NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

AGROBIOLOGICAL FACULTY
DEPARTMENT OF ANALYTICAL AND BIOINORGANIC CHEMISTRY & WATER QUALITY

"APPROVED"
Dean of Faculty of Veterinary Medicine,
Academician of the Ukrainian academy of agrarian sci.,
Doctor in biology, Professor
_____Mykola I. Tsvilikhovskiy
"____"_____, 2020

REWIED AND APPROVED
At the meeting of the department
of Analytical and Bioinorganic
Chemistry & Water Quality
Protocol # 12, "14" May, 2020
Head of the Department
Doctor in Chemistry, Professor
_____V.A.Kopilevich

SYLLABUS

Academic Discipline "INORGANIC CHEMISTRY"
For EL(educational level) "Bachelor"

Branch of knowledge – 21 – Veterinary medicine
Speciality – 211 Veterinary medicine

Syllabus compiled by : Associate Prof. L.V. Voitenko, PhD in Chemistry

Kyiv, 2020

The Working program _Inorganic Chemistry__ for
Branch of Knowledge 21 Veterinary medicine
Speciality 211 Veterinary medicine

"14" May 2020

The developer: L.V.Voitenko, Associate Professor of the Department of Analytical and Bioinorganic Chemistry & Water Quality, PhD in Chemistry
(вказати авторів, їхні посади, наукові ступені та вчені звання)

The Working program was approved at the meeting of the Department of Analytical and Bioinorganic Chemistry & Water Quality

Protocol # 12 "14" May 2020

Head of the Department of Analytical and Bioinorganic Chemistry & Water Quality, Dr.Chem.Sci, Prof.

_____ __(V.A.Kopilevich)
(підпис) (прізвище та ініціали)

Approved by the Scientific Council of Faculty of Veterinary Medicine

Protocol # ____ "____" _____ 2020

Head _____ _____
(підпис) (прізвище та ініціали)

1. Academic discipline description

Inorganic Chemistry (назва)

Field of knowledge, direction, specialty, education and qualification level		
Educational and Qualification level qualification	Bachelor	
Branch of knowledge	21 Veterinary Medicine	
Speciality	211– Veterinary Medicine	
Characteristics of training program		
Type	Ordinary	
The total number of academic hours	120	
Number of ECTS credits allocated	4	
Number of modules	3	
Forms of control	Differential test	
Indicators of academic discipline for full-time and part-time forms of training course		
	Full-time	**Part-time**
Year of study (course)	1	No
Semester	1	
Number of lecture, hours	15	
Number of seminars, practical classes	-	
Laboratory sessions (activities)	45	
Independent study	60	
Individual lessons	-	
Number of weekly in-class academic hours for full-time forms of training	4	

2. Goal and objectives of academic discipline

Inorganic chemistry is the study of inorganic matter and the changes it undergoes in alive bodies.

The discipline studies the theoretical foundations of contemporary Inorganic Chemistry and data about features of bio-elements such as Hydrogen, Halogens, Oxygen, Sulfur, Nitrogen, Phosphorus, Carbon, Tin, Lead, Boron, Aluminum, Alkaline and Alkaline-earth metals, Manganese, Iron, Cobalt, Nickel, Copper, Zinc, Molybdenum, Silver, Mercury, Cadmium, Chromium, Strontium. Chemical processes with these elements and its compounds are shown on the points of view theory of electrolytic dissociation, hydrolysis, redox processes and possibility of complex compound formations. In the labs it is shown the foundations of qualitative tests of mentioned above compounds of bio-elements and its using in the practice of veterinary medicine.

The argument has been made that inorganic chemistry is not a separate branch of chemistry, but simply the application of chemical knowledge (fig. 1).

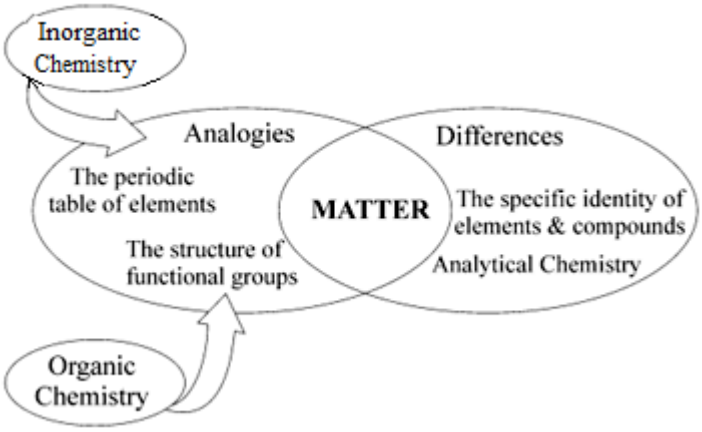


Figure 1 – Inorganic Chemistry as the Chemistry of the differences

In fact, students probably have performed foundations of chemistry of elements in other chemistry courses. For example, many introductory courses in chemistry include qualitative schemes for identifying inorganic ions and quantitative analyses involving titrations.

In general:

– Veterinarians use chemistry to diagnose disease in sick and apparently healthy animals.

– Additionally, veterinarians use chemistry to prescribe medications and treatments for sick animals and monitor response to the treatment.

– One of the most common applications for chemistry occurs when veterinarians analyze test results.

– Veterinarians use their knowledge of chemistry to interpret many diagnostic tests. For example, veterinarians may investigate the pH of an animal's blood.

So, Inorganic Chemistry is united with other chemical sciences with common chemical laws and based on studying of chemical properties of substances. Samples are diverse in nature and include mineral rocks, soils, air, animal tissues, plants, agrochemicals, water, fuel, blood, and medicines.

The Objects of Inorganic chemistry research:

− To empower students to obtain a skills orientated qualification - laboratory technician in biochemical analysis;

− To train veterinary scientists to be employed in various sectors of the animal production ;

− To train specialists for research activity in veterinary;

− To create further opportunities in research and for post-graduate studies;

- To make a national and international contribution to the promotion of research.

