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

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

**"APPROVED"**
Dean of the Faculty of Plant Protection,
the Biotechnologies, and Ecology
Dr.Agr.Sci, Prof. _____ M.M.Dolya
"____"_____, 2017

**REWIED AND APPROVED**
At the meeting of the department
of Analytical and Bioinorganic
Chemistry & Water Quality
Protocol # 9, "30" May, 2017
Head of the Department
Dr.Chem.Sci, Prof. _____V.A.Kopilevich

# SYLLABUS

## Academic Discipline "CHEMISTRY WITH FUNDAMENTALS OF BIOGEOCHEMISTRY"

**Foe EQL (educational and skill level) "Bachelor"**
**Branch of knowledge – 10 Natural Sciences**
**Speciality – 101 Ecology**

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

Kyiv, 2017

The Working program _ Chemistry with
Fundamentals of biogeochemistry for
Students of Branch of knowledge – 10 Natural Sciences
Speciality – 101 Ecology

"30" May 2017

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 # 9 "30" May 2017

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 # ____ "____" _____ 2017

Head Dr.Agr.Sci, Prof. _____ M.M.Dolya
(підпис) (прізвище та ініціали)

## 1. ACADEMIC DISCIPLINE DESCRIPTION

CHEMISTRY WITH FUNDAMENTALS OF BIOGEOCHEMISTRY

(назва)

| **Field of knowledge, direction, specialty, education and qualification level** | | |
|---|---|---|
| Educational and Qualification level qualification | Bachelor | |
| Branch of knowledge | 10 Natural Sciences | |
| Speciality | 102 - Ecology | |
| **Characteristics of training program** | | |
| Type | Ordinary (standard) | |
| The total number of academic hours | 180 | |
| Number of ECTS credits allocated | 6 | |
| Number of modules | 2 | |
| Forms of control | Final test | |
| **Indicators of academic discipline for full-time and part-time forms of training course** | | |
| | **Full-time** | **Part-time** |
| Year of study (course) | 4 | No |
| Semester | 7 | |
| Number of lecture, hours | 30 | |
| Number of seminars, practical classes | - | |
| Laboratory sessions (activities), hours | 30 | |
| Independent study, hours | 102 | |
| Individual lessons | - | |
| Number of weekly in-class academic hours for full-time forms of training | 4 | |

## 2. GOAL AND OBJECTIVES OF ACADEMIC DISCIPLINE

The study of the biological, geological and chemical factors that influence the movement of chemical elements through living systems across space and time. Processes can be studies at the microbial, ecosystem and global scales. Scales are becoming increasingly integrated. Biogeochemistry is the professional-oriented subjects. It is the component of the final stage of Bachelor's professional education in the field of ecology and environmental protection. Work educational program was prepared basing into typical program "Biogeochemistry and Environmental chemistry" for specialty "Ecology and Environmental protection", ratified by Main Administration of Cadre Policy and Agrarian Education of Agrarian Ministry of Ukraine 26.03.2003.

**Biogeochemistry** is the scientific discipline that involves the study of the chemical, physical, geological, and biological processes and reactions that govern the composition of the natural environment (including the biosphere, the hydrosphere, the pedosphere, the atmosphere, and the lithosphere). In particular,

biogeochemistry is the study of the cycles of chemical elements, such as carbon and nitrogen, and their interactions with and incorporation into living things transported through earth scale biological systems in space through time. The field focuses on chemical cycles which are either driven by or have an impact on biological activity. Particular emphasis is placed on the study of carbon, nitrogen, sulfur, and phosphorus cycles. Biogeochemistry is a systems science closely related to Systems ecology.

**The goal of the discipline:**

To study:

- General notions and laws of biogeochemistry;
- Biogeochemical cycles of main nutrients and pollutants;
- Student must can to do:
- To take a samples of water, soil, air;
- To prepare a sample to chemical analysis;
- To make a few analyses of main nutrients and pollutants of drinking water et al.

