NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

AGROBIOLOGICAL FACULTY
DEPARTMENT OF ANALYTICAL AND BIOINORGANIC CHEMISTRY & WATER QUALITY

"APPROVED"
Acting Dean of the Faculty of Plant Protection,
the Biotechnologies, and Ecology
Dr.Agr.Sci, Docent _____ Yu. V. Kolomiets
"____"_____, 2020

REWIED AND APPROVED
At the meeting of the department
of Analytical and Bioinorganic
Chemistry & Water Quality
Protocol # 12, "14" May, 2020
Head of the Department
Dr.Chem.Sci, Prof. _____V.A.Kopilevich

SYLLABUS

Academic Discipline "CHEMISTRY (V) ANALYTICAL"
For EL (educational level) "Bachelor"

Branch of knowledge – 10 Natural Sciences
Speciality – 101 Ecology

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

Kyiv, 2020

The Educational program Chemistry (V) Analytical for
Branch of knowledge – 10 Natural Sciences
Speciality – 101 Ecology

"14" May 2020

The developer: L.V. Voitenko, Associate Professor of the Department of Analytical and Bioinorganic Chemistry & Water Quality, PhD in Chemistry
(вказати авторів, їхні посади, наукові ступені та вчені звання)

The Working program was approved at the meeting of the Department of Analytical and Bioinorganic Chemistry & Water Quality

Protocol # 12 "14" May 2020

Head of the Department of Analytical and Bioinorganic Chemistry & Water Quality, Dr.Chem.Sci, Prof.

_____ (V.A.Kopilevich)
(підпис) (прізвище та ініціали)

Approved by the Scientific Council of Faculty of the Faculty of Plant Protection, the Biotechnologies, and Ecology

Protocol # ____ "____" _____ 2020

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

1. Academic discipline description

Chemistry (V) Analytical

(назва)

Branch of knowledge, direction, specialty, education and qualification level		
Educational and Qualification level qualification	Bachelor	
Branch of knowledge	10 Natural Sciences	
Speciality	101 Ecology	
Characteristics of training programme		
Type	Ordinary (standard)	
The total number of academic hours	165	
Number of ECTS credits allocated	6	
Number of modules	3	
Forms of control	Written examination	
Indicators of academic discipline for full-time and part-time forms of training course		
	Full-time	**Part-time**
Year of study (course)	2	No
Semester	4	
Number of lecture, hours	30	
Number of seminars, practical classes	-	
Laboratory sessions (activities)	45	
Independent study	90	
Individual lessons	-	
Number of weekly in-class academic hours for full-time forms of training	5	
Course work (separate program)	22	
Study workshop (separate program)	36	

2. Goal and objectives of academic discipline

Analytical Chemistry is the Chemistry of the differences. From an analytical point of view, analogies of elements, of a same column or period of the periodic table, are left aside in the same way that analogy of organic compounds, having the same functional groups, in order to pay more attention to the specific identity of elements and compounds. In this sense, Analytical Chemistry is closer to the evidences of the life experiences than other chemical disciplines and it can be well understood by our students, who appreciate the different effects of sodium and potassium on soil fertility, in spite of the fact that both are alkaline elements, or the tremendous differences between the toxicity of methanol and ethanol, which have the small difference of a carbon and two hydrogen atoms.

Analytical chemistry is often described as the area of chemistry responsible for characterizing the composition of matter, both **qualitatively** (what is present) and **quantitatively** (how much is present). This description is misleading. Almost all chemical disciplines routinely make qualitative or quantitative measurements (Figure

1). The argument has been made that analytical chemistry is not a separate branch of chemistry, but simply the application of chemical knowledge.

