National University of Life and Environmental Sciences of Ukraine

Department of General, Organic and Physical Chemistry

"APPROVED "
Dean of the faculty
of Design and Engineering
_____ (Ruzhylo Z.V.)
"15" 05 2023.

REVIEWED AND APPROVED
at the meeting of the department of
General, Organic and Physical chemistry
Protocol № 9 from 25. 04. 2023
Head of the Department
_____ (Kovshun L.O.)

"CONSIDERED"
Guarantor of OP " Branch engineering "
_____ (Bulgakov V.M.)

SYLLABUS
Academic Course "CHEMISTRY"

Speciality 133 – Branch engineering
Educational program Branch engineering
Faculty Design and Engineering

Syllabus compiled by: Associate Professor, PhD Krotenko Victoria,
Associate Professor, PhD Roman Zhyla

Kyiv – 2023

DESCRIPTION OF CORSE

CHEMISTRY

Field of knowledge, direction, specialty, education and qualification level		
Educational degree	bachelor	
Specialty	133 – Branch engineering	
Educational program	Branch engineering	
Characteristics of training programme		
Type	Obligatory	
The total number of academic hours	120	
Number of ECTS credits	4	
Number of modules	3	
Forms of control	Exam	
Indicators of academic discipline for full-time and part-time forms of training course		
	Full-time	**Part-time**
Year (course)	2023	2023
Semester	1	1
Lectures	30 hours	6
Laboratory sessions (activities)	30 hours	6
Self-study	60 hours	106
Independent study		
Number of hours a week Full-time leaning: auditorium own training −	 4 hours 4 hours	

1. Goal and objectives of academic discipline

Chemistry is one-semester introductory course that examines matter and the changes it undergoes.

Students explore the fundamental chemical principles and their applications to the properties and transformations of materials. The course provides an overview of the field of electrochemistry with a focus on the chemical aspects of the interfacial processes.

The main goals of the course are – to provide a solid foundation in the study of matter and its changes and to understand and apply basic chemistry concepts in branch engineering.

Learning outcomes of course is the student's ability as a future specialist:

- outlines the historical development of major principles, concepts and ideas in chemistry;
- describes applications of chemistry which affect society or the environment;
- explains trends and relationships between elements in terms of atomic structure, the periodic table and bonding;
- describes chemical changes in terms of energy inputs and outputs;
- compiles the different chemical reaction, describes factors that influence the type and rate of chemical reactions;
- relates the uses of carbon to the unique nature of carbon chemistry;
- applies simple electrochemical processes;

Upon completion of this course:

Students will develop knowledge and understanding of:

- the nature and practice of chemistry,
- the implications of chemistry for society and environment,
- atomic structure, the periodic table and bonding,
- chemical reactions, including acid/base reactions and chemical equilibrium,
- carbon chemistry,
- electrochemical applications.

Student will develop skill in:

- planning investigations,
- conducting simple analysis**,**
- working with laboratory equipment**,**
- working with different chemical compound.

General competences

1. Ability to abstract thinking, analysis and synthesis
2. The ability to act socially responsibly and consciously.
3. The ability to preserve and multiply moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, technology and technologies, to use various types and forms of motor activity for active recreation and leading a healthy lifestyle.

Special (professional) competences

1. The ability to implement engineering developments in industrial mechanical engineering, taking into account technical, organizational, legal, economic and environmental aspects throughout the life cycle of the machine: from design, construction, operation, maintenance, diagnostics and disposal.

Program learning outcomes

PH1. Knowledge and understanding of the basics of technological, fundamental and engineering sciences, which are the basis of industrial mechanical engineering in the relevant field.

PH5. Analyze engineering objects, processes and methods.

PH9. Choose and apply the necessary equipment, tools and methods.

2. Program and structure of the course

Structure of the course "Chemistry"

Modules and topics	Hours												
	Full time							Part time					
	Weeks	total	included					total	included				
			L	P	Lab	Ind	Self work		L	P	Lab	Ind	Self work
1	2		3	4	5	6	7	8	9	10	11	12	13
Module 1. **The basics atomic-molecular theory of the matter structure**													
Topic 1. The main concepts and laws of chemistry	1	10	1		2		7	9					9
Topic 2. Atomic structure	1	11	1		2		8	10,5	1		0,5		9
Topic 3. The periodic law and Mendeleev's periodic table of chemical elements	3	8	1		0		7	9					9
Topic 4. The chemical bond and the structure of molecules	3	11	1		2		8	11,5	1		0,5		10
Total	40		4		6		30	40	2		1		37
Змістовий модуль 2.**Основні закономірності перебігу хімічних процесів**													
Topic 1. Thermodynamic laws of chemical transformations. Kinetics of chemical reactions	5	8	1		2		5	7					7
Topic 2. Properties of solutions of	5	10	1		4		5	8,5	1		0,5		7