**The objects of research (tasks) are:**

- To study the laws of chemical composition of biosphere as the results of biogenic and a-biogenic processes;
- To explain the matter pass ways and migration of the chemical elements in the environment;
- To estimate of the environmental pollution, prognosis and simulating of pollutants behavior in biosphere;
- To establish the principles of biogeochemical zoning and reasons of biogeochemical anomalies resulted as endemic non-infection diseases;
- To study the theories of life origin and the possibilities to create “the artificial life” (nowadays data);
- To create the quantitative models of biogeochemical cycles of the macronutrients, micronutrients, toxic elements;
- To study the pass ways and species of biogenic and anthropogenic migrations of the chemical elements;
- To study the nature and mechanisms of the isotope fraction by living matter;
- To establish the role of living matter in geochemical processes of hypergenesis and weathering crust;
- To study the biogeochemical regularities based on the bio-indication methods of environmental monitoring;
- To develop the recommendations for preventing of environmental anthropogenic pollution.

***Requirements to the knowledge and skills***

**Student must to know:**

- General notions and laws of biogeochemistry;
- Biogeochemical parameters of chemical elements cycling;
- Physiological influence of chemical elements on life matter;
- Modern ideas of ecosphere developing and its transformation in noösphere;

 Methods of environmental sanitation based on biogeochemical features and their practical application;
 Chemical parameters of environmental state and preventive methods of its pollution;
 Chemical and physical methods of environmental monitoring.

**Student must to be able to do:**

 To analyze the scientific and applied literature sources in biogeochemistry;
 To know how to use the normative documents in the field of environmental regulations;
 To know statistic treatment of experimental results in environmental monitoring.

**Student must to have practical skills:**

 To use standard chemical and physical-chemical analyses for the determination of qualitative and quantitative composition of different objects of geochemical environment (soils, water, air, foods etc.);
 To know the probe sampling procedures and the ordinary operations of chemical analysis;
 To use modern analytical equipment, including express analyzers for field experiment;
 To prepare equipment, glassware, reagents for analysis;
 To know safe rules in chemical lab.

**Pre-required courses**

| Course | Chapters of course |
|---|---|
| General and Inorganic chemistry | Atomic-Molecular studies, stoichiometry, properties of the chemical compounds, hydrolysis, dissociation |
| Analytical chemistry | All chapters |
| Physical and colloidal chemistry | Chemical kinetics, equilibrium, osmosis, coagulation, ionic strength |
| Soil sciences | Organic matter of soil, soil absorption complex, humus formation theories |
| Organic chemistry | Organic dyes and ligands, indicators |
| High Mathematics | Logarithms and operations with logarithms, degree function |

## 3. SYLLABUS AND STRUCTURE OF ACADEMIC DISCIPLINE

| Title of content modules and chapters | Hours | | | | | |
|---|---|---|---|---|---|---|
| | Full-time | | | | | |
| | Total | including | | | | |
| | | lectures | seminars | Labs | Individual studies | Independed training |
| **Content module # 1 Biogeochemical characteristics of the ecosphere composition"** | | | | | | |
| *Chapter 1*. Introduction. The object of research and the goal of the discipline. Life origin on the Earth: hypotheses and experimental. | 20 | 4 | | 6 | | 10 |
| *Chapter 2*. The ecosphere, the chemical elements and biogeochemical laws | 20 | 4 | | 6 | | 10 |
| *Chapter 3.* Biogeochemical zoning | 14 | 4 | | | | 10 |
| *Chapter 4.* Endemic diseases | 18 | 4 | | 4 | | 10 |
| *Sum of content module 1* | 72 | 16 | | 16 | | 40 |
| **Content module # 2 «Biogeochemical cycles of the main bioactive chemical elements»** | | | | | | |
| *Chapter 1*. The general notions of biogeochemical cycles. Experimental modeling data. | 26 | 4 | | | | 22 |
| *Chapter 2.* Biogeochemical cycles of macronutrients and toxic elements | 52 | 8 | | 14 | | 30 |
| *Chapter 3.* Biogeochemical barriers | 12 | 2 | | | | 10 |
| *Sum of content module 2* | 90 | 14 | | 14 | | 62 |
| **Total, hours** | **162** | **30** | | **30** | | **102** |
| **Course work** | Doesn't planned | | | | | |

**Content module # 1 Biogeochemical characteristics of the ecosphere composition"**

**Lecture # 1 annotation**

Introduction. The object of research and tasks of the discipline. V.I. Vernadsky – the founder of biogeochemistry. Genesis of Biogeochemistry. The relationships of biogeochemistry with other natural sciences. Applied aspects of biogeochemistry.

