt, mercury.

Task 2. Write the equations of the reactions' chain:

$Zn \rightarrow ZnO \rightarrow ZnSO_4 \rightarrow K_2ZnO_2 \rightarrow ZnCl_2$

5.3. Examples of the solved tasks:

Task 1. Write the electron configuration of atoms and ions of copper .

Solution. $Cu^0\ 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$

$Cu^0\ 1s^2 2s^2 2p^6 3s^2 3p^6 3d^9 4s^0$

Task 2. Write the equations of the reactions' chain:

Solution. $Fe \rightarrow FeS \rightarrow FeO \rightarrow FeSO_4 \rightarrow Fe_2(SO_4)$

$Fe + S \rightarrow FeS$

$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$

$FeO + SO_3 \rightarrow FeSO_4$

$10FeSO_4 + 2KMnO_4 + 8H_2SO_4 \leftrightarrow 5Fe_2(SO_4) + 2MnSO_4 + K_2SO_4 + 8H_2O$

5 $Fe^{2+} - \bar{e} \leftrightarrow Fe^{3+}$

1 $MnO_4^- + 8H^+ + 5\bar{e} \leftrightarrow Mn^{2+} + 4H_2O$

$5Fe^{2+} + 2MnO_4^- + 6H^+ \leftrightarrow 5Fe^{3+} + 2Mn^{2+} + 8H_2O$

5.4. Study tests:

1. Copper and zinc are elements-synergetics:
   A. They enhance the biological activity of each other.*
   B. Weaken the activity of each other.
   C. Their activities are added.

2. What three elements are required for normal hematopoiesis:
   A. Fe, Zn, Co.
   B. Co, Fe, Cr.
   C. Fe, Co, Cu.*
   Д. Cu, Mo, Fe.

3. Carbon monoxide poisoning is explained by:
   A. Falling of concentration of hydrogen in alveoluses..
   B. High level of CO_2 in the bronchial tubes.
   C. High affinity of carbon monoxide (II) to Fe^{2+}.*
   Д. Low affinity of carbon monoxide (II) to Fe^{3+}.

4. What ion complex is the basis of the vitamin B_{12} molecule?
   A. Fe^{2+}.

B. Hg^{2+}.

C. Mg^{2+}.

Д. Co^{2+}.*

5. What chemical properties determine the use of $KMnO_4$ in medicine as an antiseptic?

A. Ability to complete dissociation into ions.

B. Absence of hydrolysis.

C. Reducing properties.

Д. Oxidizing properties.*

6. What ion complex is in the basis of hemoglobin molecule?

A. Co^{2+}.

B. Fe^{3+}.

C. Fe^{2+}.*

Д. Cd^{2+}.

7. Deficiency of iron (II) ion in the body leads to development of:

A. Anemia.*

B. Tuberculosis.

C. Rachitis

Д. Decompression sickness.

8. Ions of this element influence glycogenformation: reduce or increase blood sugar (hypoglycemia, hyperglycemia). This ion is:

A. Cu^{2+}.

B. Ca^{2+}.

C. Fe^{2+}.

D. Cr^{2+}.*

9. This ion has specific effects on reproductive processes. The lowering of reproductive capacity is observed during considerable deficiency of this element.