In general, *Inorganic chemistry* is the study of the composition, structure, and the properties of substances and the changes they undergo. This definition may suggest to you that chemistry has little to do with everyday life. This is not true. Your way of life would be radically different without the practical applications of chemistry. Imagine a supermarket offering only fruits and vegetables grown

without manufactured fertilizers and pesticides. The quantities and varieties offered would be far fewer. Imagine drinking water from your tap that had not been purified. The unpurified water would probably make you sick. Try to imagine a world without gasoline or heating oil. It would be very different from the world we live in.

A relative new direction of inorganic chemistry is *Inorganic chemistry*. Advances in inorganic chemistry since the 1970s have been driven by three factors: rapid determination of high-resolution structures of proteins and other bio-molecules, utilization of powerful spectroscopic tools for studies of both structures and dynamics, and the widespread use of macromolecular engineering to create new biologically relevant structures. Today, very large molecules can be manipulated at will, with the result that certain proteins and nucleic acids themselves have become versatile model systems for elucidating biological function.

Oxidation-reduction processes continue to be a central theme of biological inorganic chemistry. Well over half of the papers in this special feature deal with biological red-ox reactions in one way or another.

So, to study a course of inorganic chemistry is to understand the basic principles of acid-base processes, reactions in the water medium (dissociation, hydrolysis), red-ox reactions, complexing reactions and so on.

Practical using of the knowledge and skills in inorganic chemistry is the basis for the **applied problems solution** in **veterinary medicine**, especially in:

- Risk analysis during production and processing of animal products and the development of veterinary-sanitary standards to ensure their safety and quality in accordance with modern requirements;
- Scientific support livestock production in concordance with the requirements of Codex Alimentarius;
- Chemical risks monitoring to ensure the production of safe output of good quality;
- Determination of chemical toxicants in products of animal origin and their impact on food safety indicators;
- Effect of water-soluble form of vitamin E on the safety and quality of products of animal origin; development of scientific and methodological approaches to chemical risk analysis during manufacturing, processing and circulation of food and feed products so that to harmonize legal acts.

Control of knowledge and skills

It is realized in the form:

- Control of lab works preparation;
- Theoretical control tests;
- Control experimental problems;
- Final written differential test.

Requirements to the knowledge and skills

Student must to know:

- Safety technique in chemical laboratory;
- Bases of the atomic-molecular studies;
- Chemical properties and biological activities of the main classes of inorganic substances;
- Processes in water solutions (electrolytic dissociation, hydrolysis);
- Notion of a pH, measuring, biological application and features;
- Units of concentration expressing; recalculations;
- Preparation of solutions of different concentration;
- Analytical tests of the basic inorganic cations and anions;
- RedOx theory; chemical ideas of redox processes for realization of biochemical processes (photosynthesis etc.);
- Theory of complex compounds; their biological role; isomerism of complex compounds; preparation and properties.

Student must to be able to do:

- To carry out the chemical experiment using semimicro techniques;
- To compile the equations of chemical reaction of different types (neutralization, simple and double replacing (metathesis); redox; complexing)
- To solve quantitative calculations in concentration of solution;
- To prepare the solution of certain concentration.

Student must to have practical skills:

- Use the educational, methodical and reference literature sources in the field of inorganic chemistry;
- to carry out calculations according to chemical reactions, to carry out chemical experiment by itself;
- To present results of experimental exercises in the form of protocol;
- To make calculations using the computers,
- To prepare equipment, glassware, reagents for analysis;
- To conduct qualitative and quantitative chemical analyses according to methodical rules;
- To carry out a mathematical processing of quantitative analyses, to estimate the mistakes of analysis;
- To present results of experimental exercises in the form of protocol.

Pre-required courses

Course	Chapters of course
Advanced secondary school level	Knowledge in the volume of natural specialization (biology and chemistry) of secondary school
Organic chemistry	Organic dyes and ligands, indicators
High Mathematics	Logarithms and operations with logarithms, degree function
Biophysics	Atomic structure

3. PROGRAM AND STRUCTURE OF SUBJECT

Titles, contents, and extents of the lectures

<u>Змістовий модуль 1.</u> General theoretical notions of Bio-Inorganic Chemistry

Lecture # 1. Introduction. Subject and tasks of Inorganic Chemistry. Chemistry for veterinary medicine.

Atomic-molecular study. The mole concept in chemical calculations. General stoichiometric laws. Allotropy on the example of Carbon (especially fullerenes). Types of chemical reactions in inorganic chemistry.

Lectures # 2-3. The atomic theory and chemical bonding for inorganic compounds. Evolution of atomic ideas. The dual nature of electron. Atomic orbital. Laws of electron distribution around nucleus. The Klechkowsky's rule. Electron formulas. Valency as a function of electron structure. Exited state. Quantum numbers. S-, p-, d- and f-elements. "Octet" configuration and oxidation numbers.

Types of chemical bonding. Mechanism of formation. Biological role of hydrogen bonding. Electronegativity and its using for calculation of chemical bond type. Mendeleev Periodical Table of the chemical elements and Periodical Law.

Змістовий модуль 2. General Laws of chemical transformations without change of oxidation degree

Lecture # 4. Units of Concentration: percent (mass) concentrations (percentage weight by weight; volume by volume etc; Molar, Normal (equivalent), and Titre. Formulas of recalculations of concentration units. Preparation of solutions.

Lecture # 5. Processes in water solutions. The main foundations of electrolytic dissociation theory. Degree of dissociation. Strong and weak electrolytes. Ostwald's dilution Law. Ionic reactions. The main electrolytes in body fluids. Electrolytic drinks.