Modern directions of biogeochemistry. The environmental protection as a social factor.

**Lecture # 2 annotation**

The theories of life origin on the Earth. The Oparin-Haldane protein-coacervate Hypothesis; panspermia; DNA world. Muller-Urey experiment. Experiments of "artificial life". Alternative ecospheres. Gaia hypothesis of J. Lovelock.

**Lecture # 3 annotation**

Vernadsky' Biosphere study. Notion of life matter, its composition. Types of biospherical matter of the earth. The mail biochemical components of biosphere.

**Lecture # 4 annotation**

Conditions of the biosphere existing. Energy and matter fluxes in biosphere. Vernadsky biogeochemical principles (laws). Different types of bioelements classification – based on biological functions, physiological functions etc. Factors influences on the dynamics of bioactive elements. The consumption ratio of micronutrients. Notion of ionic potential.

**Lecture # 5 annotation**

Bioactive elements distribution in biosphere. Examples of geochemical role of life matter (calcium, iodine functions, atmospheric oxygen, formation of manganese-nickel concretions etc.). Biogeochemical functions of life matter.

**Lecture # 6 annotation**

Biogeochemical zoning as an unity of geochemical environment and functioning of life matter (according to V.V. Kowalsky). Biogeochemical chains. Biogeochemical provinces and zones (taiga-forest non-chornozemic; forest-steppe and steppe chornozemic; dry-steppe; semiarid and desert; mountain).

**Lectures # 7-8 annotation**

Endemic diseases as a consequence of abnormal distribution of chemical elements in biogeochemical environment. History of endemic diseases studying. Endemic goiter, correlation of human iodine status and IQ level. Methods of iodine deficit prevention – pro and contra. Fluorosis as a consequence of increaser content of fluorine in drinking water. Adding of fluoride compounds in toothpastes and fluoridation of drinking water. Endemic podagra, Kashin-Bek disease (Urov), Keshan disease. Endemic diseases of farm animals.

**Content module # 2 Biogeochemical cycles of the main bioactive chemical elements"**

**Lecture # 9 annotation**

The basic notions of biogeochemical cycles. Processes of cycling migration of chemical elements in environment. Fluxes and reservoirs of biogeochemical

cycles. Thermodynamics laws and biogeochemical cycles. Experimental evidences of cycling (Witherspoon radioisotope experiment; Habbard-Brook experimental forest study). Exogenic and endogenic cycles.

**Lecture # 10 annotation**

Types of ogranogenic elements cycles. Hydrological cycle. Hydrogen degasation. V. Larin theory. Global model of carbon cycle according to V. Kovda.

**Lecture # 11 annotation**

Global carbon cycle according to R. Radkliffs as the ratio of chemical state of carbon compounds (oxiding – reducting). Detrite as biogeochemical reservoir of carbon. Fossilises. Isotope distribution of carbon. Radiocarbon analysis.

**Lecture # 12 annotation**

Nitrogen biogeochemical cycle. Biogenic and abiogenic nitrogen fixation. Hypotetic structure of nitrogenaze-nitrogen metal-ferment complex. "Nitrogen barrier" in biosphere production.

**Lecture # 13 annotation**

Phosphorus biogeochemical cycle. Reservoir and exchange founds of phosphorus cycle. Ephtrofication: mechanism and prevention. Artificial ephtrofication experiments. "Phosphorus falling" in fertilizer resources and limitation of crop production.

**Lecture # 14 annotation**

Biogeochemical cycles of Mercury, Cadmium, Lead. Technogenic migration of heavy metals in envronmnet. Techno sphere and its properties.

