NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

AGROBIOLOGICAL FACULTY
DEPARTMENT OF ANALYTICAL AND BIOINORGANIC CHEMISTRY & WATER QUALITY

"APPROVED"
Acting Dean of the Faculty of Plant Protection,
the Biotechnologies, and Ecology
Dr.Agr.Sci, Docent _____Yu. V. Kolomiets
"____"_____, 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
Dr.Chem.Sci, Prof. _____V.A.Kopilevich

SYLLABUS

Academic Discipline "CHEMISTRY I (INORGANIC AND BIO-INORGANIC)"
Foe EL (educational level) "Bachelor"

Branch of knowledge – 10 Natural Sciences
Speciality – 101 Ecology

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

Kyiv, 2020

The Working program _“Chemistry I (inorganic and bio-inorganic)” for
Students of Branch of knowledge – 10 Natural Sciences
Speciality – 101 Ecology

“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 Plant Protection, the Biotechnologies, and Ecology Faculty

Protocol # ____ “____” _____ 2020

Head Dr.Agr.Sci, Docent _____ Yu. V. Kolomiets
(підпис) (прізвище та ініціали)

1. Academic discipline description

Chemistry(I) (Inorganic and Bioinorganic) (назва)

Field of knowledge, direction, specialty, education and qualification level		
Educational and Qualification level qualification	Bachelor	
Branch of knowledge	10 Natural Sciences	
Speciality	101 – Ecology	
Characteristics of training program		
Type	Ordinary	
The total number of academic hours	209	
Number of ECTS credits allocated	7	
Number of modules	4	
Forms of control	Written final examination	
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	60	
Number of seminars, practical classes	-	
Laboratory sessions (activities)	90	
Independent study	59	
Individual lessons	-	
Number of weekly in-class academic hours for full-time forms of training	10	

2. Goal and objectives of academic discipline

Contamination by inorganic chemicals is a global issue, and such toxic chemicals are found practically in all ecosystems. It is the inappropriate management of such waste (e.g., through haphazard and unregulated disposal) that poses negative impacts on the environment.

It is **the purpose** of the discipline is to learn the various aspects of inorganic chemicals and the environment and the role that inorganic can play dealing with the various issues of the environment. Students will be presented with the definitions and explanations of terms related to inorganic chemistry and how inorganic chemistry can be understood and used and the effects of the chemical on the environment.

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.

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:

– Students in the environmental sciences use chemistry to study the anthropogenic pollution of the ecosphere (air, natural waters, soils) and chemical composition of alive bodies and non-biotic matter.

– One of the most common applications for chemistry occurs when environmental scientists analyze monitoring results.

– Ecologists use their knowledge of chemistry to analyze and interpret models of the environmental pollutions.

So, Inorganic and Bioinorganic 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 and Bioinorganic chemistry research:

- To empower students to obtain a skills orientated qualification - laboratory technician in environmental chemical analysis;
- To train ecologists to be employed in various sectors of the environmental monitoring;
- To train specialists for research activity in ecology and environmental protection;
- 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 and bioinorganic chemistry* is the study of the composition, structure, and the properties of substances and the changes they undergo. This definition may suggest that chemistry has little to do with everyday life. But really we live in chemical world.

A student ecologist must understand that his task is to diagnose the environment. This can only be done on the basis of objective data from an analysis of her condition. It’s not enough to say that the environment is bad or good. It is necessary to have evidence in the form of chemical parameters of composition and properties. Therefore, chemical training for environmentalists is the main tool for obtaining accurate information about the state of the biosphere.

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.

Bioinorganic chemistry studies the function of bio-active compounds included atoms of a few metals or non-metals (excluded "Big Six"), particularly metal-complex compounds (ferine, chlorophyll etc.) and their catalyst functions in biochemical cycles.

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

- Establishing of the chemical composition of the environment needed for the normal function of the biogeocenoses;
- Risk analysis during production and processing of artificial products and the development of environmental standards to ensure their safety and quality in accordance with modern requirements;
- Chemical risks monitoring;
- Determination of chemical toxicants in the environment.