Water as an electrolyte. Ionic product of water. Notion of pH. Measuring pH. Hydrolysis of Salts. Buffer solutions.

Змістовий модуль 3. General Laws of chemical transformations with change of oxidation degree or valence

Lecture # 6. Redox reactions as processes of electron transfer. Compiling equations of redox reactions. Typical oxidizing and reducing agents. Metals and non-metals as redox agents. Classification of redox reactions. Acids as strong oxidating agents – reacting of metals. Redox reactions in qualitative analysis. Redox reactions in nature and bodies.

Lecture # 7. Verner's Theory of Complex compounds, their chemical nature, type of chemical bonding, isomerism. Coordinative compounds in Chemical qualitative

analysis. Coordinative compounds in nature. Bioinorganic systems as complex compounds.

Lecture # 8. Endemic diseases. Biogeochemical zoning. Human and animal endemic diseases as the results of the abnormal distribution of the chemical elements in the environment.

4. SUBJECT STRUCTURE

Program and structure of the subject

Назви змістових модулів і тем	Кількість годин					
	Денна форма					
	усього	у тому числі				
		лек	практ	лаб	інд	Сам. робота
1	2	3	4	5	6	7
Змістовий модуль 1. General theoretical notions of Inorganic Chemistry						
Тема 1. Introduction. Subject and tasks of Inorganic Chemistry. Chemistry for veterinary medicine. Atomic-molecular study. The mole concept in chemical calculations. General stoichiometric laws. Allotropy on the example of Carbon (especially fullerenes). Types of chemical reactions in inorganic chemistry. Introduction test.	10	2		4		4
Тема 2. The atomic theory and chemical bonding for inorganic compounds. Evolution of atomic ideas. The dual nature of electron. Atomic orbital. Laws of electron distribution around nucleus. The Klechkovsky rule. Electron formulas. Valency as a function of electron structure. Exited state. Quantum numbers. S-, p-, d- and f-elements. “Octet” configuration and oxidation numbers. Types of chemical bonding. Mechanism of formation. Biological role of hydrogen bonding. Electronegativity and its using for calculation of chemical bond type. Mendeleev Periodical Table of the chemical elements and Periodical Law. **Module test**	26	4		6		16
Разом за змістовим модулем 1:	**36**	**6**		**10**		**20**
Змістовий модуль 2. Chemical transformations without change of oxidation degree						
Тема 3. Units of Concentration: percent (mass) concentrations (percentage weight by weight; volume by volume etc; Molar, Normal (equivalent), and Titre.	34	4		18		12

1	2	3	4	5	6	7
Formulas of recalculations of concentration units. Preparation of solutions. Processes in water solutions. The main foundations of electrolytic dissociation theory. Degree of dissociation. Strong and weak electrolytes. Ostwald's dilution Law. Ionic reactions. The main electrolytes in body fluids. Electrolytic drinks. Water as an electrolyte. Ionic product of water. Notion of pH. Measuring pH. Hydrolysis of Salts. Buffer solutions. **Module test**						
Разом за змістовим модулем 2:	**34**	**4**		**18**		**12**
<u>Змістовий модуль 3.</u> General Laws of chemical transformations with change of oxidation degree or valence						
Тема 4. Redox reactions as processes of electron transfer. Compiling equations of redox reactions. Typical oxidizing and reducing agents. Metals and non-metals as redox agents. Classification of redox reactions. Acids as strong oxidating agents – reacting of metals. Redox reactions in qualitative analysis. Redox reactions in nature and bodies.	28	2		10		16
Тема 5. Verner's Theory of Complex compounds, their chemical nature, type of chemical bonding, isomerism. Coordinative compounds in Chemical qualitative analysis. Coordinative compounds in nature. Bioinorganic systems as complex compounds.	17	2		7		8
Тема 6. Endemic diseases. Biogeochemical zoning. Human and animal endemic diseases as the results of the abnormal distribution of the chemical elements in the environment.	5	1				4
Разом за змістовим модулем 3:	**50**	**5**		**17**		**28**
Усього годин:	**120**	**15**		**45**		**60**

4. CHAPTERS OF SEMINAR TRAINING

No planned

5. CHAPTERS OF PRACTICAL TRAINING

No planned

6. LAB TRAINING CHAPTERS

#	Chapter	Hours
1	General rules of working in chemical laboratory. Security techniques. Using of semi-micro method in chemical experiment. Methods of chemicals purification. Control Test: Rest of secondary school	4
2	Principles of nomenclature and classification of inorganic elements and their inorganic compounds. Lab 1. Isolation of slightly soluble compounds – analogs of nature bio-active compounds. Structure of atoms of chemical elements. Electron formulas. Interdependence of biological function and physiological properties of elements and their atomic structure. **Module control test 1.**	6
3	Rules for equations combination in solutions of electrolytes. Lab 2. Preparation of weak electrolytes. Studing of reactions in solution. Rules for equations combination of hydrolysis process and determination of pH. Lab 3. Studing of salt hydrolysis. Indicator determination of pH. Reversibility of hydrolysis. Molecular and ionic reactions of salt hydrolysis, determination of pH. **Module control test 2.**	18
4	RedOx reactions, their classification. Methods of RedOx reaction compilation. Direction of RedOx reactions. Lab 4. Influence of medium to RedOx reactions. Studding of oxidation properties of Potassium Permanganate and Potassium Dichromate. RedOx reactions in Qualitative and Quantitative Analysis. Coordinate compounds of bio-metals. Lab 5. Preparation and studding of properties of coordination compounds of Copper, Iron, Cobalt, Zinc, Nickel. Reactions of coordination compounds in Qualitative and Quantitative Analysis. **Module control test 3.**	17
	Total	45

