NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

Department of Analytical and Bioinorganic chemistry and water quality

"APPROVED"
Dean of agrobiological faculty
_____ (prof. Tonkha O. L.)
"____" _____ 2023 p.

" REVIEWED AND APPROVED "
at the meeting of the department of
Analytical and Bioinorganic chemistry
and Water quality
Protocol №8 from "24" April 2023 p.
Head of the Department
_____ (prof. Kopilevich V.A.)

"REVIEWED"
Guarantor of educational program
"Agronomy"
_____ (prof. Tonkha O. L.)

WORKING PROGRAM OF ACADEMIC DISCIPLINE «INORGANIC AND ANALYTICAL CHEMISTRY»

Specialty 201 – «Agronomy»
Educational program «Agronomy»
Faculty Agrobiological
Compiled by: Assoc. prof, PhD Prokopchuk N.M., Assoc. prof, PhD Kravchenko O.O

Kyiv - 2023

1. Academic discipline description

«Inorganic and Analytical Chemistry»

Field of knowledge, specialty, education program, qualification level		
Educational and Qualification level	*Bachelor*	
Specialty	*201 "Agronomy"*	
Educational program	*Agronomy*	
Characteristics of training program		
Type	Obligatory	
The total number of academic hours	180	
Number of ECTS credits	6	
Number of modules	4	
Course project (work) (if available)	-	
Forms of control	*Exam*	
Indicators of academic discipline for full-time and part-time forms of training course		
	Full-time	**Part-time**
Year (course)	1	
Semester	1	
Number of lectures	*30 hours*	
Number of seminars, practical classes	- *hours*	
Laboratory sessions (activities)	*75 hours*	
Independent study	*75 hours*	
Individual lessons	- *hours*	
Number of weekly in-class academic hours for full-time forms of training	*7 hours*	

2. Goal, Learning objectives and competencies of the educational discipline

Goal is to build a good foundation in chemical knowledge that allows to make qualitative and quantitative inquiries into topics in natural science.

Learning objectives are:

- apply stoichiometry in determining quantity relationships for compounds and chemical reactions;
- demonstrate an understanding of chemical equilibrium;
- understand the structure of matter on atomic and molecular levels and its correlation to chemical and physical properties;
- describe the concentration of a solution in the way that is most appropriate for a particular problem or application;
- use laboratory equipment and make observations to identify chemical and physical changes.

Learning outcomes :

Upon completion of this course, students should:

know the basic principles and topics of Inorganic and Analytical Chemistry and their application to real world problems.

be able to

- Compose a proper formula for a compound;
- Describe and name inorganic compounds;
- Write and balance chemical equations;
- Determine the composition of any atom or ion;
- Explain periodicity;
- Distinguish ionic, polar and nonpolar covalent bond;
- Describe characteristics of solutions;
- Balance oxidation-reduction reactions using the electron balance method;
- Analyze the characteristic properties of non-metals and metals;
- Use standard laboratory equipment for qualitative and quantitative analysis.

Competences provided by the discipline

Integral competence (IC): The ability to solve complex specialized problems and practical problems in agronomy, which involves application of theories and methods of inorganic and analytical chemistry

General competences (CG): Efforts to preserve the environment (CG 11).

Professional (special) competences (SC):

Knowledge and understanding of basic biological and agrotechnological concepts, rules and theories related to the cultivation of agricultural and other plants (SC 3).

The ability to use fertilizers and plant protection products on a scientific basis, taking into account their chemical and physical properties and impact on the environment (SC 7).

Program learning outcomes (PLO):

- Compare and evaluate modern scientific and technical achievements in the field of agronomy (PLO 4).
- Demonstrate knowledge and understanding of fundamental disciplines to the extent necessary to possess relevant skills in the field of agronomy (PLO 6).
- Initiate prompt and expedient solutions to production problems in accordance with zonal conditions (PLO 11).
- To organize effective and safe working conditions (PLO 16).