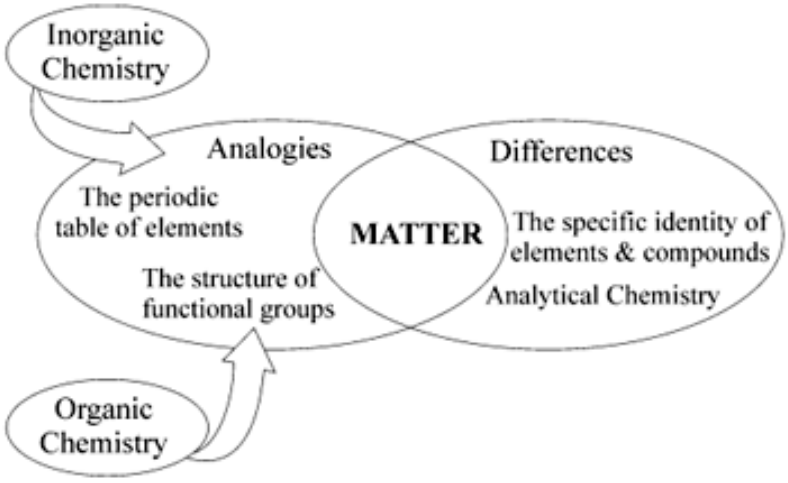


Figure 1 – Analytical Chemistry as the Chemistry of the differences

In fact, students probably have performed quantitative and qualitative analyses in other chemistry courses. For example, many introductory courses in chemistry include qualitative schemes for identifying inorganic ions and quantitative analyses involving titrations. Unfortunately, this description ignores the unique perspective that analytical chemists bring to the study of chemistry. The craft of analytical chemistry is not in performing a routine analysis on a routine sample (which is more appropriately called chemical analysis), but in improving established methods, extending existing methods to new types of samples, and developing new methods for measuring chemical phenomena.

So, Analytical 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 Analytical chemistry research:

- To empower students to obtain a skills orientated qualification - laboratory technician:
- To train natural scientists to be employed in various sectors of the economy;
- To train specialists in natural sciences;
- To create further opportunities in research and for post-graduate studies;
- To make a national and international contribution to the promotion of research.

Environmentally Friendly Analytical Chemistry

In past times, after data evaluation, it was considered that an analytical procedure was finished when all the elements to solve a problem were on the table. However, nowa-days, it is imposed by laws and by the compromise between scientists and our world to consider also the side effects of our job. In this new scenario, it is necessary to evaluate and to treat the wastes generated by the measurement processes in such a way that the less pollutant methods would be selected and the laboratory wastes decontamined. The environmental mentality in Analytical Chemistry is a recent compromise of chemistry but should be carefully considered in order to assure the sustainable development of our discipline.

Figure 2 summarizes the different stages in the evolution of the ecological mentality of the analytical laboratories, from the technical development to the bad conscience of the environment damage and the engagement of sustainable practices.

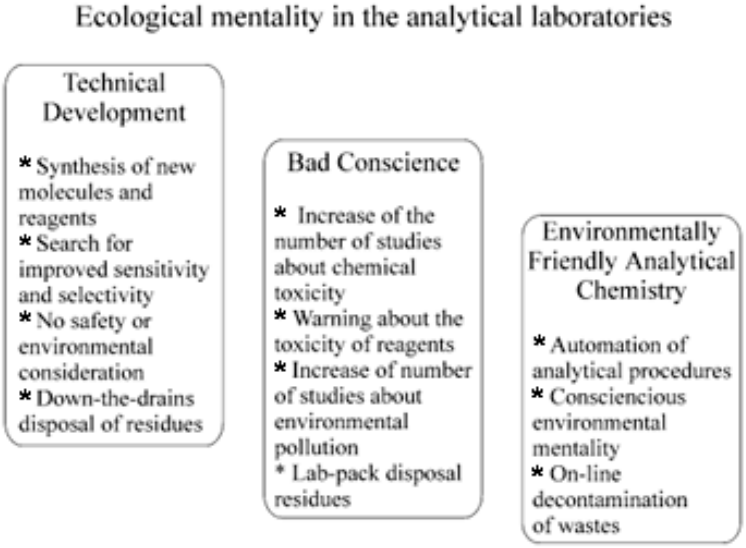


Figure 2 – Stages of the evolution of ecological mentality in the analytical laboratories

Requirements of knowledge and skills acquired during studying the discipline

Aim and Task of Subject

Is formation of Biotechnological students' theoretical and practical bases and skills, needed for the next studying in the estimated professional direction, where used chemical analysis of natural and artificial objects.

Control of knowledge and skills

It is realized in the form:

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

Requirements to the knowledge and skills

Student must to know:

- Safety technique in analytical laboratory;
- Bases of the qualitative analysis;
- Qualitative reactions of cations and anions;
- Methods of masking for prevent ions;
- Methods of ions separation in solution at qualitative determination;
- Bases of gravimetry (mass analysis) and titrimetry (volume analysis).