7. INDEPENDENT STUDY

#	Chapter	Hours
1	Modern concepts of inorganic chemistry. Bioactive compounds.	20
2	Main Concepts of Qualitative Analysis. Notion of Qualitative Chemical reagent, Qualitative test, sensibility of Qualitative test. Analytical classification of Cations and Anions. Main Concepts of Quantitative Analysis. Foundations of Neutralization method, Redox methods.	12
3	RedOx calculation of ionic species of metals of changing valencies in natural systems (iron, manganese). RedOx potential. Typical chemical disinfectants as strong oxiding agents	16
4	Chelates as a food additives, drugs, and analytical reagents. Using of complexones in environmental sanitation.	8
5	General notions of Chemistry of Elements (main and secondary sub-groups) on the examples of basic bio-active elements	4
	Total	60

8. CONTENT OF THEORETICAL QUESTIONS

1. Subjects and tasks of inorganic chemistry.
2. The foundations of atomic-molecular theory. Notions of an atom, molecule, ion, simple and complex compounds, chemical formulas. Allotropy.
3. Types of the chemical reactions.
4. The laws of stoichiometry (law of Safe, Equivalents etc).
5. The mole concept, Avogadro's Number. Relations of amount of substance, numbers of moles.
6. Evolution of atomic ideas.
7. The dual nature of electron.
8. Names and physical content of quantum numbers.
9. General rules for electronic formulas compilation - principle of energy minimum, Pauli exclusion Principle, Rule of Klechkovsky, Hund's Rule.
10. "Filling" of electrons on the examples Cu, Cr, Pd.
11. Electron formulas. Mechanism of exiting.
12. Valence as a function of electron configuration.
13. Types of the chemical bonding (ionic, covalent, metallic, hydrogen).
14. Abnormal water properties as a result of hydrogen bonding. Intermolecular hydrogen bonding in the structure of DNA double helix.
15. The Periodical Law and Mendeleev's Periodical Chart of the chemical elements.
16. Classification of inorganic substances.
17. Relations between the main classes of inorganic substances.
18. The amphoterity as acid-base duality.

19. The preparation and properties of the main classes (oxides, bases, acids, salts).
20. Structural-graphic formulas of chemical compounds. Examples.
21. Solutions. Basic units of concentration (mass concentration, molarity, normality, titr). Recalculations of units.
22. Theory of electrolytic dissociation.
23. Degree of dissociation. Strong and weak electrolytes.
24. Main classes of inorganic substances from viewpoint of theory of electrolytic dissociation.
25. Ionic reactions. Conditions of interactions in the solutions of electrolytes. Examples.
26. Ionic product of water. Notion of pH. Acid-base indicators.
27. Hydrolysis of salts. Types of hydrolysis. Determination of pH.
28. Notion of oxidation numbers. Types of Redox reactions.
29. Balancing of Redox reactions by method of electron balance.
30. Acids as strong oxiding agents. Reactions of metals with acids.
31. Werner's theory of complex compounds.
32. Structure of complex compounds. Preparation of complex compounds.
33. Isomerism of complex compounds.
34. Endemic diseases of humans and animals as the result of chemical disproportion of the non-biotic environment.

Examples of calculation

1. A sample of gaseous substance weighting 0.5 g occupies a volume of 1.12 litre under NTP (standard) conditions. Calculate the molar mass of the substance.

Solution

1 mole of any gaseous substance at NTP occupies 22.4 L.

1.12 L of gaseous substance = 0.5 g

The molar mass of the substance therefore is 10 g/mol.

2. Determine the number of moles of CO_2 in 454 grams of CO_2.

Solution

First, look up the atomic masses for carbon and oxygen from the Periodic Table. The atomic mass of C is 12.01 and the atomic mass of O is 16.00. The formula mass of CO_2 is:

12.01 + 2(16.00) = 44.01

Thus, one mole of CO_2 weighs 44.01 grams. This relation provides a conversion factor to moles CO_2 = 454 g x 1 mol/44.01 g = 10.3 moles.

3. Calculate mass of one water molecule.

Solution

$M(H_2O)$ = 18 g/mol.

1 mol of substance contains Avogadro's number of molecules ($6{,}02\cdot10^{23}$ 1/mol).

So,

So, $6{,}02\cdot10^{23}$ water molecules weight 18 g;

1 water molecule weights x g.

$X = 2{,}99\cdot10^{-23}$ g.

5. To write chemical reactions, demonstated the amphoteric properties of Al_2O_3; $Zn(OH)_2$

Solution

$Al_2O_3 + 6\ HCl = 2\ AlCl_3 + H_2O$

$Al_2O_3 + 6\ NaOH = 2\ Na_3AlO_3 + 3\ H_2O$
$Zn(OH)_2 + 2\ H_2SO_4 = ZnSO_4 + 2\ H_2O$
$Zn(OH)_2 + 2\ NaOH = Na_2[Zn(OH)_4]$

6. To write all possible reactions of $Fe(OH)_3$ and H_2S.

Solution

$2Fe(OH)_3 + 3H_2S = Fe_2S_3 + 6\ H_2O$
$Fe(OH)_3 + 3H_2S = Fe(HS)_3 + 3\ H_2O$
$Fe(OH)_3 + H_2S = FeOHS + 2\ H_2O$
$2Fe(OH)_3 + H_2S = = (Fe(OH)_2)_2S + 2H_2O$.

7. Write possible reactions between the next substances (by pairs):
BeO, $HClO_4$, KOH; P_2O_5

Solution

$BeO + 2\ HClO_4 = Be(ClO_4)_2 + H_2O$
$BeO + 2\ KOH \rightarrow K_2BeO_2 + H_2O$
$3\ BeO + P_2O_5 \rightarrow Be_3(PO_4)_2$
$HClO_4 + KOH \rightarrow KClO_4 + H_2O$
$6\ KOH + P_2O_5 \rightarrow 2\ K_3PO_4 + 3\ H_2O$

8. Describe how you would prepare 125 mL of a 2 N NaOH solution. Calculate mass concentration P (%) of this solution (M(NaOH) = 40 g/mol; d=1,143 g/cm^3).