**Lecture # 15 annotation**

Classification of biogeochemical barriers: physical, mechanical, biogenical, thechogenical. Practical using of biogeochemical barrier study for the analysis and prognosis of chemical substance transformation in polluted soils. Rationale of methods for pollution localization. Biological barriers – result of biological concentration of chemical elements. Notion of biological remediation of soils.. Physical-chemical barriers – acidic-basic, sulphide, carbonate, sulfates, Red-Ox. Example of complex geochemical barrier – oxygen-absorption – Fe(III), Mn(IV) A/G.

**4. No seminars.**

**5. No practice lessosns.**

## 6. LABS

| # | Title | Hours |
|---|---|---|
| 1 | Introduction. Safe rules in chemical laboratory. Qualitative methods of environmental chemical analysis. Probe sampling, conservation and storage of samples for analysis. Principles of statistic treatment of qualitative analytical results of environmental objects. | 4 |
| 2 | Express measuring of active residue chlorine (free, total) in chlorinated drinking water by photometric method using C-401 colorimeter. | 4 |
| 3 | Determination of nitrate content in natural fresh waters and drinking water by photometrical method according to DSTU 4078-2001 Water quality; determination of nitrate; part 3: spectrometric method using sulfosalicylic acid (ISO 7890 3:1998, MOD). Statistical treatment of analysis data. | 4 |
| 4 | Determination of ammonia content in natural fresh waters and drinking water by photometrical method according to DSTU ISO 7150-1-2003 Water quality - Determination of ammonium - Part 1: Manual spectrometric method. Statistical treatment of analysis data. | 4 |
| 5 | Determination of total iron content in tap water, buvette water and surface waters according to GOST 4011-72 Drinking water. Methods for determination of total iron. Statistical treatment of analysis data. | 4 |
| 6 | Determination of fluoride content in drinking water and a few sorts of leaf and packed according to GOST 4386-89 Drinking water. Methods for determination of fluorides mass. Statistical treatment of analysis data. | 2 |
| 7 | General chemical properties of alkaloids. Загальна характеристика алкалоїдів. Sublimation method for the caffeine dry extraction from tea leaves. Qualitative test of caffeine. | 2 |
| 8 | Determination of active oxygen content in detergents and oxygen-contained bleaches according to DSTU 2207.2-93 (GOST 22567.10-93) Synthetic detergents. Methods to determine total mass fraction of available oxygen. | 6 |
| | **Total** | **30** |

## INDEPENDENT TAINING CONTENT

| # | Chapter Title | Hours |
|---|---|---|
| 1 | Anthropogenic stage of biosphere evolution. Noösphere conception in the modern understanding. Noösphere as a. The noösphere as a logical step in the development of Earth. Characteristic features of the noösphere: i) formation of new landscapes (cultural, technogenic, agro-landscapes); ii) human civilization as a main moving force of noösphere; iii) technogeneous migration of the chemical substance; iv) significant volume of information, new types of information; v) noösphere as a consumer of energy produced by biosphere; Conditions (according to Vernadsky) of the whole transformation of biosphere to noösphere. | 16 |
| 2 | Landscape-geochemical zoning of Ukraine. Zone and intrazone provinces in Ukraine; endemic diseases in Ukraine.<br>Influence of geochemical environment into evolution of plants. Plants-adaptogenes: indifferent to the chemical elements concentration changes, typical and untypical concentrators; endemic plants. | 16 |
| 3 | Biogeochemistry of gaseous shell of the Earth. The value of atmospheric mass transfer of water-soluble forms of chemical elements. Flora as an | 16 |