Student must to be able to do:

- To carry out qualitative determination of cations and anions in solution,

contained prevented ions;
- To determinate elements, contained mixed samples (soluble and insoluble salts, oxides, free metals, hydroxides, acid solutions so on);
- To determine quantitatively elements by gravimetry;
- To solve quantitative calculations in analytical field.

Student must to have practical skills:
- To use analytical glassware and general analytical equipment;
- To do standard qualitative and quantitative procedures;
- To prepare natural and artificial samples to qualitative and quantitative analyses;
- To use the educational, methodical and reference literature sources in the field of analytical chemistry.

Pre-required courses

Course	Chapters of course
Inorganic and bio-inorganic chemistry	All chapters
Organic chemistry	Organic dyes and ligands, indicators
High Mathematics	Logarithms and operations with logarithms, Math operations on degrees

3. PROGRAM AND STRUCTURE OF SUBJECT
Titles, contents, and extents of the lectures

Змістовий модуль 1. The Foundations of the Qualitative Analysis.

Lecture # 1. Subjects and objects of the chemical analysis (analytical chemistry). Methods of quantitative analysis – chemical and physical-chemical. Subjects of qualitative and quantitative analyses. Methods of qualitative analysis – macro-, semimicro-, micro-, and ultramicromethods.

Lecture # 2. Analytical reactions and requirements to analytical reactions. Examples of qualitative reactions of different visual effects (sedimentation, colorizing etc.). "Dry" and "wet" qualitative tests. Pyrochemical methods (idea of borax bead tests, flame tests), microcrystalline analysis, analysis in drops in filter paper. Notions of specific, selective, and group reactions and reagents. Examples.

Lecture # 3. Principles of cations classification – acid-base, sulfide, ammine-phosphate. The main group reagents. Analytical purity of reagents. Ukrainian and international degrees of purity (classification техн, ч, чда, хч, осч; Analytical reagent AR, Guaranteed Reagent (GR) etc.).

Lecture # 4. The methodology of cation mixture analysis. Partial and Systematic analysis. Centrifugation, fullness testing.

<u>Змістовий модуль 2.</u> The Foundations of the Gravimetric Quantitative Analysis.

Lecture # 5. Expression of Concentration: percent (mass) concentrations (percentage weight by weight; volume by volume etc; Molar, Normal (equivalent), and Titr.

Lecture # 6. Formulas of recalculations of concentration units. Preparation of solutions. Calculation in quantitative analysis.

Lecture # 7. Heterogeneous equilibrium. Equilibrium In Saturated Solutions of Slightly Soluble Substances. Solubility product. Molar and mass solubility. Examples of calculations.

Lecture # 8. Factors effecting solubility: temperature, common ion effect, pH effect. Notion of ionic power (strength), active coefficients, and active concentrations.

Lecture # 9. Subject of gravimetric analysis. Equipment and tools (filter paper series). The experimental strategy. Calculations in gravimetric analysis. Tananaev's rule. Amorphous and crystalline sediments. Requirements to sediments in gravimetric analysis. Rules of sedimenting.

<u>Змістовий модуль 3.</u> The Foundations of the Volumetric Quantitative Analysis.

Lecture # 10. Homogeneous equilibrium. Ionic product of water. pH notion. Biological function depending pH. Measuring pH. pH calculations of strong acids and bases, weak acids and bases.

Lecture # 11. Hydrolysis and pH calculations of different salts solutions. Buffer solutions. Calculate of a pH of buffer solutions. Titration curves, equivalent points, titration jump. Acid-base indicators. Choice of indicators. Equivalent law in volumetry.

Lecture # 12. Neutralization method. Standard and working solutions, possibilities of method. Determination of water temporary hardness.

Lecture # 13. RedOx volumetry. Nernst equation. Electrode potential of redox systems. Electromoving force (EMF) of redox systems. RedOx indicators.

Lecture # 14. Foundations of permanganatometry and iodometry.

Lecture # 15. Complexonometry. Bases of method. Standard and working solutions, possibilities of method. Metallochromic indicators. Determination of total

temporary hardness. Precipitation titration. Mohr' method of chloride determination. Fixation of equivalent point. Experimental strategy.

