

Educational Establishment  
Belarusian State Technological University

«**APPROVED**»

Vice Rector for Academic Work

\_\_\_\_\_ S. A. Kasperovich  
« \_\_\_ » \_\_\_\_\_ 2013

**CHEMISTRY OF COMPLEX COMPOUNDS**

Syllabus

(Translation from Russian)

Speciality

1-48 01 02 – Chemical Technology of Organic Substances, Materials and Products;  
1-48 01 05 – Chemistry technology of wood processing;  
1-48 02 01 – Biotechnology;  
1-48 02 02 – Technology of medicines;  
1-57 01 03 – Bioecology

Faculty Chemical Technology and Engineering

Department General and Inorganic Chemistry

Year \_\_\_\_\_ 2 \_\_\_\_\_

Semester \_\_\_\_\_ 3 \_\_\_\_\_

Lectures – 26  
(academic hours)

Laboratory classes – 8  
(academic hours)

Total academic hours (classwork): –34

Total academic hours – 50

Credit 3  
(semester)

Form of getting

Attendance full-time

The syllabus is based on the Standard Syllabus for Higher Educational Institutions «Chemistry of complex compounds» approved 1.12.2008, registration number ТД-1.094/тип.

Reviewed and recommended for approval at the meeting of the Department of General and Inorganic Chemistry, educational institution «Belarusian State Technological University»

Minutes No 7 from 29.02.2013  
Head of department

\_\_\_\_\_ I.E.Malashonok

Author

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## EXPLANATORY NOTE

### 1.1. Goals and Objectives of Teaching and Learning of the subject

#### Goal:

- to teach would-be chemical industrial engineer to comprehend the chemistry of complex compounds essence correctly.

#### Objectives:

- to create the students' understanding of the complex compounds structure on the basis of the up-to-date theory of chemical bond;
  - to study the complex compounds classification and nomenclature;
- to study the chemistry of complex compounds, their conduct in solutions and in various interacting;
- to form students' understanding about fields of applications of complex compounds.

### 1.2. Demands to the level of mastering the subject

**Students must have knowledge** about classification, nomenclature and structure of complex compounds. Chemical properties of complex compounds which depend on structure and fields of applications must be considered.

#### The students ought to know:

- the foundations of different theories of chemical bond, which describe structure of complex compounds (theory of valence linkage, theory of crystalline field, theory of ligand field);
- objective laws of complex compounds conduct in solutions depending on their structure and resistance; influence of different factors on equilibrium and reversibility of chemical reactions;

#### The students ought to be able:

- to use nomenclature and knowledge about isomerism;
- to apply the knowledge acquired.

### 1.3. Connection with the subjects, studied before

Chemistry of complex compounds is based on the knowledge acquired while studying subjects: "Theoretical foundations of chemistry", "Inorganic chemistry", "Analytical chemistry", "Organic chemistry".

### Approximate theme outline

Theme	lecture	Laboratory practicals
Introduction	1	–
1. The main notions and terms	3	–
2. Structure and nomenclature of complex compounds	2	–
3. Classification and isomerism of complex compounds	4	–
4. Ligands of complex compounds	4	–
5. Chemical bond in complex compounds	4	–
6. Solutions of complex compounds	2	4
7. Chemical properties of complex compounds	4	4
8. Application of complex compounds	2	–
TOTAL	26	8

## 2. SUBJECT MATTER

### Introduction

Subject “Chemistry of complex compounds” and its place amount other chemical science. Role chemistry of complex compounds in the sphere of nanotechnologies, streamlined synthesis of nanoparticles and monomolecular layers.

### The main notions and terms

Donor atoms. Denticity and ambident behaviour. Polytopness. Coordination polyhedra.

### Structure and nomenclature of complex compounds

Complex compounds. Sequestrant (complexing agent). Ligands, their classification and denticity. Coordination number of atom (ion)- sequestrant. Inside and outside sphere of complex compounds. Nomenclature of complex compounds. Kinds of complex compounds. Intracomplex compounds. Complexonates of metals. Complexes with macrocyclic ligands.

### Classification and isomerism of complex compounds

Complex compounds classification by the type of coordinating ligands. Ammoniates. Aquacomplexes. Anionhalogenates and kationhalogenates. Hydride complexes. Metal carbonyls. Special groups of complex compounds: complexes with unsaturated molecules ( $\pi$ -complex); cyclic complex compounds (chelates); polynuclear complex compounds. Clusters.