Control of knowledge and skills

It is realized in the form:

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

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.
- Chemical properties of the main groups of the bio-active elements and their transformations in the environmental conditions.

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 and bio-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

Змістовий модуль 1. General theoretical foundations of Inorganic and Bioinorganic Chemistry

Lecture # 1. Introduction. Subject and tasks of Inorganic and bioinorganic Chemistry. Chemistry for the environmental protection. Chemiphobia and Zonnerism.

Lecture # 2. The foundations of atomic-molecular study. The mole concept in chemical calculations.

Lecture # 3. General stoichiometric laws. Allotropy on the example of Carbon (especially fullerenes). Types of chemical reactions in inorganic chemistry.

Lecture # 4. The atomic theory and chemical bonding for inorganic compounds. Evolution of atomic ideas. The dual nature of electron. Atomic orbital.

Lecture # 5. 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.

Lecture # 6. 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.

Lecture # 7. Periodic Properties: Atomic and ionic radii, ionization energy, electron affinity and electronegativity definition, methods of determination or evaluation, trends in periodic table and applications in predicting and explaining the chemical behaviour.

Lecture # 8. Chemical kinetics. The rate of the chemical reactions. The Law of acting masses. Factors affecting on the rate (pressure, temperature, catalyst).

Lecture # 9. Chemical equilibrium. Constant of equilibrium. Factors affecting on equilibrium shifting according to Le Chatelier's principle.

Lecture # 10. Chemical kinetics and equilibrium principles and "greenhouse" effect.

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

Lecture # 11. 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 # 12. Processes in water solutions. The main foundations of electrolytic dissociation theory. Degree and constant of dissociation. Strong and weak electrolytes. Ostwald's dilution Law.

Lecture # 13. Ionic reactions. The main electrolytes in body fluids. Electrolytes and osmosis phenomena in the biology.

Lecture # 14. 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 # 15. Redox reactions as processes of electron transfer. Compiling equations of redox reactions. Typical oxidizing and reducing agents.

Lecture # 16. Metals and non-metals as redox agents. Classification of redox reactions. Acids as strong oxidating agents – reacting of metals. Electrofe potential. Activity of metals. Redox reactions in qualitative analysis. Redox reactions in nature and bodies.

Lecture # 17. Verner's Theory of Complex compounds, their chemical nature, type of chemical bonding, isomerism.

Lecture # 18. Coordinative compounds in Chemical qualitative analysis. Coordinative compounds in nature. Bioinorganic systems as complex compounds.

Змістовий модуль 4. Bioinorganic properties and application of the main groups of the chemical elements

Lecture # 19. Chemistry of Hydrogen.

Lecture # 20. Chemistry of the Noble gases.

Lecture # 21. Chemistry of the Halogens.

Lecture # 22. Chemistry of Oxygen.

Lecture # 23. Chemistry of Sulfur.

Lecture # 24. Chemistry of Nitrogen.

Lecture # 25. Chemistry of Phosphorus.

Lecture # 26. Chemistry of Boron and Aluminium.

Lecture # 27. Chemistry of Alkaline and Alkali-Earth elements.

Lecture # 28. Chemistry of the transition elements.

Lecture # 29. Chemistry of the rare elements.