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. The Foundations of the Qualitative Analysis						
Тема 1. Subjects and objects of the chemical analysis (analytical chemistry). Methods of quantitative analysis. Subjects of qualitative and quantitative analyses. Methods of qualitative analysis (macro-, semimicro-, micro-, and ultramicro-methods). Analytical reactions and requirements to analytical reactions. Examples of qualitative reactions of different visual effects (sedimentation, colorizing etc.). "Dry" and "wet" qualitative tests. Pyrochemical methods, microcrystalline analysis, drop analysis. Notions of specific, selective, and group reactions and reagents.	14	4		2		8
Тема 2. Sulfide, acid-base, and ammine-phosphate classification of cations. Qualitative tests of I-IV cation groups. The main group reagents. Analytical classification of anions.	14	2		6		6
Тема 3. Analytical purity of reagents. Ukrainian and international degrees of purity. The methodology of cation mixture analysis. Partial and Systematic analysis. Centrifugation, fullness testing. *Experimental test.* To analyze and determine the composition of cation mixture. *Theoretical quiz.* Qualitative analysis of cations.	22	4		8		10
Тема 4. Qualitative tests of anions. *Experimental module test.* Qualitative analysis of soluble salts, and insoluble substances (salts, free metals, oxides). *Theoretical quiz.* Qualitative analysis of inorganic substances.	16			6		10
Разом за змістовим модулем 1:	**66**	**10**		**22**		**34**

1	2	3	4	5	6	7
Змістовий модуль 2. The Foundations of the Gravimetric Quantitative Analysis						
Тема 1. Expression of Concentration: percent (mass) concentrations (percentage weight by weight; volume by volume etc; Molar, Normal (equivalent), and Titr. Formulas of recalculations of concentration units. Preparation of solutions.	14	4				10
Тема 2. Analytical techniques and procedures of Quantitative mass analysis (gravimetry). Subject of gravimetric analysis. Equipment and tools (filter paper series). The experimental strategy. Calculations in gravimetric analysis. Tananaev's rule. Amorphous and crystalline sediments. Requirements to sediments in gravimetric analysis. Experimental strategies of sedimentation. *Experimental module test.* Determination of barium content in the barium chloride hydrate. *Theoretical quiz.* The foundations of mass analysis, heterogeneous equilibrium.	22	4		8		10
Разом за змістовим модулем 2:	**36**	**8**		**8**		**20**
Змістовий модуль 3. The Foundations of the Volumetric Quantitative Analysis						
Тема 1. Ionic product of water. pH notion. Biological function depending pH. Measuring pH. pH calculations of strong acids and bases, weak acids and bases. pH calculations of different salts solutions. Buffer solutions. Calculate of a pH of buffer solutions. Titration curves, equivalent points, titration jump. Acid-base indicators. Choice of indicators. Equivalent law in volumetry.	18	4				14
Тема 2. Neutralization method. Standard and working solutions, possibilities of method. *Experimental module test.* Determination of alkali content in solution, and water temporary hardness. *Theoretical quiz.* Units of concentration.	10	2		4		4
Тема 3. RedOx volumetry. Nernst equation. Electrode potential of redox systems. Electromoving force (EMF) of redox systems. RedOx indicators. Bases of permanganatometry and iodometry. RedOx volumetric methods. Permanganatometry method. Standard and working solutions, possibilities of method. *Experimental module test.* Determination of iron(II) content in Mohr's salt solution.	23	4		6		13

1	2	3	4	5	6	7
Iodometry method. Standard and working solutions, possibilities of method. *Experimental module tests.* Permanganatometric determination of iron(II) content in Mohr's salt solution. Iodometric determination of copper content in copper vitriol.						
Тема 4. Complexonometry. Bases of method. Standard and working solutions, possibilities of method. Metallochromic indicators. Determination of total temporary hardness. Precipitation titration. Mohr' method of chloride determination. Fixation of equivalent point. Experimental strategy. *Experimental module test.* Complexonometric determination of Calcium content in solution. *Theoretical quiz.* Foundations of Redox and complexonometric methods.	12	2		5		5
Разом за змістовим модулем 3:	**63**	**12**		**15**		**36**
Усього годин:	**165**	**30**		**45**		
COURSE work IN ANALYTICAL CHEMISTRY	**36**					