3. The structure of the curriculum of academic discipline for full-time form of training.

The names of the content modules and topics	Hours												
	Full time							Part time form					
	Weeks	Total	including					Total	including				
			l	p	lab	ind	indep		l	p	lab	ind	indep
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Module №1. **Theoretical foundations of inorganic chemistry. The Main Laws of chemical transformations**													
Topic #1. Introduction. General notions, stoichiometrical laws and types of chemical reactions	1	12	2	-	6	-	4						
Topic #2. Atomic structure of chemical elements. Electronic formulas	1	12	2	-	4	-	6						
Topic #3. The Periodic Law and Periodic Table of chemical elements	1	6	2	-	-	-	4						
Topic #4. Chemical bonding and structure of molecule. Chemical kinetics and equilibrium	1	12	2	-	4	-	6						
Total hours (module 1)	**42 hours**		**8**	**-**	**14**	**-**	**20**						
Module №2. **Chemical transformations with change of oxidation number of elements or their valence**													
Topic #5. Solutions, their nature and properties. Hydrolysis of salts	1	12	2	-	6	-	4						
Topic #6. Red-Ox reactions	1	16	2	-	8	-	6						
Topic #7. General properties of non-metals	1	8	2	-	2	-	4						
Topic #8. General properties of metals	1	8	2	-	2	-	4						
Topic #9. Coordination compounds	1	10	2	-	6	-	2						
Total hours (module 2)	**54 hours**		**10**	**-**	**24**	**-**	**20**						
Module №3. **Principles and methods of Qualitative Analysis of Cations and Anions**													
Topic #10. Introduction to Analytical chemistry	1	28	2	-	15	-	11						
Topic #11-12. Qualitative analysis. The main principle of qualitative analysis of unknown substances	2	20	4	-	8	-	8						
Total hours (module 3)	**48 hours**		**6**	**-**	**23**	**-**	**19**						
Module №4. **Theoretical and experimental foundations of Quantitative chemical analysis. Gravimetry and neutralization method. Red Ox methods and complexing methods.**													
Topic #13. Theoretical and experimental foundanion of	1	12	2	-	6	-	4						

Quntitative analysis													
Topic #14. Titrimetry (volumetry, volumetric analysis). Neutralization method	1	12	2	-	4	-	6						
Topic #15. Oxidation-reduction (Redox) Titration (Redoxmetry). Complexometric Titration	1	12	2		4		6						
Total hours (module 4)	**36 hours**		**6**	**-**	**14**	**-**	**16**						
Total hours	**180**		**30**	**-**	**75**	**-**	**75**						

4. Themes of seminars

№	Themes	Numbers of hours
1	-	

5. Themes of practical activities

№	Themes	Numbers of hours
1	-	

6. Themes of laboratory activities

№	Themes	Numbers of hours
Inorganic chemistry		
Module №1. **Theoretical foundations of inorganic chemistry. The Main Laws of chemical transformations**		
1.1	The main classes of inorganic substances	4
1.2	Control Test "Classification of Inorganic Substances"	2
1.3	Atomic structure. Chemical bonding	2
1.4	Control Test "Atomic Structure. Electron configurations of atoms. Chemical bonding"	2
1.5	Theory of electrolytic dissociation	2
1.6	Control Test "Theory of electrolytic dissociation"	2
Module №2. **Chemical transformations with change of oxidation number of elements or their valence**		
2.1	Ionic product of water. Hydrolysis of salts	4
2.2	Control Test "Hydrolysis of Salts"	2
2.3	Oxidation-reduction reactions	8
2.4	Control Test "RedOx reactions with products"	2
2.5	Control Test "RedOx reactions without products"	2
2.6	Complex (coordination) compounds	4
2.7	Control test "Complex (coordination) compounds"	2
Total hours from the section "Inorganic chemistry": 38 hours.		

Analytical chemistry		
Module №3. **Principles and methods of Qualitative Analysis of Cations and Anions**		
3.1.	The first group of Cations	2
3.2	The second group of Cations	5
3.3	The third group of Cations	4
3.4	The fourth group of Cations	2
3.5	The first group of Anions	2
3.6	The second group of anions	2
3.7	The third group of Anions.	2
3.8	Control Test "Analysis of Unknown substance"	4
Module №4. **Theoretical and experimental foundations of Quantitative chemical analysis. Gravimetry and neutralization method. Red Ox methods and complexing methods**		
4.1	Preparation of solution	4
4.2	Control test "Concentration of Solutions"	2
4.3	Determination of alkali solution normality	4
4.4	Determination of Water Hardness	4
Total hours from the section "Analytical chemistry": 37 hours.		
	Total lab hours:	**75 hours.**

7. Themes of independent works

№	Назва теми	Кількість годин
1	Basic concepts of chemistry. Classification of inorganic substances	20
2	Chemical transformations metals and non-metals	20
3	Analysis of unknown substances	19
4	Solutions. Methods of expressing the concentration of solutions	16

8. Samples of control questions, tests to determine the level of knowledge acquisition by students.

NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE			
Educational and Qualification level *Bachelor* **Specialty** *201-Agronomy*	**Department of Analytical and Bioinorganic chemistry and Water quality**	**Exam variant № 1** from discipline **"Inorganic and analytical chemistry"**	**Head of the Department** _____ (sign) **prof. Kopilevich V.A.**

Theoretical questions

1. Units of concentrations: Percent by mass (Mass percent); Molarity; Normality;Titre. Formulas for its calculations. Calculate, how many grams of $CuSO_4$ are required to prepare 400 ml of 0.1 N solution? T-?