electrolytes and non-electrolytes. Electrolytic dissociation													
Topic 3. The redox processes and their conditions	7	8	2		2		4	8,5	1		0,5		7
Topic 4. Fundamentals of electrochemistry. Chemical current sources	9	7	1		2		4	8	0,5		0,5		7
Topic 5. Electrolysis of melts and solutions of electrolytes as oxidation - reduction process	9	7	1		2		4	8	0,5		0,5		7
Total	40		6		12		22	40	3		2		35
Змістовий модуль 3**. Хімія елементів і сполук елементів, що складають основу неорганічних і органічних будівельних матеріалів**													
Topic 1. Properties of metals and their compounds in building materials.	11		1		4		6	6,5					9
Topic 2. Corrosion processes and materials protection against corrosion	11		1		4		6	7	0,5		0,5		10
Topic 3. Bases of organic chemical compounds.	13		2		2		5	8	0,5				9
Topic 4. Polymeric materials and their applications in engineering	15		1		2		6	8			0,5		10
Total	40		5		12		23	40	1		1		38
Total hours of the course	120		15		30		75	120	6		4		110
Course project (work) with			-	-	-		-						
Only hours	120		15		30		75	120	6		4		110

6. Topics of laboratory works

№	Topic	Hours
1.	Introduction. Equipment and safety in chemical laboratory. Methods of chemical experiments.	2
2.	Bases of modern nomenclature and classification of inorganic compounds.	2(0,5)
3.	The structure of the atom and Mendeleev's periodic law	2

4.	Determination of the types of chemical bonds between atoms in compounds. The relative electronegativity of atoms.	2(0,5)
5.	Determination of the thermal effect of the neutralization and dissolution of anhydrous salts.	2
6.	Calculation of kinetic parameters of the reaction according to the experiment.	2
7.	Determination of the conductivity of electrolyte solutions. Indicator method of pH solutions calculation.	2(0,5)
8.	The preparation of solutions given concentration	2
9.	The properties of metals in redox reactions.	2
10.	The dependence of electromotive force from galvanic cells of metals.	2
11.	Investigation of electrolysis of aqueous solutions of electrolytes. The calculations of the aount of substances using Faraday's law.	2(0,5)
12.	Determination of corrosion mass index rate.	2(0,5)
13.	The chemical properties of metals and their compounds.	2(0,5)
14.	The genetic link between the classes of organic compounds, the methods of detection og organic compounds.	1(0,5)
15.	The properties of polymers. Introduction to methods of determining the quality of fuels.	2(0,5)

30hours (4hours)

7. Example of module tests

Module №1

«Atomic structure and chemical bond»

Variant № 1

1. The possible values of main(principal) quantum number are:

A.	integers from 0 to n-1;	B.	+½, - ½;
C.	integers from 1 to ∞;	D.	integers from + *l* to - *l* .

2. The total number of orbitals in an s-subshell is?….. :

(write right answer to the answer sheet)

3. Which electron configuration reprsents an atom Sb in the ground state:

A.	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^3$;	B.	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^2 5p^6 5d^{10}$;
C.	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^8 5s^2 5p^5$;	D	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^1 5p^4$

4. To give the characteristics of elements:

№ 17, № 50

Scheme of answer:

- To determine (according to the placement of element in the periodic system):
- element properties - metal or non-metal;
- the total number of electrons, the total number of shells, the total number of valence electrons;
- To compile electronic and graphic structure of atom of elements.
- To determine the possible valence and oxidation number of element.
- To give an examples of compounds (oxides, bases, acids, salts) with all of possible oxidation numbers.
- To confirm chemical properties with the proper chemical equations.