4. CHAPTERS OF SEMINAR TRAINING

No planned

5. CHAPTERS OF PRACTICAL TRAINING

No planned

6. LAB TRAINING CHAPTERS

#	Chapter	Hours
1	Introduction. Lab Safety rules. Semimicro qualitative lab techniques. Basic characteristics of Qualitative tests (sensitivity, selectivity.	2
2	Qualitative classification of cations. Qualitative tests of the I cation group (NH_4^+, K^+, Na^+)	2
3	Qualitative tests of the II cation group (Mg^{2+}, Ca^{2+}, Sr^{2+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, and Al^{3+}). Action of group, selective, and specific reagents.	4
4	Qualitative tests of the III cation group (Zn^{2+}, Cu^{2+}, Co^{2+}, and Ni^{2+}), and the IV cation group (Ag^+, Pb^{2+}). Action of group, selective, and specific reagents.	3
5	Partial and Systematic analyses of cation mixture. Idea of cation separation. *Experimental test.* Determine the composition of cation mixture.	5
6	Qualitative classification of anions. Qualitative tests and methods of separations of anions SO_4^{2-}, SO_3^{2-}, CO_3^{2-}, PO_4^{3-}, SiO_3^{2-}, MoO_4^{2-}, BO_2^-, Cl^-, Br^-, I^-, NO_3^-, NO_2^-, and CH_3COO^-	2

7	*Experimental module test.* Qualitative analysis of soluble salt (1 item), and insoluble substance (1 item) (salts, free metals, oxides).	4
	Змістовий модуль 1	**22**
8	*Experimental module test.* Determination of barium content in the barium chloride hydrate.	8
	Змістовий модуль 2	**8**
9	Neutralization method. Standard and working solutions, possibilities of method. *Experimental module test.* Determination of alkali content in solution, and water temporary hardness.	4
10	RedOx volumetric methods. Permanganatometry method. Standard and working solutions, possibilities of method. *Experimental module test.* Determination of iron(II) content in Mohr's salt solution.	3
11	Iodometry method. Standard and working solutions, possibilities of method. *Experimental module test.* Iodometric determination of copper content in copper vitriol.	3
12	Complexonometry. Bases of method. Standard and working solutions, possibilities of method. *Experimental module test.* Complexonometric determination of Calcium content in solution.	5
	Змістовий модуль 3	**15**
	Разом	**45**

7. INDEPENDENT STUDY

#	Chapter	Hours
1	Application of chemical analysis. Sampling. Types of analysis. Use of literature. Common techniques. Factors affecting the choice of analytical methods. Data acquisition and treatment.	8
2	Principles of sulfide-free methods of cation classifications. Dissolving of the sample. "Soda" extracting. Methods of heterogeneous mixture separating.	6
3	Determination of analytical purity of the chemicals for the different purposes of environmental analysis (air, fresh water, soils, foods, microbiological analysis etc.). Methods of analytical separation of cations in natural systems	10
4	Analytical methods of environmental item qualitative tests	10
5	Training calculations of concentration units recalculations in the environmental application (heavy metals analysis, salty waters mineralization, etc)	10
6	The ionic strength of natural water systems (salty sea waters, blood, cell juice etc.). Osmosis and ionic strength. Calculation of common ion effect and environmental problems (how to immobilize the heavy metals in soils etc.).	18
6	pH graphic method determination. How to prepare of buffer solutions. TRIS solution – preparation and application. How to calculate titration curves of acid mixture titration. Choice of the best	10

	acid-base indicators and their preparation.	
7	RedOx calculation of ionic species of metals of changing valencies in natural systems (iron, manganese). RedOx potential of natural waters and soils. Chemical oxygen demand (COD) of natural waters as application of RedOx volumetric methods in the environmental analysis.	13
8	Chelates as a food additives, drugs, and analytical reagents. Using of complexones in environmental sanitation.	5
	Разом	**90**