Lecture # 30. The chemical processes controlling transformations of the chemical compounds 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 and Bioinorganic Chemistry						
Тема 1. Introduction. Subject and tasks of Inorganic and bioinorganic Chemistry. Chemistry for the environmental protection. Chemiphobia and Zonnerism. The foundations of atomic-molecular study. The mole concept in chemical calculations. General	11	6		4		1

stoichiometric laws. Allotropy on the example of Carbon (especially fullerenes). Types of chemical reactions in inorganic chemistry.						
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 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. Periodic Properties: Atomic and ionic radii, ionization energy, electron affinity and electronegativity definition, methods of determination or evaluation, trends in periodic table and applications in predicting and explaining the chemical behaviour.	19	8		8		3
Тема 3. Chemical kinetics. The rate of the chemical reactions. The Law of acting masses. Factors affecting on the rate (pressure, temperature, catalyst). Chemical equilibrium. Equilibrium constant. Factors affecting on equilibrium shifting (Le Chatelier's principle). Chemical kinetics and equilibrium principles and "greenhouse" effect.	15	6		8		1
Разом за змістовим модулем 1:	**45**	**20**		**20**		**5**
Змістовий модуль 2. Chemical transformations without change of oxidation degree						
Тема 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. Processes in water solutions. The main foundations of electrolytic dissociation theory. Degree and constant of dissociation. Strong and weak electrolytes. Ostwald's dilution Law. Ionic reactions. The main electrolytes in body fluids. Electrolytes and osmosis phenomena in the biology. Water as an electrolyte. Ionic product of water. Notion of pH. Measuring pH. Hydrolysis of Salts. Buffer solutions.	43	8		20		15
Разом за змістовим модулем 2:	**43**	**8**		**20**		**15**

1	2	3	4	5	6	7
<u>Змістовий модуль 3.</u> General Laws of chemical transformations with change of oxidation degree or valence						
Тема 5. Lecture # 15. Redox reactions as processes of electron transfer. Compiling equations of redox reactions. Typical oxidizing and reducing agents. Lecture # 16. Metals and non-metals as redox agents. Classification of redox reactions. Acids as strong oxidating agents – reacting of metals. Electrofe potential. Activity of metals. Redox reactions in qualitative analysis. Redox reactions in nature and bodies.	24	4		10		10
Тема 6. 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.	23	4		10		9
Разом за змістовим модулем 3:	**47**	**8**		**20**		**19**
<u>Змістовий модуль 4.</u> Bioinorganic properties and application of the main groups of the chemical elements						
Тема 7. Inorganic and Bioinorganic Chemistry of Hydrogen, the Noble gases, the Halogens, Oxygen, Sulfur, Nitrogen, Phosphorus, Boron and Aluminium; Alkaline and Alkali-Earth elements; the transition elements; the rare elements. Acidic rains etc. The chemical processes controlling transformations of the chemical compounds in the environment.	74	24		30		20
Разом за змістовим модулем 4:	**74**	**24**		**30**		**20**
Усього годин:	**209**	**60**		**90**		**59**

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	10
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.**	10
3	Rules for equations combination in solutions of electrolytes. Lab 2. Preparation of weak electrolytes. Studing of reactions in the water 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.**	20
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.**	20
5	Inorganic and Bioinorganic Chemistry of the chemical elements Lab 6. Research of the chemical properties of the Hydrogen Lab 7. Research of the chemical properties of the Halogens Lab 8. Research of the chemical properties of Sulfur.	30

	Lab 9. Research of the chemical properties of Oxygen Lab 10. Research of the chemical properties of Nitrogen Lab 11. Research of the chemical properties of Phosphorus Lab 12. Research of the chemical properties of Boron and Aluminium Lab 13. Research of the chemical properties of Alkaline and Alkali-Earth elements Lab 14. Research of the chemical properties of the transition elements Lab 15. Research of the chemical properties of the rare elements. **Module control test 4.**	
	Total	**90**

7. INDEPENDENT STUDY

#	Chapter	Hours
1	Modern concepts of inorganic chemistry. Bioactive compounds.	5
2	Main Concepts of biological activity of the chemical elements	15
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	19
4	Chelates as a food additives, drugs, and analytical reagents. Using of complexones in environmental sanitation.	10
5	General notions of Chemistry of Elements (main and secondary sub-groups) on the examples of basic bio-active elements	10
	Total	**59**