5. To compile equation between simple substances formed by elements with atomic number 30and 8, specify the type of chemical bond of obtained compound

6.Determine the types of chemical bonds for the following compounds:

manganese; potassium carbonate; phosphate acid; calcium hydroxide; ferrum (III) sulfate

Variant № 2

1. What's formula determine value of secondary(azimunthal) quantum number:

A.	$2l + 1$;	B.	$2n^2$;	C.	$2(2l + 1)$;	D.	$0 \div n-1$.

2. Electronic structure of atom Manganese ….. :

(write right answer to the answer sheet)

3. The total number of shells (levels) of atom is equal to the number of..:

A.	Group ;	B.	Element;
C	Period;	D	Series.

4. To give the characteristics of elements:

№ 15, № 40

Scheme of answer:

- To determine (according to the placement of element in the periodic system):
- element properties - metal or non-metal;
- the total number of electrons, the total number of shells, the total number of valence electrons;
- To compile electronic and graphic structure of atom of element.
- To determine the possible valence and oxidation number of element.
- To give an examples of compounds (oxides, bases, acids, salts) with all of possible oxidation numbers.
- To confirm chemical properties with the proper chemical equations.

5. To compile equation between simple substances formed by elements with atomic number 16 and 19, specify the type of chemical bond of obtained compound

6.Determine the types of chemical bonds for the following compounds:

steel; chrome (III) nitrate; silicate acid; carbon (IV) oxide; chlorine

Variant № 3

1. The total number of orbitals in an f-subshell is:

A.	7;	B.	3;	C.	5;	D.	1.

2. The orientation of an orbital inspace is specified by ……. quantum number:

(write only one word to the answer sheet)

3. Which electron configuration reprsents an atom Zr in the ground state:

A.	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^2 5p^2$;	B.	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2 4p^6 5s^2 5p^4$;
Б.	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^2 5s^2$;	Г	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^3 5s^1$

4. To give the characteristics of elements:

№ 7, № 23

Scheme of answer:

- To determine (according to the placement of element in the periodic system):
- element properties - metal or non-metal;
- the total number of electrons, the total number of shells, the total number of valence electrons;
- To compile electronic and graphic structure of atom of element.
- To determine the possible valence and oxidation number of element.
- To give an examples of compounds (oxides, bases, acids, salts) with all of possible oxidation numbers.
- To confirm chemical properties with the proper chemical equations.

5. To compile equation between simple substances formed by elements with atomic number 7 and 8, specify the type of chemical bond of obtained compound

6. Determine the types of chemical bonds for the following compounds:

barium chlorate; potassium carbonate; 2 molecule of fluoride acid; zinc hydroxide; scandium

Module №2

«The bases of electrochemistry»

Variant № 1

1. **Specify the number of lost or attached electrons according to the scheme**
   $HNO_3 \rightarrow NH_3$:
   A. +2, **B.** -2, **C.** -3, **D.** +8.
2. **To write molecular, complete and net ionic equations:**
   $ZnCl_2 + K_3PO_4 \rightarrow$ $Ba(NO_3)_2 + H_2SO_4 \rightarrow$
   $K_2SiO_3 + HCl \rightarrow$ $Fe_2O_3 + HNO_3 \rightarrow$
   $Zn(OH)_2 + Ca(OH)_2 \rightarrow$ $(NH_4)_2SO_4 + NaOH \rightarrow$
   $Ba + H_2SO_{4\ conc.} \rightarrow$ $Mn + HNO_{3\ dil.} \rightarrow$
   $Cu + HCI \rightarrow$ $Na + H_2O \rightarrow$
   $Al + NaOH \rightarrow$ $Zn(CH_3COO)_2 + Mg \rightarrow$
3. **To calculate EMF for the Fe-Cu galvanic cell:**
   A. 1,92 V **B.** -1,92 V **C.** 2,8 V, **V.** -2,8 V
4. **Make the circuit electrode processes that occur on. cathode and anode during the electrolysis of aqueous solutions of potassium sulfate and melt sodium chloride?**
5. **Calculate amount of Copper on the cathode during electrolysis of aqueous solution of nickel sulfate for 30 minutes at a current 2A??**
   A. 71,6 g **B.** 4,12 g, **C.** 2,38 g, **D.** 1,19 g.

Variant № 2

1. **Specify the number of lost or attached electrons according to the scheme**
   $HNO_3 \rightarrow HNO_2$:
   A. +2, **B.** -2, **C.** +1, **D.** +8.
2. **To write molecular, complete and net ionic equations::**
   $CoCl_2 + Na_3PO_4 \rightarrow$ $BaCl_2 + H_2SO_4 \rightarrow$
   $K_2SO_3 + HNO_3 \rightarrow$ $NH_4NO_3 + NaOH \rightarrow$
   $Al(OH)_3 + NaOH \rightarrow$ $Cr_2O_3 + HClO_4 \rightarrow$
3. **To calculate EMF for the Zn-Cu galvanic cell:**
   A. 0,1 V **B.** -0,78 V, **C.** 0,78 V, **D.** 1,1 V.
4. **Make the circuit electrode processes that occur on. cathode and anode during the electrolysis of aqueous solutions of plumbum nitrate and melt of potassium chloride?**
5. **Calculate amount of Nickel on the cathode during electrolysis of aqueous solution of nickel sulfate for 80 minutes at a current 5A?**
   A. 1,83g **B.** 14,7 g, **C.** 7,3 g, **D.** 2,23 g.