Solution

V (solution) = 125 mL = 0,125 L
N = 2 g-eg/L
---
m (NaOH) - ?
P - ?
$m\ (NaOH) = N \cdot V_{solution} \cdot E_{solute} = 2\ g\text{-}eq/L \cdot 0{,}125\ L \cdot 40{,}00\ g/mol = 10\ g.$
E(NaOH) = M(NaOH)=40,00 g/mol;
1. Weight 10 g of solid NaOH used analytical balance.
2. Transport weighed example into 125 mL volume flack.
2. Add distilled water to fixed volume.

$$P = \frac{N \cdot E}{10d} = 6{,}999\ \% \approx 7\ \%.$$

9. Write the ionic reactions of dissociation: $Fe(OH)_2$; H_3PO_4; $NaHSO_3$

Solution

$Fe(OH)_2 \leftrightarrow FeOH^+ + OH^-$
$FeOH^+ \leftrightarrow Fe^{2+} + OH^-$
$H_3PO_4 \leftrightarrow H^+ + H_2PO_4^-$
$H_2PO_4^- \leftrightarrow H^+ + HPO_4^{2-}$
$HPO_4^{2-} \leftrightarrow H_+ + PO_4^{3-}$
$NaHSO_3 \leftrightarrow H^+ + HSO_3^-$
$HSO_3^- \leftrightarrow H^+ + SO_3^{2-}$

10. Write the molar, ionic and net ionic (if possible) 1st step hydrolysis equations of salts (See chart of salt solubility). Determine whether the salt is acidic, basic or neutral in aqueous solution:

NH_4I $CoSO_4$ Al_2S_3

Solution

$NH_4I + HOH \leftrightarrow NH_4OH + HI$
$NH_4^+ + I^- + HOH \leftrightarrow NH_4OH + H^+ + I^-$
$NH_4^+ + HOH \leftrightarrow NH_4OH + H^+$ (acidic)
2. $2\ CoSO_4 + 2HOH \leftrightarrow (CoOH)_2SO_4 + H_2SO_4$
$2\ Co^{2+} + 2\ SO_4^{2-} + 2HOH \leftrightarrow 2\ CoOH^+ + SO_4^{2-} + 2H^+ + SO_4^{2-}$

$Co^{2+} + HOH \leftrightarrow CoOH^{+} + H+$ (acidic)

3. $Al_2S_3 + 6HOH \leftrightarrow 2Al(OH)_3 + 3H_2S$

$2Al^{3+} + 2S^{2-} + 6HOH \leftrightarrow 2Al(OH)_3 + 3H_2S$ (neutral)

11. Write the reaction of complex compounds preparation:

$AgCl + KCl \rightarrow$

$NaSCN + Cu(SCN)_2 \rightarrow$

$Cr(OH)_3 + NaOH$ (in excess) $\rightarrow$

Solution:

$AgCl + KCl \rightarrow K[AgCl_2]$

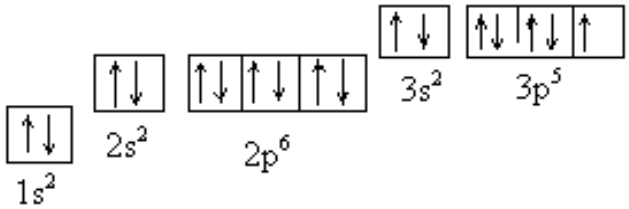
$NaSCN + Cu(SCN)_2 \rightarrow Na_2[Cu(SCN)_4]$

$Cr(OH)_3 + NaOH$ (in excess) $\rightarrow Na_3[Cr(OH)_6]$

12. To compile electron-graphic formula of Cl atom in ground and exited states, determine possible values of valencies and oxidation numbers

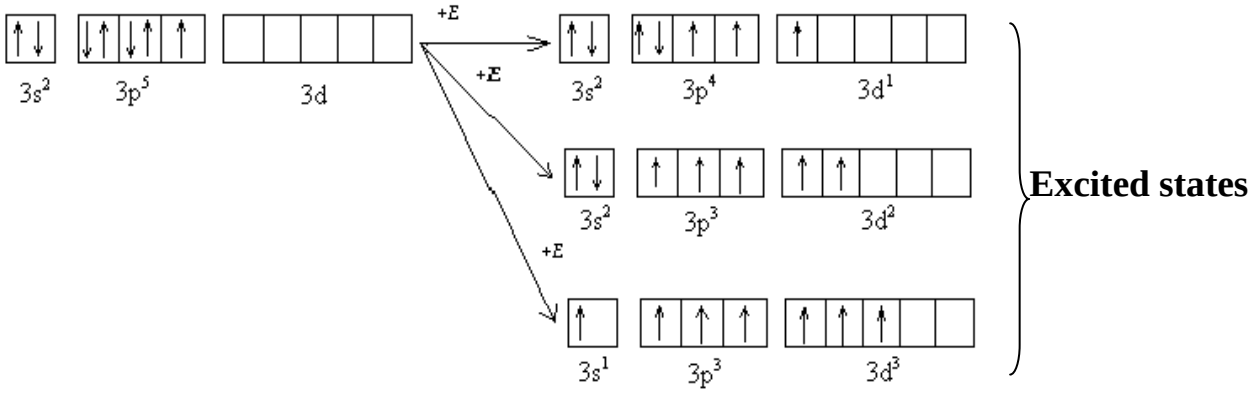
Solution

17Cl $1s^2 2s^2 2p^6 3s^2 3p^5$



Electrons located on the last, third level, may go into free *d*-sublevel when atom was excited.