A. F^-.

B. Fe^{3+}.

C. Zn^{2+}.*

D. Co^{2+}.

10. Mercury amidohlorid $HgNH_2Cl$ is usedas ointments in dermatology. Determine the oxidation state of mercury:

A. 0.

B. 1+.

C. 2+.*

D. 4+.

11. Gout (the disorder of a metabolism of uric acid) is observed with a deficiency of the element:

A. Mn.

B. Mo.*

C. Fe.

D. Co.

12. Which element is a part of the main antioxidant compounds and strengthens the immune defense?

A. Co.

B. Se.*

C. Zn.

D. Cr.

13. Fe^{2+} is a part of:

A. Hemoglobin.*

B. Insulin.

C. Chlorophyll.

D. Myoglobin.*

14. Cobalt is one of:

A. Microelements.*

B. Oligo biogenic elements.

C. Organogen.

15. Cobalt is a part of the vitamin:

A. D_2.

B. A.

C. B_6.

D. B_{12}.*

E. C.

16. The biological role of zinc:

A. It is included in the 40 enzymes and is involved in all kinds of exchange.*

B. The biological role has not been studied.

C. It is a part of hemoglobin and is involved in the transport of oxygen.

D. It is a part of vitamin B12 and is involved in hematopoesis.

17. The part of the hemoglobin structure is:

A. Fe.

B. Fe^{+2}.*

C. Fe^{+3}.

18. What substances can act as ligands in "bioinorganic" complexes with "lifemetal" in the body?

A. Lipids.

B. Carbohydrates

C. Amino acid residues, peptides, proteins.*

D. Nucleic acids.*

19. Molibden-containing enzymes catalyze the process of transformation of molecular nitrogen to ammonia and other nitrogen-containing substances. What kind of the reactions are these processes?

A. Acid-base.

B. Redox.*

C. Precipitation.

D.Complexformation.

20. The enzyme superoxide dismutase (SOD) has an important physiological function. It accelerates the decomposition reaction of superoxide ion O2- that is a free radical which destroys cells. Which metal is a part of the active site of superoxide dismutase?

A. Mn.

B. Ca.

C. Fe.

D. Co.

E. Cu.*

21. Such important respiratory enzyme as cytochromeoxidase (COX) belongs to oxidases which catalyzes the final stage of tissue breath. What element oxidation state changes during the catalytic process?

A. Mn.

B. Mo.

C. Fe.

D. Co.

E. Cu.*

22. What happens when you add a small amount of aqueous ammonia to the copper (II) sulphate:

A. Blue precipitate is formed.*

B. Color of the solution does not change.

C. Blue solution is formed.

D. The solution is decolorized.

23. What color precipitate is formed at interaction of salt of iron(II) with potassium hexacyanoferrate(III)?

A. White.

B. Green.

C. Brown.

D. Blue.*

E. Black.

24. What is observed during the addition of a substantial excess of aqueous ammonia to the copper (II) sulphate?

A. Blue precipitate is formed.

B. Color of the solution does not change.

C. Blue solution is formed.*

D. The solution is decolorized.

25. What color precipitate is formed at interaction of salt of iron (III) with potassium hexacyanoferrate (II)?

A. White.

B. Green.

C. Brown.

D. Blue.*

E. Black..

26. Hemoglobin is one of the most important natural intra coordination compounds. Which element is connected to a group of heme iron?

A. O.

B. N.*

C. H.

D. C.

E. P.

27. Ammonium molybdate is used in medicine. Choose its formula:

A. NH_4MoO_4.

B. $(NH_4)_2MoO_4$.*

C. $(NH_4)_2MoO_3$.

Д. NH_4MoO_3.

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2. LevitinYe.Ya. General and Inorganic Chemistry : textbook for students of higher schools / Ye. Ya. Levitin, I. A. Vedernikova. - Kharkiv : Golden Pages, 2009. - 360 p.

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6. LABORATORY WORK

Determination of Zn^{2+} ions

1. Reaction with hexacyanoferrate (II) potassium

Put 3-4 drops of Zn^{2+}-ions solution and the same amount of of $K_4[Fe(CN)_6]$ solution into a test tube. White sediment should be observed.

2. Reaction with sodium sulfide

Put 1-2 drops of Na_2S solution to 2-3 drops of Zn^{2+}-ions solution in a test tube. White sediment should be observed.

Determination of Fe^{2+}- ions

Reaction with hexacyanoferrate (III) potassium

Put 2-3 drops of Fe^{2+}-ions solution into a test tube, add 1-2 drops of 2 M solution of hydrochloric acid and 2 drops of $K_3[Fe(CN)_6]$ solution (red blood salt. Blue sediment («turnbule blue») should be observed.