Module №3

« Chemistry of the elements»

Variant № 1

1. **To write the dissociation equation for the ions of the following compounds:**
   ferrum (III) carbonate, itric acid, potassium hydroxide.
2. **Specify the number of lost or attached electrons according to the scheme**
   $NO_3^- \rightarrow NH_3$:
   A. +2, **Б.** -2, **B.** -3, **Г.** +8.
3. **Balance Redox reactions using method of electron balance. Point out oxidizing and reducing agents:**
   $Ba + H_2SO_{4\ conc.} \rightarrow$ $Mn + HNO_{3\ dil.} \rightarrow$

$Cu + HCI \rightarrow$ $Na + H_2O \rightarrow$

$Al + NaOH \rightarrow$ $Zn(CH_3COO)_2 + Mg \rightarrow$

4. Determine reactions of oxygen depolarization of iron:

1.	$Fe - 2\bar{e} \rightarrow Fe^{2+}$;	**3.**	$1/2O_2 + H_2O + 2\bar{e} \rightarrow 2OH^-$;
2.	$Fe^{2+} + 2\bar{e} \rightarrow Fe$;	**4.**	$2H^+ + 2\bar{e} \rightarrow H_2$.

Variant № 2

1. **To write the dissociation equation for the ions of the following compounds:** Aluminium hydroxide, mangane (II) chloride, sulfate acid.
2. **Specify the number of lost or attached electrons according to the scheme $NO_3^- \rightarrow NO_2$:**
   А. +2, **Б.** -2, **В.** +1, **Г.** +8.
3. **Balance Redox reactions using method of electron balance. Point out oxidizing and reducing agents:**

$Ca + H_2SO_{4\ conc.} \rightarrow$ $Cu + HNO_{3dil.} \rightarrow$

$Au + HCI \rightarrow$ $Ba + H_2O \rightarrow$

$Cr + NaOH \rightarrow$ $Cu(CH_3COO)_2 + Zn \rightarrow$

4. Point the correspondence of the coating and processes:

A	Non-damage	**1.**	(C) $Zn^{2+} + 2\bar{e} \rightarrow Zn$;	**3.**	(C) $Fe^{2+} + 2\bar{e} \rightarrow Fe$;
B	damaged	**2.**	(A) $Fe - 2\bar{e} \rightarrow Fe^{2+}$;	**4.**	(A) $Zn - 2\bar{e} \rightarrow Zn^{2+}$.

8. Methods of teaching

In conducting lectures appropriate to use verbal teaching methods: explanation, narration, discussion, educational debate, with a combination of visual learning methods: illustration, showing. In carrying out laboratory work should be used such as verbal learning method of instruction on the combination of visual learning methods of illustration and demonstration, the aspect of these studies is that they facilitate communication theory and practice. Laboratory work in the laboratory are equipped basic chemical and electrochemical equipments.

9. Forms of control

The main methods of control of knowledge and skills students have to study the subject "Remote sensing for land resources monitoring" are: oral examination, written and practical test, standardized control in the form of modular test papers, assessment for individual learning task, the final test. The total value of these methods is to make the best possible to ensure timely and comprehensive feedback between students and teachers, by which establishes how students perceive and learn the material. The purpose determines the choice of control methods, it should be borne in mind that these methods can be applied in all kinds of control - only complete applications allows regularly and objectively identify the dynamics of the formation of knowledge and skills of students. Each control method has its advantages and disadvantages, scope of application, none of them can not be the only one able to diagnose all aspects

of the learning process. So: - to control the absorption of lectures: oral questioning, written modular test papers, current testing score for an individual learning task, the final test. - for the monitoring and evaluation of laboratory work: practical test and evaluation of each laboratory work.