Isomerism of complex compounds: geometric (plane symmetric), optical, hydrated, bonded, ionization. Transformational isomerism. Coordination isomerism and polymery. Conformation isomerism.

Complex compounds with coordination number from 2 to 10 and more.

### **Ligands of complex compounds**

Ligands of complex compounds. Molecules of water and hydroxide-ion. Amines. Organic nitriles. Phosphites. Trialkylphosphites. thioethers, mercaptans, ethylene, acetylene and their derivatives. Halogenide-, cyanide-, rhodanide-ions and etc. Mutual influence of ligands in inside sphere of complex compounds. Rules of Peirone and Iergensen. Objective laws of trans-effect and cis-effect.

### **Chemical bond in complex compounds**

Chemical bond in complex compounds, electrostatic. Theory of the valence bond. Valence-shell electron-pair repulsion conception. Theory of crystalline field, method of molecular orbital. Molecules with deficit of electrons.

Chelate effect. Chelate compounds, isomerism of chelate complexes.

### **Solutions of complex compounds**

Equilibrium in solutions of complex compounds. Stepwise character of equilibrium. Stability and instability of complex ions. Factor of influence on their acidic properties, acid-base equilibrium in solutions of hydrated complexes. Polymerization of hydroxocomplexes. Basicity of complex compounds.

### **Chemical properties of complex compounds**

Mechanism of reactions of coordination compounds. Chemical reactivity of coordination ligands of complex compounds. Redox (reduction-oxidation) properties of complex compounds. Kinds of redox transformation of electrode potential.

### **Application of complex compounds**

Application of complex compounds. Analytical and organic chemistry. Catalysis. Dyestuffs. Pigments and etc.

### Teaching and methodic chart of the discipline

Number of the section, topic, lecture	Name of the section, topic, lecture; the list of studied themes	Number of academic hours		Material supplies (visual, methodical teaching aids etc)	Literature	Form of control
		lectures	Laboratory Studies			
	<b>Chemistry of Complex Compounds</b>	26	8			
1, 2	Complex compounds. Sequestrant (complexing agent). Ligands, their classification and denticity. Coordination number of atom (ion)- sequestrant. Inside and outside sphere of complex compounds. Nomenclature of complex compounds. Kinds of complex compounds. Intracomplex compounds. Complexonates of metals. Complexes with macrocyclic ligands.	4	2	Manuals and tutorials	[1,2] [3]	Credit
3	Complex compounds classification by the type of coordinating ligands. Ammoniates. Aquacomplexes. Anionhalogenates and kationhalogenates. Hydride complexes. Metal carbonyls. Special groups of complex compounds: complexes with unsaturated molecules ( $\pi$ -complex); cyclic complex compounds (chelates); polynuclear complex compounds. Clusters.	1	2	Manuals and tutorials	[1,2] [10] [12]	Credit
3, 4	Isomerism of complex compounds: geometric (plane symmetric), optical, hydrated, bonded, ionization. Transformational isomerism. Coordination isomerism and polymery. Conformation isomerism.	2		Manuals and tutorials	[1,2] [5]	Credit
5	Complex compounds with coordination number	1		Manuals and	[1,2]	Credit

	from 2 to 10 and more.			tutorials		
6, 7	Chemical bond in complex compounds, electrostatic. Theory of the valence bond. Valence-shell electron-pair repulsion conception. Theory of crystalline field, method of molecular orbital. Molecules with deficit of electrons.	5		Manuals and tutorials	[1,2] [6] [9,13,14]	Credit
8	Chelate effect. Chelate compounds, isomerism of chelate complexes.	1		Manuals and tutorials	[1,2] [4] [8]	Credit
8, 9	Ligands of complex compounds. Molecules of water and hydroxide-ion. Amines. Organic nitriles. Phosphites. Trialkylphosphites. thioethers, mercaptans, ethylene, acetylene and their derivatives. Halogenide-, cyanide-, rhodanide-ions and etc. Mutual influence of ligands in inside sphere of complex compounds.	2		Manuals and tutorials	[1,2] [12] [13]	Credit
10, 11	Equilibrium in solutions of complex compounds. Stepwise character of equilibrium. Stability and instability of complex ions. Factor of influence on their acidic properties, acid-base equilibrium in solutions of hydrated complexes.	3,5	2	Manuals and tutorials	[1,2] [7] [13]	Credit
11	Polymerization of hydroxocomplexes. Basicity of complex compounds.	0,5		Manuals and tutorials	[1,2]	Credit
12	Redox (reduction-oxidation) properties of complex compounds. Types of redox transformations of complex compounds. Influence of complexation on electrode potential.	2		Manuals and tutorials	[1,2] [5] [12]	Credit
13	Chemical reactivity of coordination ligands of complex compounds. Application of complex compounds. Analytical and organic chemistry. Catalysis. Dyestuffs. Pigments and etc.	2	2	Manuals and tutorials	[1,2] [8] [15]	Credit