Ground state



Valencies – I, III, V, VII

Oxidation numbers - -1, 0, +1, +3, +5, + 7

13. To compile the red-ox reaction, balance it electron balancing method, nore redicting and oxiding agents: Zn + HNO_3 (concentrated)

Solution:

$3\ Zn + 8\ HNO_3$ (concentrated) $\rightarrow 3\ Zn(NO_3)_2 + 2\ NO + 4\ H_2O$

$N^{5+} + 3\bar{e} \rightarrow N^{2+}$	2 (reduction, oxiding agent);
$Zn^0 - 2\bar{e} \rightarrow Zn^{2+}$	3 (oxidation, reducing agent).

EXAMPLE OF MODULE TEST
CONTROL TEST 2
GENERAL LAWS OF CHEMICAL TRANSFORMATIONS WITHOUT CHANGE OF OXIDATION STATE OR VALENCE
Variant 1

1. Write the dissociation equations of the following compounds: ***(10 points)***

$Sr(OH)_2$ ↔
$Al_2(SO_4)_3$ ↔
$TiOHCl_3$ ↔
$KHCO_3$ ↔
H_3AsO_4 ↔

2. Write molecular, complete ionic and net ionic (if possible) equations: ***(20 points)***

$CoSO_4 + K_3PO_4 \rightarrow$
$Na_2SO_3 + HI \rightarrow$
$Al(CH_3COO)_3 + NaOH \rightarrow$
$NH_4Cl + LiOH \rightarrow$

3. Write the molar, ionic and net ionic (if possible) 1st step hydrolysis equations of salts (See chart of salt solubility). Determine whether the salt is acidic, basic or neutral in aqueous solution:
(30 points)

NH_4I
$CoSO_4$
Al_2S_3
Na_3PO_4

4. **Calculate equivalent concentration N** of 10% NaOH solution (density d=1,115 g/cm^3, M (NaOH)=40 g/mol).
(20 points)

5. Calculate volume (in mL) of 50% Sulfate acid solution (density d=1,40 g/cm^3) for preparation of 5 L 0,01 N solution (M (H_2SO_4) = 98 g/mol)
(20 points)

TOTAL: 100 points

EXAMPLE OF FINAL TEST

Екзаменаційні питання

1. Valency as a function of electron structure. Notion of "octet" configuration. Mechanism of exiting (example of S). "Filling" of electrons on the example of Cu.

2. Calculate the mass, in grams, of solute for preparing 500 mL of a 0,01 M sucrose ($C_{12}H_{22}O_{11}$) (M=342 g/mol) solution. Calculate promille (‰ or ppt) concentration of this solution (d=1,02 g/cm^3).

Тестові завдання різних типів

1. Point the correspondence of the oxide formulas and their chemical nature:

A.	Basic	**1**	CO
B.	Non-salting	**2**	Cl_2O_7
C.	Acidic	**3**	BaO
D.	Amphoteric	**4**	ZnO

2. The chemical elements of the main sub-group of any group of the Mendeleev's Periodical Chart have the same:

A.	Quantity of electron shells	**C.**	The charge of atomic nucleus
B.	Quantity of the electrons on the last shell	**D.**	The relative atomic weight

3. To write the electron formula of C atom in the ground and exited states

Answer as: C 1s_____

C* 1s_____

4. Note Redox reaction of disproportion type (self-oxidation-reduction):

A.	$3\ S + 6\ KOH \xrightarrow{t,°C} 2\ K_2S + K_2SO_3 + 3\ H_2O$	**C.**	$2FeSO_4 + 2H_2O \leftrightarrow (FeOH)_2SO_4 + H_2SO_4$
B.	$Cl_2 + 2HBr \rightarrow 2HCl + Br_2$	**D.**	$3\ CH_2O + O_2 \xrightarrow{t,°C} CO_2 + H_2O$

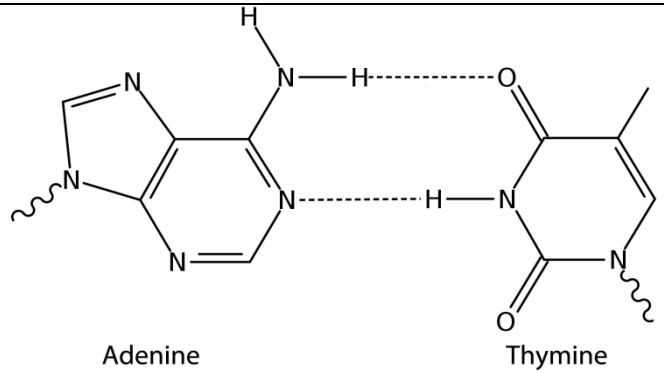
5. Note color of methyl orange indicator in the aqua solution of Na_2CO_3

6. Calculate pH 0,1 N NaOH.

7. Note ionic reaction corresponded to such molecular reaction $CaO + 2HCl = CaCl_2 + H_2O$

A.	$CaO + H_2O \rightarrow CaO + 2H^+$	**C.**	$CaO + 2Cl^- \rightarrow CaCl_2 + O^{2-}$
B.	$CaO + 2H^+ \rightarrow Ca^{2+} + H_2O$	**D.**	$Ca^{2+} + 2HCl \rightarrow CaCl_2 + 2H^+$

8. Point the correctness of the statement: *Multiple <u>ionic</u> bonds are motes the dots on the picture above.*



A.	True	**B.**	False

9. Note the coordinate number of Cr and it's valence in $[Cr(NH_3)_3(H_2O)_3]Cl_3$

10. Determine medium of the RedOx process of $KMnO_4$ and KNO_2, if their products are KNO_3, $MnSO_4$, and K_2SO_4

A.	Neutral	**B.**	Acidic	**C.**	Alkaline

8. TEACHING METHODS

Before teaching a course, the instructor must identify what she or he intends for the students to learn. For most analytical chemistry instructors, this usually involves an assessment of what methods and techniques to include and at what depth to cover them. There are many other skills, though, that will be important to students for their future success. Most university classes in analytical chemistry are taught in a lecture format. An alternative to lecturing is the use of cooperative learning. Cooperative learning offers the potential to develop skills such as teamwork, communication, and problem-solving that are more difficult to impart in a lecture format. The laboratory component of analytical chemistry courses is often an underutilized learning resource. More often than not, the lab is used to demonstrate fundamental wet and instrumental analysis techniques and develop rudimentary laboratory skills. The analytical lab should also be used to develop meaningful problem-solving skills and to demonstrate and have students participate in the entire analytical process.