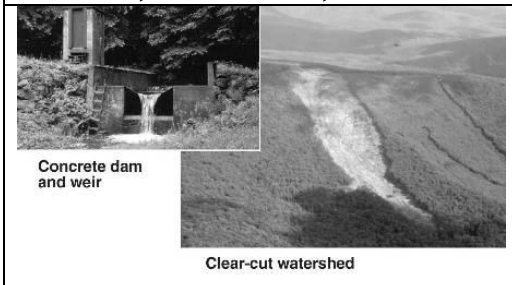
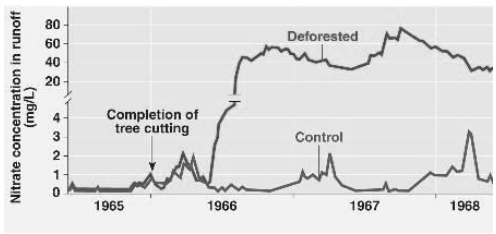
| | | |
|---|---|---|
| | absorber of gaseous pollutants. | |
| 4 | Biogeochemistry of lithosphere and pedosphere. Chemical composition of soils and bottom sediments. Types of chemical elements migration in lithosphere and pedosphere (hypogenic, supergenic and anthropogenic migrations). Organic matter of pedosphere. | 16 |
| 5 | Biogeochemistry of hydrosphere. Classification of the natural waters on mineralization, type of mineral matrix.<br>Requirements to the water quality for different types of water using (for drinking, for irrigation, for animal and poultry drinking, for fish breading, for recitation etc.). Acidic rains in Ukraine. | 16 |
| 6 | Biochemical cycling of matter and energy in biosphere. Cycling of elements migrated in biosphere in the result of manta degassing (hydrogen, carbon, oxygen, nitrogen). Cycles of elements migrated in biosphere in the result of manta crystallization (calcium, potassium, silicon, phosphorus). | 22 |
| 7 | Interaction of life and abiogenic matters – the base if biogenic migration of substances. Notion of small biological cycling of chemical elements. Energy of life matter – the moving force of geochemical and biogeochemical cycling of the chemical elements. | 4 |
| 8 | Hydrogen cycle. Chemical properties of hydrogen, its content in lithosphere, atmosphere, life matter, humus, plants. Water as source for the organic synthesis, as a medium for life matter existing. Average water content in biosphere. Water biogeochemical cycle and its duration. The . Drinking water supply provision and water consumption in different countries. Water contaminants, their classification. | 12 |
| | **Total** | **102** |

## INDIVIDUAL LASSONS

**No planned**

## 7. CONTROL TESTS

### Final test (example)

| ***Завдання*** |
|---|
| **1.**Describe the Vernadsky Biogeochemical Laws. Illustrate the idea of ‘all-over” of life (“black smokers”, “moon milk”, “blood fall” etc.).. |
|  <br>  <br>Nitrogen in runoff from watersheds<br>**2.** Comment the results on nitrates content monitoring in The Hubbard Brook Experiment *(see figures)* |

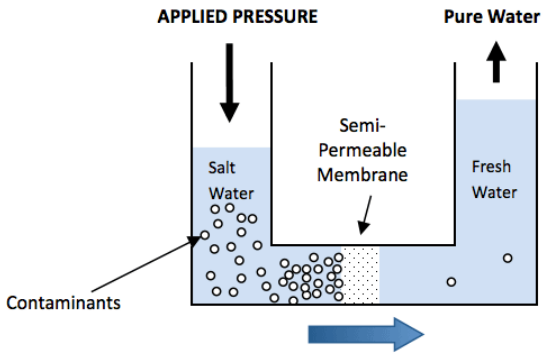
*Тестові завдання різних типів*

1. Note the equation of reaction described the chemosynthesis process which is an energy source for anaerobes

| | | | |
|---|---|---|---|
| A | $3CH_3O + H_2O = CO_2 + 2CH_3OH$ | C | $6\ CO_2 + 6H_2O = C_6H_{12}O_6 + 6O_2$ |
| B | $4\ NO_2 + O_2 + H_2O = 4\ HNO_3$ | D | $6\ CO_2 + 6H_2O + 3H_2S = C_6H_{12}O_6 + 3H_2S$ |

2. Note the chemical element which is a central in the cycling of chemical elements in biosphere (according to Zavarsin, 1998):

| | | | |
|---|---|---|---|
| A | Oxygen | C | Silicon |
| A | Carbon inorganic | D | Phosphorus |
| B | Iron | E | Carbon organic |




3. Name the method of drinking water purification

4. What type of drinking water pollution and its duration is a cause of "blue baby" syndrome?

| | | | |
|---|---|---|---|
| A | Acute poisoning of nitrates | D | Acute poisoning of nitrites |
| B | Chronic toxicity of nitrates | E | Acute poisoning of ammonia |
| C | Chronic toxicity of ammonia | F | Chronic toxicity of nitrites |