Determination of Fe^{3+}- ions

1. Reaction with hexacyanoferrate (II) potassium

Put2-3 drops of Fe^{3+}- ions solution into a test tube, add 1-2 drops of 2 M hydrochloric acid solution, 2 drops of $K_4[Fe(CN)_6]$ solution (yellow blood salt). Blue sediment («Berlin blue») should be observed.

2. Reaction with ammonium thiocyanate

Put 3-4 drops of Fe^{3+}- ions solution into a test tube, add 2-3 drops of ammonium thiocyanate solution. Red color of the solution should be observed.

Determination of Cu^{2+}- ions

Reaction with ammonia solution (equivalent and excess)

Put 3-4 drops of Cu^{2+}-ions solution into a test tube. add 1-2 drops of 2 M solution of NH_3. Bluish-green precipitate should be observed. Study the action of concentrated ammonia solution on the obtained sediment (precipitate dissolves to form intensely blue solution).

7. TRAINING AND CONTROL MEANS:

– cards for determination of initial level of knowledge and skills;
– control questions;
– tests.

Tutorial # 3

1. THEME: Complexing in biological systems

2. PURPOSE: To study the theory of coordination compounds formation, their properties and use in medicine

3. OBJECTIVIES:

3.1. Learning how to write the formula of coordination compounds and their names according to the international nomenclature.

3.2. Learn to identify the charge of the inner sphere and complexing ion in the coordination compounds.

3.3. Learning how to write the equation of the instability and stability constants of the inner sphere ion.

4. PLAN AND ORGANIZATIONAL STRUCTURE OF THE TUTORIAL:

4.1. Organizational part …….,,,,,,,,….....5 min

4.2. Goal-setting and motivation of the theme studying (opening address of the teacher)…….....…….....5 min

4.3. Determination of initial knowledge level …….....15 min

4.4. Correction of the initial knowledge level.…….....25 min

4.5. Organization of independent work of students (target teacher guidance, rules of accident prevention) ……...5 min

4.6. Laboratory work ……..…….45 min

4.7. Final comtrol: cheking of the laboratory work results and protocols ……...….....10 min

4.8. Concluding remarks of the teacher, guidance to the next lesson ……...……...…….....3 min

5. REFERENCE FOR SELF-STUDY:

5.1. Questions for self-study

1. Coordination compounds, their composition and structure. Concepts: complexing agent (central atom), ligands, coordination number, denticity, external and internal coordination sphere of the coordination compound.
2. Classification of coordination compounds: according to the charge of the inner coordination sphere, the nature of the ligands, chelate compounds, polynuclear complexes, clathrates.
3. Equilibria in solutions of coordination compounds (primary and secondary dissociation). Coordination compounds stability.
4. The biological role of coordination compounds in the human body: metal-ligand homeostasis and its disorders.
5. Medical application of coordination compounds. Application of chelating agents as antidotes for heavy metals poisoning and as antioxidants for drug storage.

5.2. Solve tasks:

Task 1. To write the name of the complex: $K_4[Fe(CN)_6]$; $K_3[Fe(CN)_6]$; $(NH_4)_2[Co(SCN)_4]$; $[Fe(SCN)_3]$.

Task 2. Determine the charge of the inner sphere ion and the complexing agent (the central atom) in compounds: $Na_3[Co(NO_2)_6]$, $K_2[HgI_4]$, $[Pt(NH_3)_4Cl_2]Cl_2$.

Task 3. Write the formula of the copper coordination compound with ammonia $CuSO_4 \cdot 4NH_3$ and explain its composition.

Task 4. Write the equations of constant instability and stability for the inner sphere ion $[Fe(CN)_6]^{4-}$.

5.3. Examples of the solved tasks:

Task 1. To write the name of the complex: $[Cr(H_2O)_6]Cl_3$; $Na_3[FeF_6]$.