10. Distribution of grades received by students during study.

Current testing			Rating of educational work $R_{НР}$	Rating of additional work $R_{ДР}$	Negative Rating $R_{ШТР}$	Final test	Total amount of scores
Module 1	Module 2	Module 3					
0-100	0-100	0-100	0-70	0-20	0-5	0-30	0-100

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

де $R^{(1)}_{ЗМ}$, … $R^{(n)}_{ЗМ}$ – rating of 1st, 2nd and 3d modules by 100 mark scale;

n – number of modules;

$К^{(1)}_{ЗМ}$, … $К^{(n)}_{ЗМ}$ – credits ECTS;

$К_{ДИС} = К^{(1)}_{ЗМ} + … + К^{(n)}_{ЗМ}$ – total amount of credits ECTS;

$R_{ДР}$ – rating of additional work;

$R_{ШТР}$ – penal rating.

A rating of discipline can be calculated by formula:

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

Required and recommended literature

11. Methodical support

1. Жила Р.С., Кротенко В.В. CHEMISTRY. Lecture course for students of the specialty 133 – Industrial Mechanical Engineering.- К. : ДДП «Експо-Друк», 2021. 161 с.
2. Антрапцева Н.М., Кравченко О.О., Солод Н.В. Chemistry. Methodological guidelines for laboratory practice and self-guided study for students specialty: 133 – Branch engineering". - Видавничий центр « Експо-Друк », 2022. – 155 с.
3. Антрапцева Н.М., Солод Н.В., Кравченко О.О. Chemistry. Methodical guidelines for the English-language course mastering for students of technical direction. - К.: Видавничий центр «»Експо-Друк, 2018. - 151 с.
4. Антрапцева Н.М., Солод Н.В., Кравченко О.О. Chemistry. Methodological guidelines for self-guided work of students (Part 1. General and Inorganic chemistry) specialties 133 – Industrial Mechanical Engineering. - К.: Видавничий центр «»Експо-Друк, 2018. - 130 с.
5. Антрапцева Н.М., Солод Н.В., Кравченко О.О. Chemistry. Laboratory practice (with basic theory) for bachelor students speciality 133 – "Industrial Mechanical Engineering" (Republication). - К.: Видавничий центр «»Експо-Друк, 2018. - 235 с.
6. Антрапцева Н.М., Кочкодан О.Д., Жила Р.С. Хімія. Тестові завдання для самостійної роботи студентів спеціальностей: 151 – Автоматизація та комп'ютерно-інтегровані технології, 133 – Галузеве машинобудування, 192 – Будівництво та цивільна інженерія. К.: НУБіП, 2016. – 160 с.

12. Basic literature

1. David R. Klein. Organic Chemistry, 4th (January 5, 2019) 1st edition. Wiley. – 1390p.
2. Ластухін Ю.О., Воронов С.А. Органічна хімія. – Львів: Центр Європи, 2001. – 863 с.
3. General and InorganicChemistry: Textbook / V. O. Kalibabchuk [et al.] ; ed. V. O. Kalibabchuk. – Kyiv : AUS Medicine Publishing, 2019. – 455 p.
4. Основи загальної та неорганічної хімії: навчальний посібник. Перевидання / Н. М. Антрапцева, О. Д. Кочкодан. - К. : ФОП Ямчинський О.В., 2020. - 331 с.
5. Органічна, біоорганічна, фізична і колоїдна хімія: навчальний посібник / В. В. Кротенко, Л. О. Ковшун ; Національний університет біоресурсів і природокористування України. - Перевидання. - К. : НУБіП України, 2022. - 425 с.

Supplemental materials

1. Arthur Winter. Organic Chemistry I For Dummies, 3nd Edition, 2019. – 384 p.
2. Хімія: навчальний посібник для студентів спеціальності 201 "Агрономія" скороченого терміну навчання / В. В. Кротенко, О. І. Хижан, Л. О. Ковшун ; Національний університет біоресурсів і природокористування України. - К. : НУБіП України, 2019. - 429 с.

13. IT resources

1. https://ptable.com/
2. https://learningapps.org/
3. https://chemequations.com/en/
4. https://learningcenter.unc.edu/services/stem/chemistry-resources/
5. https://edu.rsc.org/
6. https://bioapi.lk/chemistry-resource-book-sinhala-bioapi/
7. http://simplescience.ru/video/about:chemistry/
8. http://chemistry-chemists.com/Video.html
9. https://www.youtube.com/c/Thoisoi/
10. https://www.youtube.com/c/ChemistryEasy/
11. http://simplescience.ru/video/about:chemistry/
12. http://chemistry-chemists.com/Video.html
13. http://www.chemicum.com/ru/
14. https://www.youtube.com/channel/UCD2fRmgV93G8ZUxZTGLbScA