5. Insert a missing word: *Redfield ratio or Redfield stoichiometry is the _____ ratio of carbon, nitrogen and phosphorus found in plankton and throughout the deep oceans.*

6. Classify the processes controlled biogeochemical cycles:

| | | | |
|---|---|---|---|
| A | Physical | 1 | Dissolution |
| B | Biochemical | 2 | Precipitation |
| | | 3 | Biodegradation |
| | | 4 | Oxidoreductive biotransformations |
| | | 5 | Volatilization |

7. Note the main biological role of sulfur:
A. Energy source in the form of ATP;
B. Respiration function;
C. Synthesis of amino acids (methionine, cysteine).

8. Note the reason of low biological activity of atmospheric nitrogen $N_2$.

9. According to WHO data, life span is determined by the factor of the environment of ___%.

10. Describe the biochemical role of caffeine (congruency with ATP).

## Example of the module test 1

Module quiz 1 (20 points) (Module 1 – the main concepts of biogeochemistry)

Question 1. Presence in the atmosphere of the any planet in the Universe of gaseous _____ means the life like in the Earth (according to J. Lovelock) *(1 point):*

| | | | | | |
|---|---|---|---|---|---|
| A | $N_2$ | C | CO | E | $O_2$ |
| B | $H_2S$ | D | $CO_2$ | F | $CH_4$ |

Answer: _____

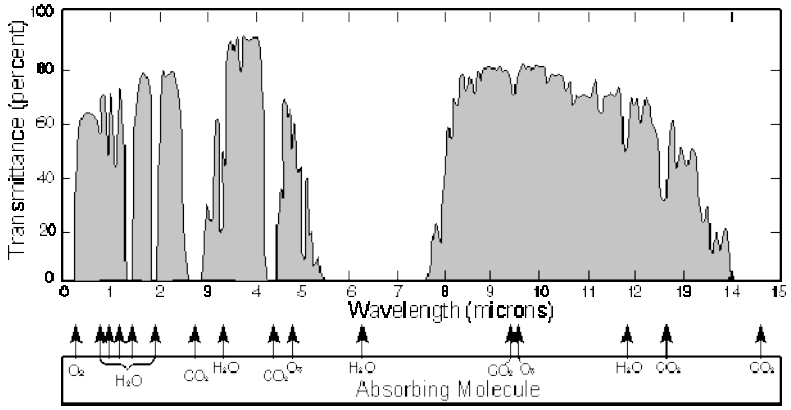
Question 2. Describe the examples of extremely ecosystems illustrated the Vernadsky's term «all over» propagation of life on the surface of the Earth *(at least two examples) (2 points)*

Question 3. Note the main dangerous result of drinking water chlorination *(1 point)*

| | | | |
|---|---|---|---|
| A | Bad water odor and taste | C | Corrosion of water pipes |
| B | Formation of by-products – Trihalomethanes and other chloroderivates of cancer activity | D | The risk of any leakage of gaseous chlorine for water treatment plants |

Question 4. Insert the missing word: First biogeochemical law - biogenic _____ of chemical elements in the biosphere tends to its maximum development *(1 point).*

Question 5. Using data about the atmospheric transparency in Infra red spectra (see picture), note the substances (excepting carbon dioxide) which are the absorbers of IR radiation (Answer – as the chemical formulas) *(2 points)*




Question 6. Note the maximum permitted limit of total and free residual chlorine content of drinking water according to the requirements of DSanPiN 2.2.4-171-10 *(two figures and unit of concentration) (2 points).*

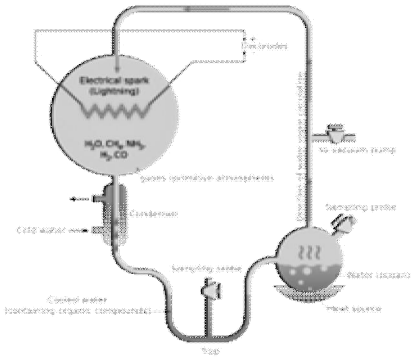
Question 7. Why is no reason to include the dissolved oxygen content as the parameter of the drinking water quality for human consumption? *(Answer – as a sentence) (1 point)*