Solution.Hexaaquqchromium(III) chloride; sodium hexafluoroferrate (III).

Task 2. Determine the charge of the complexing agent in the compound: $K[PtNH_3Cl_5]$.

Solution. $+1+X+(-5)=0$, then $X=+4$

Task 3. Write the equations of instability and stability constant for the inner sphere ion $[Ag(CN)_2]^-$.

Solution. Inner sphere ion dissociates according to the scheme (secondary dissociation):

$[Ag(CN)_2]^- \leftrightarrow Ag^+ + 2CN^-$

$$K_{inst.} = \frac{[Ag^+]\cdot[CN^-]^2}{[[Ag(CN)_2]^-]} \quad ;\beta = \frac{[[Ag(CN)_2]^-]}{[Ag^+]\cdot[CN^-]^2}$$

5.4. To study tests:

1. What oxidation state does copper exhibitin the compound $[Cu(NH_3)_4]Cl_2$?

A. 0.

B. 2+.*

C. 1+.

Д. 3+.

2. What oxidation state does nickel exhibit in the compound $[Ni(NH_3)_6]SO_4$:

A. 0.

B. 2+.*

C. 3+.

D. 4+.

3. What is the name of the corresponding coordination compound $[Co(NH_3)_4Cl_2]Cl$?

A. Hexaammincobalt(III) chloride.

B. Trichlorotriammincobalt(III).

C. Dichlorotetraammincobalt(III) chloride.*

D. Chloride dichlorotetraammincobalt(III).

4. What substance solution doesn't carry electric current?

A. $[Cu(NH_3)_4](NO_3)_2$.

B. $K_2[Cu(CN)_4]$.

C. $[Cu(NH_3)_2(SCN)_2]$.*

D. $[Cu(NH_3)_4]SO_4$.

6. What coordination compound is the strongest?

A. $[Cd(NH_3)_4]^{2+}$ ($K_{inst.} = 2{,}8 \cdot 10^{-7}$).

B. $[Cu(NH_3)_4]^{2+}$ ($K_{inst.} = 9{,}3 \cdot 10^{-13}$).

C. $[Ag(NH_3)_2]^+$ ($K_{inst.} = 5{,}8 \cdot 10^{-8}$).

D. $[Co(NH_3)_6]^{3+}$ ($K_{inst.} = 6{,}2 \cdot 10^{-36}$).*

7. What ions are mainly formed at dissolution of the coordination compound $K_2[Cu(CN)_4]$?

A. K^+; CN^-.

B. K^+; $[Cu(CN)_4]^{2-}$.*

C. Cu^{2+}; CN^-.

D. K^+; Cu^{2+}; CN^-.

8. What formula corresponds to coordination compound potassium pentacyanoaquaferrate(II)?

A. $K_2[Fe(CN)_5H_2O]$.

B. $K_2[Fe(CN)_4(H_2O)_2]$.

C. $Ca[Fe(CN)_5H_2O]$.

D. $K_3[Fe(CN)_5H_2O]$.*

9. What formula corresponds to coordination compound potassium hexacyanoferrate(II)?

A. $K_3[Fe(CN)_6]$.

B. $K_2[Fe(CN)_4]$.

C. $K_4[Fe(CN)_6]$.*

D. $K_4[FeF_6]$.

10. What is coordination number of the central atom in coordination compound $[Pt(NH_3)_2Cl_4]$?

A. 6.*

B. 2.

C. 4.

D. 0.

11. What formula corresponds to the coordination compound chloropentammincobalt(III) hydroxide?

A. $[Co(H_2O)_5Cl](OH)_2$.

B. $[Co(NH_3)_2(OH)_3]$.

C. $[Co(NH_3)_5Cl](OH)_2$.*

D. $[Co(NH_3)_6](OH)_3$.

12. What is the oxidation state of the central atom in the inner sphere ion $[Cr(H_2O)_5(NO_3)]^{2+}$?

A. +3.*

B.+2.