8. CONTENT OF THEORETICAL QUESTIONS

1. Subjects and tasks of inorganic and bio-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. The main concepts of the chemical kinetics. How to regulate the rate of the homogeneous and heterogeneous chemical processes.
17. The conception of the chemical equilibrium and its application to the describing of the environmental problems (e.g., "greenhouse effect").
18. Classification of inorganic substances.
19. Relations between the main classes of inorganic substances.
20. The amphoterity as acid-base duality.
21. The preparation and properties of the main classes (oxides, bases, acids, salts).
22. Structural-graphic formulas of chemical compounds. Examples.
23. Solutions. Basic units of concentration (mass concentration, molarity, normality, titr). Recalculations of units.
24. Theory of electrolytic dissociation.
25. Degree of dissociation. Strong and weak electrolytes.
26. Main classes of inorganic substances from viewpoint of theory of electrolytic dissociation.
27. Ionic reactions. Conditions of interactions in the solutions of electrolytes. Examples.
28. Ionic product of water. Notion of pH. Acid-base indicators.
29. Hydrolysis of salts. Types of hydrolysis. Determination of pH.
30. Notion of oxidation numbers. Types of Redox reactions.
31. Balancing of Redox reactions by method of electron balance.
32. Acids as strong oxiding agents. Reactions of metals with acids.
33. Werner's theory of complex compounds.
34. Structure of complex compounds. Preparation of complex compounds.
35. Isomerism of complex compounds.
36. The distribution in the nature, isolation, main chemical properties of the bio-active chemical elements and their compounds.

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-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) $\rightarrow$

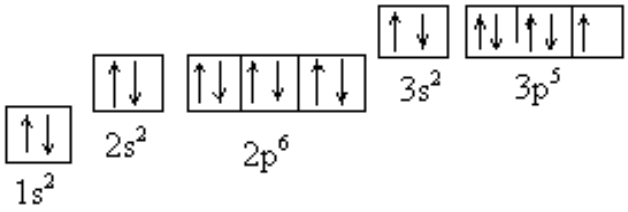
Solution:

$AgCl + KCl \rightarrow K[AgCl_2]$
$NaSCN + Cu(SCN)_2 \rightarrow Na_2[Cu(SCN)_4]$
$Cr(OH)_3 + NaOH$ (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

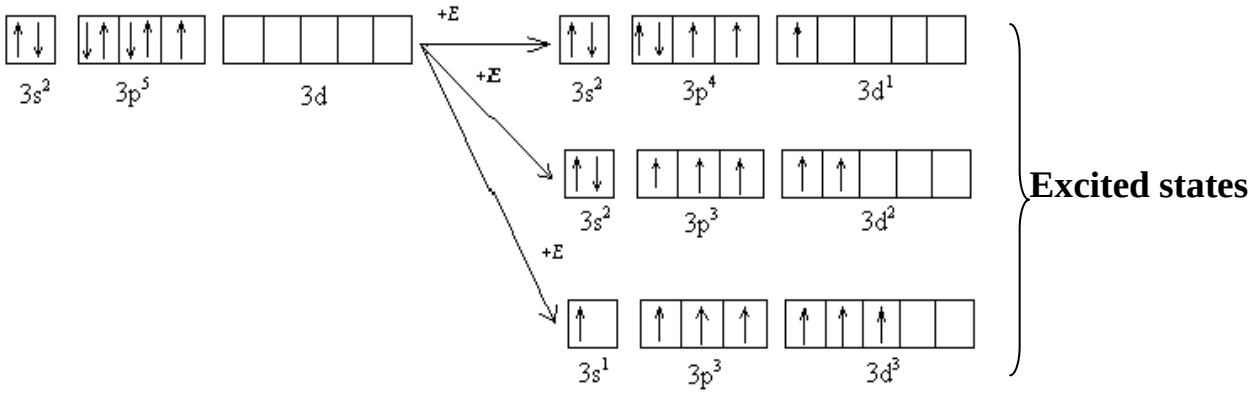
Solution

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) → 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
MODULE CONTROL TEST 3
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)***
$CoSO_4 + K_3PO_4$ →
$Na_2SO_3 + HI$ →
$Al(CH_3COO)_3 + NaOH$ →
$NH_4Cl + LiOH$ →