Question 8. What is the name of American social activist and former US Vice President, who received in 2007 the Nobel Peace Prize for a campaign against the "greenhouse effect" *(1 point)*

Question 9. What type of drinking water pollution and its duration is a cause of "blue baby" syndrome? *(1 point)*

| | |
|---|---|
| A | Chronic toxicity of nitrates |
| B | Acute poisoning of nitrates |
| C | Chronic toxicity of ammonia |
| D | Acute poisoning of nitrites |
| E | Acute poisoning of ammonia |

Question 10. The Muller-Urey experiment was a reason of the life origin theory: *(1 point)*




| | |
|---|---|
| A | Panspermia |
| B | Creationism |
| C | Spontaneous generation |
| D | Biochemical evolution (Oparin-Haldane's) |
| E | The RNA world |

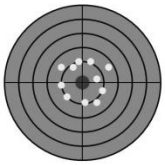
Answer: _____

Question 11. Insert the missing word: Second Biochemical law - the evolution of species, leading to the creation of life forms that are stable in the biosphere should be in the direction, _____ expression of the biogenic migration of atoms in the biosphere. *(1 point)*

Question 12. Describe the risks to human health associated with chlorination of drinking water for its disinfection *(answer as the sentences) (2 points)*

Question 13. Note the main sources of underground water pollution of nitrates in Ukraine *(2 points)*

Question 14. Note relationship of accuracy versus precision for the next situation (*high, low) (1 point):*



Answer: _____ accuracy, _____ precision

Question 15. Note analytical method used for the residual chlorine content in drinking water of express-method (Colorimeter C 401, for example) *(1 point)*

| | | | |
|---|---|---|---|
| A | Neutralization | C | Permanganatometry |
| B | Atomic absorption | D | Photometry |

## 9. 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.

## 10. 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 conrol 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 cources 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 consistuents 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 and ECTS**

| National grade | ECTS grade | Grade according to national system | Percentage score |
|---|---|---|---|
| Passed | A | Excellent | 90-100 |
| | B | Very good | 82-89 |
| | C | Good | 74-81 |
| | D | Satisfactory | 64-73 |
| | E | Satisfactoty enough | 60-63 |
| Non-passed | FX | Unsatisfactory | 35-59 |
| | F | Unsatisfactory – serious work is needed | 0-34 |

## 11. TECHNOLOGY AND METHODOLOGICAL REQUIREMENTS

У робочому навчальному плані передбачено в одному навчальному семестрі лекцій – 30 годин, лабораторних занять – 45 годин та самостійної роботи - 98 годин, що в сумі становить 173 годин (6 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 (іспит) | Загальна кількість балів |
|---|---|---|---|---|---|---|
| Змістовий модуль 1 | Змістовий модуль 2 | | | | | |
| 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 $\mathbf{К^{(1)}_{ЗМ} = \ldots = К^{(n)}_{ЗМ}}$. Тоді вона буде мати вигляд:

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

Навчальне навантаження студента для їх вивчення та засвоєння складає:

1-й модуль $(\mathbf{R_1})$ – 1,0 кредит ($К_1$)

2-й модуль $(\mathbf{R_2})$ – 1,0 кредит ($К_2$)

**Критерії оцінки змістових модулів:**

$\mathbf{R_1}$ складається з 4-х лабораторних робіт, самостійної та контрольних робіт. Захист лабораторних робіт та виконання самостійної роботи оцінюються від 5 до 10 балів кожна. Модульна контрольна робота 1 оцінюється від 0 до 20 балів кожна.

$\mathbf{R_2}$ складається з 2 лабораторних робіт, самостійної та контрольних робіт. Захист експериментальної роботи та виконання самостійної роботи оцінюються від 5 до 10 балів кожна. Модульна контрольна робота № 2 оцінюється від 0 до 20 балів кожна.