8. CONTENT OF THEORETICAL QUESTIONS

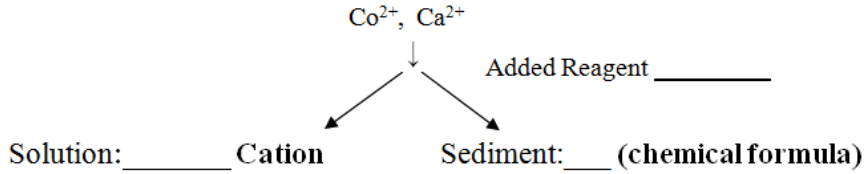
Qualitative analysis

1. Subjects and objects of the chemical analysis (analytical chemistry).
2. Methods of quantitative analysis – chemical and physical-chemical.
3. Subjects of qualitative and quantitative analyses.
4. Methods of qualitative analysis – macro-, semimicro-, micro-, and ultramicromethods.
5. Analytical reactions and requirements to analytical reactions. Examples of qualitative reactions of different visual effects (sedimentation, colorizing etc.)
6. "Dry" and "wet" qualitative tests. Pyrochemical methods (idea of borax bead tests, flame tests), microcrystalline analysis, analysis in drops in filter paper.
7. Notions of specific, selective, and group reactions and reagents. Examples.
8. Principles of cations classification – acid-base, sulfide, ammine-phosphate. The main group reagents.
9. Analytical purity of reagents. Ukrainian and international degrees of purity (classification техн, ч, чда, хч, осч; Analytical reagent AR, Guaranteed Reagent (GR) etc.)
10. Expression of Concentration: 1. percent (mass) concentrations; 2. Molar, 3. Normal (equivalent), and 4. Titr.
11. Formulas of recalculations of concentration units.
12. Heterogeneous equilibrium. Equilibrium In Saturated Solutions of Slightly Soluble Substances. Solubility product. Molar and mass solubility. Examples of calculations.
13. Factors effecting solubility: temperature, common ion effect, pH effect. Notion of ionic power (strength), active coefficients, and active concentrations.
14. Subject of gravimetric analysis. Equipment and tools (filter paper series). The experimental strategy. Calculations in gravimetric analysis.
15. Tananaev's rule. Amorphous and crystalline sediments. Requirements to sediments in gravimetric analysis. Rules of sedimenting.
16. Ionic product of water. pH notion. Biological function depending pH. Measuring pH.
17. pH calculations of strong acids and bases, weak acids and bases.
18. pH calculations of different salts solutions.
19. Buffer solutions. Calculate of a pH of buffer solutions.
20. Titration curves, equivalent points, titration jump. Acid-base indicators. Choice of indicators. Equivalent law in volumetry.

21. Neutralization method. Standard and working solutions, possibilities of method. Determination of water temporary hardness.
22. RedOx volumetry. The Nernst equation. How to calculate the electrode potential of redox systems. Electromoving force (EMF) of redox systems. RedOx indicators.
23. Theoretical foundations of permanganatometry and iodometry/iodatometry.
24. Complexonometry. Bases of method. Standard and working solutions, possibilities of method. Metallochromic indicators.
25. Determination of total temporary hardness.

EXAMPLES OF CALCULATING TASKS AND REACTIONS QUESTIONS

1. **All specific reagents and reactions of cation analysis.**
2. **Propose the reagent for the separation of cations:**



Write the molecular equation of the precipitation reaction.
3. **Write the equation of the chemical reaction of group reagent $(NH_4)_2HPO_4$** (in the presence of ammonia $NH_3 \cdot H_2O$ and soluble Magnesium salt (in MOLECULAR form):$Mg(NO_3)_2$ + $(NH_4)_2HPO_4$ + $NH_3 \cdot H_2O$ = _____
Write the equation of the dissolving of obtained sediment in the Acetic acid CH_3COOH.

4. **Special tests of anions (used in analysis of unknown salts).**

5. **Calculate gravimetric factor *f*** for the quantitative determination of Magnesium content in the form MgO (M=23,015 g/mol), if the weighted form of the sediment is $Mg_2P_2O_7$ (M=222,57 g/mol).
6. **Calculate ionic strength I** of solution contained 17,43 g K_2SO_4 (M=174,26 g/mol) per 1 L.
7. **Determine the active concentrations (a = γ·c)** of 0,01 M Cl^- solution and 0,0001 M Al^{3+} solution in soil solution where ionic power of solution is equals to 0,0005.
8. **Calculate equivalent weight** of a $K_2Cr_2O_7$ (M=294,10 g/mol) for RedOx titration in acidic medium
9. **Calculate equivalent weight** of a H_3PO_4 (M=97,99 g/mol) for neutralization reaction:

