**КАБІНЕТ МІНІСТРІВ УКРАЇНИ**

**НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ БІОРЕСУРСІВ І ПРИРОДОКОРИСТУВАННЯ УКРАЇНИ**

Агробіологічний факультет

**Кафедра аналітичної і біонеорганічної хімії та якості води**

**«ЗАТВЕРДЖУЮ»**
Декан факультету захисту рослин,
біотехнологій і екології
д. с.-г. н., професор _____ Ю.В. Коломієць
“ ” _____ 2022 р.

**«СХВАЛЕНО»**
на засіданні кафедри аналітичної
і біонеорганічної хімії та якості води
Протокол № 12 від 23.05.2022 р.
Завідувач кафедри
д. х. н., проф. _____ В.А. Копілевич

**«РОЗГЛЯНУТО»**
Гарант ОП Екологія
д. пед. н., проф. _____ В.М. Боголюбов

**NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE**

**AGROBIOLOGICAL FACULTY**
**DEPARTMENT OF ANALYTICAL AND BIOINORGANIC CHEMISTRY & WATER QUALITY**

**"CONFIRMED"**
Dean of the Faculty of Plant Protection,
the Biotechnologies, and Ecology
Dr. Agr. Sci, Prof. _____ Yu. V. Kolomiets
"____"_____, 2022

**«APPROVED»**
At the meeting of the department
of Analytical and Bioinorganic
Chemistry & Water Quality
Protocol # 12, "23" May, 2022
Head of the Department
Dr.Chem.Sci, Prof. _____V.A.Kopilevich

**«REWIED»**
Guarantor of Educational Program Ecology
Dr. Pedagogical Sci, Prof. _____V.M. Bogolyubov

# SYLLABUS

## Academic Discipline
## "CHEMISTRY 1 (INORGANIC & BIOINORGANIC)"

**Speciality – 101 Ecology**
**Educational Program - Ecology**
**Faculty Plant Protection, the Biotechnologies, and Ecology**
**Syllabus was created by: Associate Prof. Cand. Chem Sci L.V. Voitenko**

Kyiv, 2022

## 1. ACADEMIC DISCIPLINE DESCRIPTION

CHEMISTRY 1 (INORGANIC AND BIOINORGANIC)

(назва)

| **Field of knowledge, specialty, educational program, educational level** | | |
|---|---|---|
| Educational level | Bachelor | |
| Speciality | 101 - Ecology | |
| Educational program | Ecology | |
| **Characteristics of the educational program** | | |
| Type | Ordinary (standard) | |
| The total number of academic hours | 209 | |
| Number of modules | 4 | |
| Number of ECTS credits | 7 | |
| Forms of control | Written Exam | |
| **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 | |
| Lectures | 60 hours | |
| Laboratory training | 90 hours | |
| Independent study, | 59 hours | |
| Number of weekly in-class academic hours for full-time forms of training | 10 | |

## 2. GOAL, OBJECTIVES, AND COMPETENCES OF THE 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 goal** 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.

**Student's knowledge skills are:**

- 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.
- 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's professional skills are:**

- 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.<br>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.<br>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).<br>Chemical equilibrium. Equilibrium constant. Factors affecting on equilibrium shifting (Le Chatelier's principle).<br>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.<br>Processes in water solutions. The main foundations of electrolytic dissociation theory. Degree and constant of dissociation. Strong and weak electrolytes. Ostwald's dilution Law.<br>Ionic reactions. The main electrolytes in body fluids. Electrolytes and osmosis phenomena in the biology.<br>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.<br>Lecture # 16. Metals and non-metals as redox agents. Classification of redox reactions. Acids as strong oxidating agents – reacting of metals. Electrode 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.<br>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.<br>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.<br>Control Test: Rest of secondary school | 10 |
| 2 | Principles of nomenclature and classification of inorganic elements and their inorganic compounds.<br>Lab 1. Isolation of slightly soluble compounds – analogs of nature bio-active compounds.<br>Structure of atoms of chemical elements. Electron formulas. Interdependence of biological function and physiological properties of elements and their atomic structure.<br>**Module control test 1.** | 10 |
| 3 | Rules for equations combination in solutions of electrolytes.<br>Lab 2. Preparation of weak electrolytes. Studing of reactions in the water solution.<br>Rules for equations combination of hydrolysis process and determination of pH.<br>Lab 3. Studing of salt hydrolysis. Indicator determination of pH. Reversibility of hydrolysis. Molecular and ionic reactions of salt hydrolysis, determination of pH.<br>**Module control test 2.** | 20 |
| 4 | RedOx reactions, their classification. Methods of RedOx reaction compilation. Direction of RedOx reactions.<br>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.<br>Coordinate compounds of bio-metals.<br>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.<br>**Module control test 3.** | 20 |
| 5 | Inorganic and Bioinorganic Chemistry of the chemical elements<br>Lab 6. Research of the chemical properties of the Hydrogen<br>Lab 7. Research of the chemical properties of the Halogens<br>Lab 8. Research of the chemical properties of Sulfur. | 30 |

| | | |
|---|---|---|
| | Lab 9. Research of the chemical properties of Oxygen<br>Lab 10. Research of the chemical properties of Nitrogen<br>Lab 11. Research of the chemical properties of Phosphorus<br>Lab 12. Research of the chemical properties of Boron and Aluminium<br>Lab 13. Research of the chemical properties of Alkaline and Alkali-Earth elements<br>Lab 14. Research of the chemical properties of the transition elements<br>Lab 15. Research of the chemical properties of the rare elements.<br>**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).<br>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.

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

**n** – кількість змістових модулів;

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

$\mathbf{К_{ДИС} = К^{(1)}_{ЗМ} + \dots + К^{(n)}_{ЗМ}}$ – 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 $\mathbf{К^{(1)}_{ЗМ} = \dots = К^{(n)}_{ЗМ}}$. 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/