***Рейтинг з додаткової роботи*** $\mathbf{R_{ДР}}$ додається до $\mathbf{R_{НР}}$ 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*** $\mathbf{R_{ШТР}}$ не перевищує 3 балів і віднімається від $\mathbf{R_{НР}}$. 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:

$$\mathbf{R_{дис.} = R_{нр.} + R_{ат}}$$

Форма контролю – іспит.

Атестації з дисципліни в цілому оцінюються за 100 бальною шкалою згідно ECTS.

## 12. REQUIRED AND RECOMMENDED LITERATURE

### Basic

1. Kopilevich, V.A. et al. (2004), Environmental chemistry, Fenix Publ., Kyiv (412 pp.) (In Ukrainian) (available in University Library).
2. Schlesinger, W.H. (1997), Biogeochemistry: An analysis of global change, Academic Press, San Diego, CA. (available on Amazon.com)

Lab Manual

Voitenko, L.V. et al. (2015), Lab manual of Biogeochemistry for Bachelor students of Ecology, NUBIP Publ., Kyiv (120 pp.)

### Additive

1. Добровольский В.В. Основы биогеохимии. - М.:Академия, 2003. - 397 с.

2. Введение в химию окружающей среды/Дж. Андруз, П. Бримблекумб, Т. Джикелз и др. - Пер. с англ. А.Г. Заварзиной. - М.: Мир, 1999. - 271 с.
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4. Аналітична хімія природного середовища:Підручник/Б.Й. Набиванець, В.В. Сухан, Л.В. Калабіна. – К,: Либідь, 1996. – 304 с.
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6. Чернобаев И.П. Химия окружающей среды.- К.: Вища шк., 1990. – 191 с.
7. Мікроелементози сільськогосподарських тварин. – К.: Урожай, 1974. – 151 с.

## 13. IT RESOURCES

1. Державна стратегія регіонального розвитку на період до 2015 року (Затверджена Постановою Кабінету Міністрів України № 1001 від 26.07.2006 р. - [Електронний ресурс]. – Режим доступу: http://lawua.info/bdata1/ukr1279/index.htm
2. World Water Day: A Billion People Worldwide Lack Safe Drinking Water - [Електронний ресурс]. – Режим доступу: http://environment.about.com/od/environmentalevents/a/waterdayqa.htm
3. Ayers R.S.Water quality for agriculture/ R.S. Ayers, D.W. Westcot // FAO Irrigation and Drainage paper. – Roma, 1994. – 147 pp. [Електронний ресурс] / Режим доступу: http://www.fao.org/DOCREP/003/T0234E/ T0234E00.HTM
4. Повестка дня на XXI век / Принята Конвенцией ООН по окружающей среде и развитию // Рио-де-Жанейро, 3-14 июля 1992 года [Електронний ресурс] /Режим доступу: http://www.un.org/ru/documents/decl_conv/conventions/agenda21_ch18f.shtm
5. Національна доповідь про якість питної води та стан питного водопостачання в Україні у 2011 році. – К.: Мінрегіонрозвитку України, 2012. – 642 с. [Електронний ресурс] /Режим доступу: http://minregion.gov.ua/images/Pidrozdily/MEDVED/_._2011_.pdf
6. 15. Екологічні карти України (25 карт) - [Електронний ресурс]. Режтм доступу: http://road.elitno.net/?attachment_id=21
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11. Vladimir N. Bashkin, 2002, Modern Biogeochemistry. Kluwer, ISBN 1-4020-0992-5.
12. Samuel S. Butcher et al. (Eds.), 1992, Global Biogeochemical Cycles. Academic, ISBN-0-12-147685-5.
13. Susan M. Libes, 1992, Introduction to Marine Biogeochemistry. Wiley, ISBN 0-471-50946-9.
14. Dmitrii Malyuga, 1995, Biogeochemical Methods of Prospecting. Springer, ISBN 978-0306106828.
8. Global Biogeochemical Cycleshttp://www.agu.org/journals/gb/
16. Biogeochemistry http://www.springer.com/west/home/geosciences?SGWID=4-10006-70-35757517-0. A journal published by Springer.