A teaching method comprises the principles and methods used for students teaching. Commonly used teaching methods for styding subject "Analytical chemistry" include on-time participation, demonstration, recitation, memorization, or combination of these. The choice of teaching method or methods to be used depends largely on the information or skill that is being taught, and it may also be influenced by the aptitude and enthusiasm of the students.

Explaining, or lecturing, is the process of teaching by giving spoken explanations of the subject that is to be learned. Lecturing is often accompanied by visual aids to help students visualize an object or problem.

Demonstrating is the process of teaching through examples or experiments. For example, a chemistry teacher must teach an idea by performing an experiment for students. A demonstration may be used to prove a fact through a combination of visual evidence and associated reasoning.

Demonstrations in analytical chemistry and own experiment are permit to obtain experimental skills needed for environmental monitoring etc. Memorization of a list of facts is a detached and impersonal experience, whereas the same information, conveyed though demonstration, becomes personally relatable. Demonstrations help to raise student interest and reinforce memory retention because they provide connections between bacts and real-world applications of those facts. Lectures, on the other hand, are often geared more towards factual presentation than connective leaning.

Collaboration allows students to actively participate in the leaning process by talking with each other and listening to other points of view. Collaboration establishes a personal connection between students and the topic of study and it helps students think in a less personally biased way. Group projects and discussions are examples of this teaching method. Teachers may employ collaboration to assess students' abilities to work as a team, leadership skills, or presentation abilities.

Collaborative discussions can take a variety of forms, such as fishbowl discussions. After some preparation and with clearly defined roles, a discussion may constitute most a lesson, with the teacher only giving short feedback at the end or in the following lesson.

Learning by teahing in the method, when students assume the role of teacher and teach their peers. Students who each others as a geoup or as individuals must study and understand a topic well enough to teach it to their peers. By having students participate in the teaching process, they gain self-confidence and strengthen their speaking and communication skills.

9. FORMS OF CONTROL

The main forms of knowledge control are control at the lectures at labs and workshops, outside the classrooms, and the consultations, tests and exams.

I. Control of the lectures can be conducted as a selective oral questioning of students or tests using the previously laid material, particularly in sections of the course that are necessary for the understanding of the lecture topics, read, or to establish a degree of mastery of the material lectures (held by the manner of the late first or early second hour lectures). Testing during lectures designed to teach students to systematic elaboration covered material and prepare for the upcoming lectures, establish the degree of assimilation theory to identify the most difficult students to read chapters from the following explanation of them. Control of ther lectures has to subtract time. By spending time to control oral examination yields control, programmable for cards.

II. Current control on laboratory studies conducted to elucidate ready students for employment in the following forms:

1. Writing (30 min.). Control work.

2. Colloquium on separate sections of theoretical courses (modules or themes).

III. Credits. Some subjects (theoretical courses, practical training) is applied differential test of performance appraisal on a five point scale. In a lecture course or its individual parts, which are not accompanied by laboratory or practical classes, the teacher may conduct interviews or colloquium, offer oral or written questions. Often, students are subject to crediting as a minor, insignificant and do not give enough time to prepare for it. Of a major sources before credit of colloquium useful.

Term papers are the product of many days of work. They include elements of scientific research. Protecting course work – a special form of offset in the commission of two or three teachers. Best of course work submitted for scientific student conference.

IV. Examinations. Exam is a final step in the study of the whole or part of the discipline and are designed to test students' knowledge on the theory and identify the skills apply the acquired knowledge in solving practical problems, as well as independent work skills with educational and scientific literature.

Student's rating of knowledge of an academic discipline consists of training work rating – 70 points and final attestation – 30 points. Thus, rating of content modules, that are constituents of an academic discipline, makes 70 points. Rating of content modules as well as attestation rating are also measured by 100-point-scale.

Assessment and grading

Grading system: National scale

National grade	**Grade according to national system**	**Percentage score**
Відмінно	Excellent	90-100
Добре	Very good	82-89
	Good	74-81
Задовільно	Satisfactory	64-73
	Satisfactory enough	60-63
Незадовільно	Unsatisfactory	35-59
	Unsatisfactory – serious work is needed	0-34

10. TECHNOLOGY AND METHODOLOGICAL REQUIREMENTS

У робочому навчальному плані передбачено в одному навчальному семестрі лекцій – 15 годин, лабораторних занять – 30 годин та самостійної роботи - 30 година, що в сумі становить 75 годин (2, 5 кредитів ECTS).

Тривалість навчального семестру – 15 тижнів.