2. Propose and write out the procedure of qualitative analysis of $CuCl_2$. Write it in a step by step manner so that someone else performing the experiment could follow it. Write balanced molecular equations for the formation of any precipitates and positive visual effects that appeared.

Tests

1. How many ions will form after dissociation of Chromium(III) Sulphate molecular?			
A.	2	D.	5
B.	3	E.	6
C.	4		

2. Point the correspondence between cation and correspondent reagent:			
A.	Na^+	1.	$NaBiO_3$
B.	Zn^{2+}	2.	$K[Sb(OH)_6]$
C.	Mn^{2+}	3.	$K_3[Fe(CN)_6]$
D.	NH_4^+	4.	NaOH

3. Calculate equivalent of H_3PO_4 (Mr = 98)			
A.	98	C.	24,5
B.	49	D.	32,7

4. How many neutrons include nucleus of Se atom?			
A.	21	C.	45
B.	34	D.	79

5. What aqueous solution of salt will have alkaline medium?			
A.	K_2SO_3	C.	KI
B.	NH_4NO_3	D.	NH_4F

6. Point the correspondence of inorganic substances and their chemical nature:			
A.	HNO_2	1.	Basic oxide
B.	SiO_2	2.	Acidic oxide
C.	CaO	3.	Amphoteric oxide
D.	$Sr(OH)_2$	4.	Base
E.	SnO	5.	Acide

7. If chlorine water is added to NaI solution with benzene, what observation would be made? *(to write equation in justification form)*			
A.	Remains brown	C.	Changes from colorless to purple
B.	Changes from colorless to black	D.	Changes from colorless to brick red

8. Calculate a sum of coefficients in REDOX reaction
$Ca + HNO_3$(conc.) →
(*To write number in answer sheet, to write equation in justification form*):

9. How many salts are obtained during interaction of NaOH and H_3PO_4 (taking into account the possibility of neutral, acidic and basic salts forming) *(to write equations in justification form):*

A	2	C	4
B	3	D	5

10. The product of complexation reaction: $KF + AlF_3 \rightarrow$ *(to write formula in answer sheet, to write equation in justification form*):

11. Which elements changed their oxidation degrees in the Redox reaction:
$NaNO_3 + KI + H_2SO_4 =$ *(to write equation in justification form):*

A	Na	C	N
B	S	D	I

12. Which of the metals does not react with hydrochloric acid under normal conditions?

A	copper;	C	gold;
B	silver;	D	lead;

13 For preparation 600 ml 0,25M solution, it is necessary to take $CaCl_2$ (M=111,08 g/mol) in amount: *(to write equation in justification form):*

14 The solubility of the phosphate precipitate (formed by the action of the group reagent) in CH_3COOH indicates the presence of cations:

A	Ca^{2+}, Mn^{2+}	C	Ba^{2+}, Fe^{2+}
B	Ba^{2+}, Fe^{3+}	D	Al^{3+}, Fe^{3+}

15. What gas is released during the interaction of copper with dilute nitric acid: *(to write only the formula, to write equation in justification form)*

16. Specify the accuracy of weighing on technochemical scales:

A	± 0,01 g;	C	± 0,0001 g;
B	± 0,1 g;	D	± 0,001 g;

17. Find the correspondence between the type of chemical reaction and its example:

A	RedOx;	1	$ZnO + SO_3 = ZnSO_4$;
B	Single replacement (substitution);	2	$2NaOH + H_2SO_4 = Na_2SO_4 + 2H_2O$;
C	Decomposition;	3	$Fe(OH)_2 \xrightarrow{t} FeO + H_2O$;
D	Composition	4	$Zn + H_2SO_{4\ розб.} = ZnSO_4 + H_2\uparrow$.