## THE LIST OF RECOMMENDED LITERATURE

### a) the main

1. Кукушкин, Ю.Н. Химия координационных соединений / Ю.Н. Кукушкин. – М.: Высшая школа, 1985. – 455 с.
2. Координационная химия: учеб.пособие / В.В.Скопенко [и др.]. – М.: ИКЦ «Академкнига», 2007. – 488 с.

### b) the additional

3. Гринберг, А.А. Введение в химию комплексных соединений / А.А. Гринберг. – 4-е изд., исправленное. – Л.: Химия, 1971. – 631 с.
4. Кукушкин, В.Ю. Теория и практика синтеза координационных соединений / В.Ю. Кукушкин, Ю.Н. Кукушкин; под ред. акад. Н.М.Жаворонкова. – Л.: Наука, 1990. – 260 с.
5. Дятлова, Н.М. Комплексоны / Н.М. Дятлова, В.Я. Темкина, Р.П. Ластовский; под ред. д.х.н. М. Ластовского. – М.: Химия, 1970. – 417 с.
6. Берсукер, И.Б. Электронное строение и свойства координационных соединений: Введение в теорию / И.Б. Берсукер. – 3-е изд., перераб. – Л.: Химия, 1986. – 288 с.
7. Макашев, Ю.А. Соединения в квадратных скобках / Ю.А. Макашев, В.М.Замяткина. – Л.: Химия, 1976. – 216 с.
8. Комплексоны в биологии и медицине: обзорная информация / Химическая промышленность, серия «Реактивы и особо чистые вещества». – М.: НИИТЭХИМ, 1986. – 50 с.
9. Кукушкин, Ю.Н. Соединения высшего порядка / Ю.Н. Кукушкин. – Л.: Химия, 1991. – 112 с.
10. Комплексные соединения: метод. указания по курсу «Общая и неорганическая химия» для студ. спец. 25.03»Технология электрохимических производств» / Л.Н.Новикова, В.Б.Дроздович, И.Г.Гуенько. – Минск: БГТУ, 1993. – 30 с.
11. Волков, А.И. Большой химический справочник / А.И. Волков, И.М.Жарский. – Минск: Современная школа, 2005. – 608 с.
12. Гликина, Ф.Б. Химия комплексных соединений / Ф.Б. Гликина, Н.Г. Ключников. – М.: Просвещение, 1972. – 167 с.
13. Костромина, Н.А. Химия координационных соединений / Н.А. Костромина, В.Н. Кумок, Н.А. Скорик; – под ред. проф. Н.А. Костроминой. – М.: Высшая школа, 1990. – 431 с.
14. Бек, М. Исследование комплексообразования новейшими методами / М. Бек, И. Надьпал. – М.: Мир, 1989. – 408 с.
15. Пешкова, В.М. Методы абсорбционной спектроскопии в аналитической химии / В.М. Пешкова, М.И. Громова. – М.: Высшая школа, 1976. – 279 с.



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**Recommended to be approved by:**

The Department of General and Inorganic Chemistry of Belarusian State Technological University (minutes № 4 from 20.11.2008);

The Scientific-methodology Council of Belarusian State Technological University (minutes № 3 from 24.12.2008)

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Matveiko N.P. – professor, head of the Department of Physicochemistry of materials of Belarusian State Economical University, Doctor of Chemical Science

**Chemistry of Complex Compounds:** Regular Curriculum for Higher Education  
Institution / dev.: V.A. Ashuyko – Minsk: BSTU, 2009. – 8 p.

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University, 2009  
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