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

Екзаменаційні питання

1. 10 points Describe subject of Chemistry, the importance of Chemistry for modern society. How Does Chemistry transform the Environment? What is Chemophobia? Typical objects of chemophobia (parabens, preservatives, laundry detergents, contained phosphates etc.). Zohnerism phenomenon (e.g., DMHO hoax, structured drinking water, etc.).

2. 10 points Explain the Non-metals position in the Periodical Chart of Chemical Elements. Describe the features of their atomic structure, physical properties. Bioactive activities of non-metals ("Big Six"). General RedOx properties of free non-metals. Chemistry of Hydrogen: abundance, isotopes. "Heavy water" D_2O and its biological effects. Production of free Hydrogen. Uses of free Hydrogen, included as ecologically safe fuel.

Тестові завдання різних типів

1. 1 point Indicate the correspondence of the salt formulas and medium in their water solutions:

A.	$CaCl_2$	**1**	Neutral
B.	$Al_2(SO_4)_3$	**2**	Alkaline
C.	NH_4NO_2	**3**	Acidic
D.	$Ca(ClO)_2$		

2. 1 point Note net ionic reaction corresponded to molecular reaction $(CH_3COO)_2Zn + 2NH_4OH = Zn(OH)_2 + 2NH_4CH_3COO$

A.	$CH_3COO^- + H^+ \rightarrow CH_3COOH$
B.	$Zn^{2+} + 2NH_4OH \rightarrow Zn(OH)_2 + 2OH^-$
C.	$CH_3COO^- + NH_4OH \rightarrow NH_4^+ + CH_3COO^- + OH^-$
D.	No net ionic form

3. 1 point Complete RedOx reaction with the electron balance. Calculate sum of coefficients.

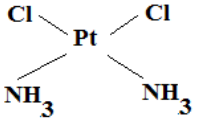
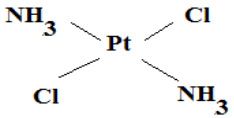
$Na_2SO_3 + Na_2S + H_2SO_4 \rightarrow$

4. 1 point Determine the correspondence of the biological functions of the chemical elements in the human body:

A.	Basic element of organic life	**1**	C
B.	Micronutrient needed for thyroxin synthesis, marine products are enriched by it	**2**	Fe
C.	Component of blood gem	**3**	Co
D.	Micronutrient, component of vitamin B_{12}	**4**	I

5. 1 point The structure of the last energy level of the Halogens is:

A.	ns^2np^3
B.	ns^2np^5
C.	ns^2np^4
D.	ns^2np^6

6. 1 point The following two complex compounds  and  are

A.	*Cis-trans* isomers
B.	Isotopes
C.	Weak electrolytes
D.	Copolymers

7. 1 point Determine the correctness of the statement: *All soluble salts are strong electrolytes.*

A.	False	**B.**	True

8. Calculate weight of lead nitrate, $Pb(NO_3)_2$ (M=331,2 g/mol) for preparation 0,200 L of 0.0100 N $Pb(NO_3)_2$.

A.	0,053 g	**B.**	0,331 g	**C.**	8,694 g	**D.**	16,56 g	**E.**	0,828 g

9. 1 point Determine atoms or ions may be only reducing agents *(possible more than one true answer):*

A	Cl^-	**D**	Ca^0
B	S^{-2}	**E**	Fe^{2+}
C	C^0	**F**	Cl^{7+}

10. 1 point Write the equation of complex compound formation *(coordination number of central atom is 6):* $CoCl_2 + NH_3$ *(in excess)* →

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 group 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

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

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 $\mathbf{К^{(1)}_{ЗМ} = \ldots = К^{(n)}_{ЗМ}}$. 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/