C. -3.

D. +1.

13. What of the coordination compounds is anionic?

A. $Na_3[Cr(OH)_6]$.*

B. $[Cr(H_2O)_4Br_2]Cl$.

C. $[Cr(H_2O)_4PO_4]$.

D. $[Cr(NH_3)_4PO_4]$.

14. What formula corresponds to coordination compound potassium hexanitrocobaltate(III)?

A. $K_4[Co(NO_2)_6]$.

B. $K_3[Co(NO_2)_6]$.*

C. $K_3[Co(NO_2)_4(NH_3)_2]$.

D. $[Co(NH_3)_6]Cl_3$.

15. To which type of coordination compounds does the tetraaquapentamminchromium(III) chloride belong?

A.Neutral.

B. Cationic.*

C. Anionic.

D. Mixing.

16. What formula corresponds to the coordination compound potassium pentacyanoaquaferrate(II)?

A. $K_2[Fe(CN)_5H_2O]$.

B. $K_2[Fe(CN)_4(H_2O)_2]$.

C. $Ca[Fe(CN)_5H_2O]$.

D. $K_3[Fe(CN)_5H_2O]$.*

17. What substance solution doesn't carry electric current?

A. $[Cu(NH_3)_2]Cl$.

B. $[Cu(NH_3)_4]SO_4$.

C. $[Cu(H_2O)_2Cl_2]$.*

D. $[Cu(H_2O)_4](NO_3)_2$.

18. What is the coordination number of the central atom in the coordination compound $[Co(NH_3)_5Cl](NO_2)_2$?

A. 6.

B. 2.

C. 5.

D. 3.*

19. What is the name of the corresponding coordination compound $K_3[Fe(CN)_6]$?

A. Potassium hexacyanoferrate(II).

B. Potassium tetracyanoferrate(III)

C. Potassium hexacyanoferrate(III). *

D. Calcium hexacyanoferrate(III).

20. What ions are mainly formed by dissolving of the coordination compound $Na_3[Co(NO_2)_6]$?

A. Na^+; NO_2^-.

B. Na^+; $[Co(NO_2)_6]^{3-}$.*

C. Co^{2+}; NO^{2-}.

D. Na^+; Co^{3+}; NO_2^-.

21. What is the charge of the inner sphere ion in the coordination compound $K_2[Cu(CN)_4]$?

A. 2^-.*

B. 2^+.

C. 1^+.

D. 1^-.

22. What formula corresponds to the coordination compound dichlorodiamminplatinum?

A. $[Pt(NH_3)_2Cl]Cl$.

B. $[Pt(NH_3)_4]Cl_2$.

C. $[Pt(NH_3)_4Cl_2]$.

D. $[Pt(NH_3)_2Cl_2]$.*

23. What is the oxidation state of the central atom in the inner sphere ion $[Co(NH_3)_4Cl_2]^+$?

A. -1.

B. +2.

C. +3.*

D. -3.

24. Indicate the formula of the coordination compound potassium hexahydroxochromate(III):

A. $Na_2[Cr(OH)_2]$.

B. $Na_3[Cr(H_2O)_6]$.

C. $Na_3[Cr(OH)_6]$.*

D. $Na_4[Cr(OH)_7]$.

25. Medical application of coordination compounds for removing toxic substances is based on:

A. Destruction of less stable coordination compounds.*

B. Solvation of toxins.

C. Restoration of enzyme activity.

D. Oxidation of toxins.

26. Indicate the name of the coordination compound - $[Pt(NH_3)_2Cl_2]$:

A. Dichlorodiamminplatinum(II).*

B. Diaminodichloroplatinate(II).

C Diaminodichloroplatinate(IV).