Поточний контроль			Рейтинг з навчальної роботи $R_{НР}$	Рейтинг з додаткової роботи $R_{ДР}$	Рейтинг штрафний $R_{ШТР}$	Підсумкова атестація **(залік диферен-ційний)**	Загальна кількість балів
Змістовий модуль 1	Змістовий модуль 2	Змістовий модуль 3					
0-100	0-100	0-100	0-70	0-10	0-3	0-30	0-100

Відповідно до «Положення про кредитно-модульну систему навчання в НУБіП України», затвердженого ректором університету 03.04.2009 р., рейтинг студента з навчальної роботи $\mathbf{R_{НР}}$ стосовно вивчення певної дисципліни визначається за формулою

$$R_{НР} = \frac{0{,}7 \cdot (R^{(1)}_{ЗМ} \cdot К^{(1)}_{ЗМ} + \ldots + R^{(n)}_{ЗМ} \cdot К^{(n)}_{ЗМ})}{К_{ДИС}} + R_{ДР} - R_{ШТР},$$

де $\mathbf{R^{(1)}_{ЗМ}, \ldots R^{(n)}_{ЗМ}}$ – рейтингові оцінки змістових модулів за 100-бальною шкалою;

n – кількість змістових модулів;

$\mathbf{К^{(1)}_{ЗМ}, \ldots К^{(n)}_{ЗМ}}$ – кількість кредитів ECTS, передбачених робочим навчальним планом для відповідного змістового модуля;

$\mathbf{К_{ДИС} = К^{(1)}_{ЗМ} + \ldots + К^{(n)}_{ЗМ}}$ – кількість кредитів ECTS, передбачених робочим навчальним планом для дисципліни у поточному семестрі;

$\mathbf{R_{ДР}}$ – рейтинг з додаткової роботи;

$\mathbf{R_{ШТР}}$ – рейтинг штрафний.

Наведену формулу можна спростити, якщо прийняти $\mathbf{K^{(1)}_{ЗМ} = \ldots = K^{(n)}_{ЗМ}}$. Тоді вона буде мати вигляд:

$$R_{НР} = \frac{0{,}7 \cdot (R^{(1)}_{ЗМ} + \ldots + R^{(n)}_{ЗМ})}{n} + R_{ДР} - R_{ШТР}.$$

Навчальне навантаження студента для їх вивчення та засвоєння складає:

1-й модуль (**R_1**) – 1,0 кредит ($К_1$)

2-й модуль (**R_2**) – 1,0 кредит ($К_2$)

3-й модель (R_3) – 0,5 кредита ($К_3$)

Критерії оцінки змістових модулів:

R_1 складається з 3-х лабораторних робіт, самостійної та контрольної роботи. Захист практичних робіт та виконання самостійної роботи оцінюються від 5 до 10 балів кожна. Контрольна робота № 1 та 2 оцінюється від 0 до 50 балів.

R_2 складається з 2 лабораторних робіт, самостійної та контрольної роботи. Захист практичної роботи та виконання самостійної роботи оцінюються від 5 до 10 балів кожна. Контрольна робота № 2 оцінюється від 0 до 50 балів кожна.

R_3 складається з 2 лабораторних робіт, самостійної та контрольної роботи. Захист практичної роботи та виконання самостійної роботи оцінюються від 5 до 10 балів кожна. Контрольна робота № 3 оцінюється від 0 до 50 балів.

Рейтинг з додаткової роботи **$R_{ДР}$** додається до **$R_{НР}$** і не може перевищувати 10 балів. Він визначається лектором і надається студентам рішенням кафедри за виконання робіт, які не передбачені навчальним планом, але сприяють підвищенню рівня знань студентів з дисципліни.

Рейтинг штрафний **$R_{ШТР}$** не перевищує 3 балів і віднімається від **$R_{НР}$**. Він визначається лектором і вводиться рішенням кафедри для студентів, які матеріал змістового модуля засвоїли невчасно, не дотримувалися графіка роботи, пропускали заняття тощо.

Для допуску до атестації студенту необхідно набрати з навчальної роботи не менше 60% з кожного змістового модуля, а загалом не менше, ніж 42 бали з навчальної роботи.

Реальний рейтинг з дисципліни $R_{дис.}$ Визначається за формулою:

$$R_{дис.} = R_{нр.} + R_{ат}$$

Форма контролю – залік.

Атестації з дисципліни в цілому оцінюються за 100 бальною шкалою.

11. REQUIRED AND RECOMMENDED LITERATURE

Basic

1. Chambers, C., Holliday A.K. Modern Inorganic Chemistry. http://www.torrentz.com/be251001769c5a5cebbaa177a46e524d225fdff2
2. Glinka N.N. General Chemistry. Moscow: Nauka, 1966.
3. Inorganic Chemistry. Manual//Voytenko L., Kosmatiy V., Kopilevich V. - Kyiv: NAU Publish., 2004. - 148 pp.
4. Workbook for specialist' student in veterinary medicine. Subject Bio-Inorganic chemistry and examples of tests (part I). –NUBIP Publish., 2010. – 120 pp.
5. Workbook for specialist' student in veterinary medicine. Subject Bio-Inorganic chemistry and examples of tests (part II). –NUBIP Publish., 2010. – 100 pp.

Supplemental

1. Vogel 's Textbook of macro and semimicro qualitative inorganic analysis, 5th Edition, revised by G. Svehla, Queen's University, Belfast, Longman Co., 1979.

2. О.І. Карнаухов, Д.О. Мельничук, К.О. Чеботько, В.А. Копілевич. Загальна та біонеорганічна хімія. – К.: Фенікс, 2001. – 678 с.

12. NORMATIVE LITERATURE

1. ISO 6353-2:1983 Reagents for chemical analysis – Part 2: Specifications – First series.
2. ISO 6353-2:1983/Add.2:1986(en) Reagents for chemical analysis — Part 2: Specifications — First series ADDENDUM 2.
3.

13. IT RESOURCES

1. VIPEr. Virtual inorganic pedagogical electronic resource: a community for teachers and students of inorganic chemistry. Bioinorganic chemistry. - https://www.ionicviper.org/subdiscipline/Bioinorganic%20Chemistry
2. Periodical Table - http://www.webqc.org/periodictable.php.
2. Calculator of Molar weight (FW) - http://www.graphpad.com/quickcalcs/Molarityform.cfm
3.Units convertor - http://www.webqc.org/unitconverters.php.
4. pH calculator - http://www.webqc.org/phsolver.php.
8. Sigma-Aldrich reagents - https://www.sigmaaldrich.com/