18. Indicate the empirical formula of Iron (II) hydrogendiphosphate: *(in the answer sheet give the formula of the compound)*

19. The products of hydrolysis of Na_2CO_3 salt (in the first degree) are: *(in the justification form give the equation of hydrolysis of salt)*

A	NaOH	C	H_2CO_3
B	$NaHCO_3$	D	CO_2

20. Point the correspondence between formula of compound and type of a chemical bond

A	A metallic bond	1	NH_3
B	An ionic bond	2	KCl
C	A non-polar covalent bond	3	Cl_2
D	A polar covalent bond	4	Cu
E	A hydrogen bond	5	2 H_2S

Assoc. Prof._____(O.O. Kravchenko)

9. Teaching methods.

A **teaching method** comprises the principles and methods used for teaching. Commonly used teaching methods for studying subject Water Resources Management include class participation, demonstration, recitation, memorization, or combinations 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 science teacher may 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 are similar to written storytelling and examples in that they allow students to personally relate to the presented information. Memorization of a list of facts is a detached and impersonal experience, whereas the same information, conveyed through demonstration, becomes personally relatable. Demonstrations help to raise student interest and reinforce memory retention because they provide connections between facts and real-world applications of those facts. Lectures, on the other hand, are often geared more towards factual presentation than connective learning.

Collaboration allows students to actively participate in the learning 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 student's 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 of a lesson, with the teacher only giving short feedback at the end or in the following lesson.

Learning by teaching is the method, when students assume the role of teacher and teach their peers. Students who teach 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 seminars and workshops, outside the classroom, at 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 the lectures has to subtract time. By spending time to control oral examination yields control, programmable for cards. II. Current control on practical, seminar and laboratory studies conducted to elucidate ready students for employment in the following forms:

1. Writing (45 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 (with tickets) questions. TeacherUseful browse the students' notes. Often, students are subject to crediting as minor, insignificant and do not give enough time to prepare for it. Of the major courses 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 coursework submitted for scientific student conference. IV. Examinations. Exam is the 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 attestation rating – 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.

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11. Distribution of points received by students.

Assessment of student knowledge is on a 100-point scale and is translated into national assessments according to table. 1 "Regulations on examinations and tests in NUBiP of Ukraine" (order of entry into force of 03.03.2021 № 7)

Student rating, points	**National Assessment for the results of the assembly**	
	Exam	**Credit**
90-100	**Excellent**	**Passed**
74-89	**Good**	
60-73	**Задовільно**	
0-59	**Satisfactory**	**Not-passed**

To determine the rating of the student (listener) for mastering the discipline $\mathbf{R_{dis}}$ (up to 100 points), the received rating from the attestation (up to 30 points) is added to

the rating of the student (listener) from educational work **Rew** (up to 70 points): **Rdis**= **Rew** + **Rat**

11. Educational and methodological support

1. Methodological guidelines "Inorganic and analytical chemistry for bachelor students specialty 201 – "Agronomy". Voitenko L.V., Kopilevich V.A., Prokopchuk N.M. Savchenko D.A., Kravchenko O.O. – Kyiv: Експо-Друк., 2022. - 219 p.
2. Laboratory manual on Inorganic and Analytical Chemistry. Savchenko D.A., Voytenko L.V., Prokopchuk N.M.- Kyiv: Експо-Друк., 2017. - 216 p.

12. Recommended sources of information

Required literature

1. General and Inorganic Chemistry : textbook / V.O. Kalibabchuk, V.V. Ohurtsov, V.I. Halynska et al. ; edited by V.O. Kalibabchuk. — Kyiv : AUS Medicine Publishing, 2019. — 456 p.
2. Introduction in General, Organic and Biochemistry, 7th Edition, by Morris Hein, Leo R. Best, Scott Pattison and Susan Arena, Brooks/Cole Publishing Co., 2021, 872 pp.
3. Inorganic Chemistry, second edition, D. F. Shriver, P. W. Atkins, and C.H. Langford; W. H. Freeman and Co., New York, 2004, 913 pp.

Supplemental

1. Concepts and Models of Inorganic Chemistry, third edition, B. E. Douglas, D. H. McDaniel and J. J. Alexander; John Wiley & Sons, Inc., New York, 2014. 993 p.
2. Inorganic Chemistry, A Modern Introduction, T. Moeller; John Wiley & Sons, New York, 2008. 846 p.
3. Chemistry of the Elements, N. N. Greenwoo and A. Earnshaw; Pergamon Press, New York, 2004. 1542 pp.

IT resources

1.Introduction to inorganic chemistry: https://bit.ly/3IAEddt ;
2.Khan Academy about Chemical Reactions: https://bit.ly/3IDtn6u;
3.Analytical chemistry. Laboratory Manual: https://bit.ly/3KHh63A
4.Virtual lab for Chemistry https://chemcollective.org/vlabs;
5.Periodic Videos by Tedex platform https://ed.ted.com/periodic-videos;
6.Modern dynamic Periodic Table of Elements http://bit.ly/3Z56Bf5;
7.Global Fertilizer impact monitor http://bit.ly/3Z50lDS.