D. Diaminodichloroplatinate(II).

27. Chelating is used in medicine as:

A. Antidotes.*

B. Analytical reagents.

C. Antidepressants.

D. Coagulants.

28. Select the formula of the coordination compound ammonia dihydroxotetrachloroplatinate(IV):

A. $(NH_4)_2[Pt(OH)_2Cl_4]$.*

B. $(NH_4)[Pt(H_2O)_2Cl_4]$.

C. $(NH_4)_3[Pt(OH)_2Cl_4]$.

D. $(NH_4)_2[Pt(H_2O)_2Cl_4]$.

29. Coordination compounds with polydentate ligands are called:

A. Clusters.

B. Chelates.*

C. Polynuclear.

D.Gomoligand.

30. Indicate the name of the coordination compound $[Ag(NH_3)_2]Cl$:

A. Diamminargentate(I) chloride.

B. Diamminochloridargentum(I).

C. Diamminargentum(I) chloride.*

D. Diamminochlorosilver(I).

31. The bond which has to be present in coordination compounds is:

A. Ionic.

B. Covalent formed according to the donor-acceptor mechanism.*

C. Covalent polar formed according to the exchange mechanism.

D. Hydrogen.

32. What is in the center of the complex?

A. Anion.

B. Cation.

C. Ligand.

D. Complexing agent.*

E. Atom.

33. In the coordination compound $K[Co(NH_3)_2Cl_4]$ the complexing agent is:

A. K^+.

B. Co^{3+}.*

C. NH_3.

D. Cl^-.

34. In the coordination compound $[Cr(NH_3)_5CN]Cl_2$ the complexing agent is:

A. Cr^{3+}.*

B. CN^-.

C. NH_3.

D. Cl^-.

E. Cl_2.

35. What is a ligand in the following complex $K_2[Cu(CN)_4]$?

A. K^+.

B. Cu^{2+}.

C. CN^-.*

D. $[Cu(CN)_4]^{2-}$.

36. Which of these coordination compounds has coordination number equal to 4?

A. $K[Fe(SO_4)_2]$.*

B. $K_2[SnCl_6]$.

C. $[Cu(NH_3)_4]Cl_2$.*

D. $K_4[Fe(CN)_6]$.

37. What is the coordination number of the complexing agent in $K_3[Fe(H_2O)(CN)Cl_4]$:

A. 1.

B. 2.

C. 3.

D. 4.

E. 6.*

38. Indicate a complex with a coordination number 4:

A. $[Ag(NH_3)_2]Cl$.

B. $[Cr(H_2O)_4C1(OH)]Br$.

C. $[Ni(NH_3)_2Cl_2]$.*

D. $K_4[Fe(CN)_6]$.

38. Indicate which of the coordination compounds is of cationic type:

A. $K_2[Zn(OH)_4]$.

B. $[Ni(NH_3)_4]SO_4$.*

C. $K_3[Fe(CN)_6]$.

D. $[Pt(NH_3)_2Cl_2]$.

39. Indicate the charge of the inner sphere ion of the coordination compound $K[Co(NH_3)_2(CN)_4]$.

A. 2+.

B. 3+.*

C. 3-.

D. 2-.

E. 1-.

40. What particles are formed in the solution of the coordination compound $[Fe(CN)(NH_3)_5]Cl_2$ as a result of primary dissociation?

A. Fe^{3+}.

B. CN–.

C. NH_3.

D. $C1_2$.

E. Cl^-.*

41. Which of the coordination compounds formed by iron has charge 3-?

A. $[Fe(CN)_6]$.*

B. $[Fe(H_2O)_6]$.

C. $[Fe(SCN)_3]$.

D. $[Fe(NH_3)_2F_4]$.

42. Indicate coordination compounds in which chromium has an oxidation state +3:

A. $Na_2[Cr(OH)_4]$.

B. $Na[Cr(OH)_4]$.*

C. $[Cr(CO)_6]$.

D. $[Cr(H_2O)_6]C1_3$.*

43. Select the bond type between the central atom and the ligands:

A. Ionic

B. Hydrogen.

C. Covalent polar.

D. Covalent nonpolar..

E. Covalent polar formed according to the donor-acceptor mechanism.*

44. Select the bond type between the inner and outer spheres of the coordination compound:

A. Ionic.*

B. Hydrogen.

C. Covalent polar.

D. Covalent nonpolar.

E. Covalent polar. is formed according to the donor-acceptor mechanism.

45. What inner sphere ion is the most stable?

A. $K_2[CoCl_4]$ ($K_{inst.} = 1{,}3 \cdot 10^{-3}$).

B. $K_2[HgCl_4]$ ($K_{inst.} = 8 \cdot 10^{-13}$).

C. $K_2[PbCl_4]$ ($K_{inst.} = 1 \cdot 10^{-13}$).

D. $K_2[PtCl_4]$ ($K_{inst.} = 1 \cdot 10^{-16}$).*

46. Determine which complex is the most stable comparing the instability constant:

A. $[Ag(NO_3)_2]^+$ ($K_{inst.} = 1{,}3 \cdot 10^{-3}$).

B. $[Ag(NH_3)_2]^+$ ($K_{inst.} = 6{,}8 \cdot 10^{-3}$).

C. $[Ag(S_2O_3)_2]^{3-}$ ($K_{inst.} = 1 \cdot 10^{-13}$).

D. $[Ag(CN)_2]^{-}$ ($K_{inst.} = 1 \cdot 10^{-21}$).*

47. The complexing agent of hemoglobin is:

A. Cu^{+}.

B. Cu^{2+}.

C. Fe^{2+}.*

D. Fe^{3+}.

E. Co^{3+}.

48. In the reaction $Cu^{2+} + 4HOH \rightarrow [Cu(H_2O)_4]^{2+}$ the water is:

A. Acid.

B. Reducing agent.

C. Base.

D. Oxidant.

E. Ligand. *

49. Which central atom can more fully bind the ammonia?

A. Cd^{2+} ($K_{inst.} = 2,8 \cdot 10^{-7}$).

B. Cu^{2+} ($K_{inst.} = 9,3 \cdot 10^{-13}$).

C. Ag^{+} ($K_{inst.} = 5,8 \cdot 10^{-8}$).

D. Co3+ ($K_{inst.} = 6,2 \cdot 10^{-36}$).*

Literature

1. Inorganic Chemistry : textbook / ed.: D. F. Shriver, P. W. Atkins. - 3th ed. - [s. l.] : Oxford University Press, 2004. - 763 p.

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6. LABORATORY WORK

6.1. Preparation of compounds with complex anion

Put 3 drops of$Bi(NO_3)_3$ solution into the test tube, add KI solution by drops until dark brown sedimentation formation. You should add by drops KI solution to the received sedimentation until fully dissolved.

Note the color of the resulting solution. Write down the equation of the reaction. Name the coordination compound. Write down the equation of the general instability constant of the inner sphere ion.

6.2. Preparation of complex aluminate

Instill 1 drop of $A1C1_3$ solution into the test tube and add 1 drop of NaOH solution, you will receive sedimentation. Then add the excess of NaOH solution.

Describe an external effect. Write down the chemical equation. Name the coordination compounds.

6.3. Instability of the inner sphere ions

Instill 2 drops of $CoC1_2$ solution into the test tube and add 3 drops of NH_4SCNconcentrated solution until formation of blue solution. Then add water until decolorization of solution.

Describe an external effect. Write down the chemical equation. Name the coordination compounds.

6.4. Preparation of potassium triiodide (Lugol's solution)

Put 1-2 crystal of iodine and 2 ml of d-water into the test tube. Then add KIconcentrated solution by drops until fully dissolved.

Write down the chemical equation. Name the coordination compounds.

7. TRAINING AND CONTROL MEANS:

– cards for determination of initial level of knowledge and skills;

– control questions;

– tests.

CONTENT