$$H_3PO_4 + NaOH = NaH_2PO_4 + H_2O.$$

10**. Calculate volume** (in mL) of 50% Sulfate acid solution (density d=1,40 g/cm^3) for preparation of 5 L 0,01 N solution (Molar weight (H_2SO_4) = 98 g/mol).
11. **Calculate molarity o**f HCl solution of the Titr 0,o1 g/mL.
12. **Calculate pH** of a 0,1 N NH_4Cl solution (pK ($NH_3 \cdot H_2O$)=4,77)

13. **Calculate pH** of a 10 N hydrochloric acid HCl (to consider as a strong acid, dissociated completely)
14. **Calculate the pH** of a 0.1 M H_3PO_4 (pK_1=1,96; pK_2=6,70; pK_3=12,44)
15. **Calculate the pH** of a 0.01 M NaClO (pK_{acid} = 7,50)
16. **Calculate the pH** of a 1 M Na_2CO_3 (pK_1 = 6,52; pK_2 = 10,22)
17. **Calculate ppm concentration** of solution contains 0,05 g of solute per 1000 g of solution.
18. **Calculate solubility** (in mol/L and g/L) of $Ni(OH)_2$ ($SP=1,6\cdot10^{-14}$, Molar weight 92,71 g/mol) in solution of 0,1 N KOH (*Be attentive: effect of the common ion into solubility*).
19. **Sample of lime** (m_{sample} = 0,8960 g) was dissolved in the nitrate acid and total volume of obtained solution was equal to 200 mL ($V_{measuring\ flack}$). Aliquot of this solution (20 mL, $V_{pipette}$) was titrated triply by 0,0505 N Trilon B and obtained the next results: 14,6; 13,6; 13,5 mL. Calculate **Calcium content (%) in this sample.**
20. **Calculate mass** of $FeSO_4\cdot7H_2O$ (MW=278,01 g/mol) for the Iron gravimetric determination on the form of Fe_2S_3 (MW=207,89 g/mol) according to the Tananaev's recommendation.
21. **Calculate Copper** (A=63,548 g/mol) **percent content** in 1,0000 g malachite sample, if for iodometric titration 20 mL solution taken of 200 mL measuring flack was used 15,0 mL 0,0500 N $Na_2S_2O_3$.

EXAMPLE OF MODULE TEST 1

Question 1. **Note the specific analytical reagent of** Nickel Ni^{2+} **ions:**

A	NH_3 (concentrated) in excess	F	Ammonium Thiocyanide NH_4SCN
B	Yellow blood salt $K_4[Fe(CN)_6]$	J	Ammonium oxalate $(NH_4)_2C_2O_4$
C	Red blood salt $K_3[Fe(CN)_6]$	K	Zinc-Uranyl-Acetate $Zn(UO_2)_3(CH_3COO)_8$
D	Hydrochloric acid HCl	L	Nessler's reagent $K_2[HgI_4]$+KOH
E	Dimethylglioxime (Chugaev's reagent) $C_4H_8N_2O_2$ in ammonia medium	M	Ammonium chloride NH_4Cl

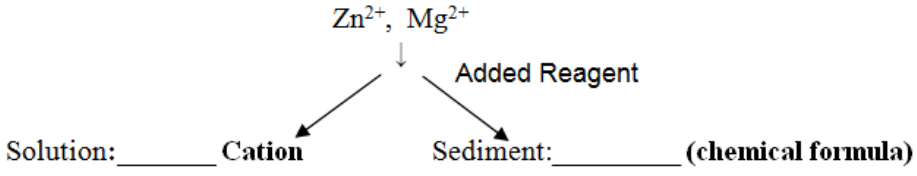
Write the correspondent equation of the chemical reaction in MOLECULAR form:
$Ni(NO_3)_2$ + _____ = _____

Visual effect, corresponded the reaction _____
(precipitation, odor, change of color etc.)

Question 2. 2.1. Write the equation of the chemical reaction of group reagent $(NH_4)_2HPO_4$ (in the presence of ammonia $NH_3\cdot H_2O$ and soluble Magnesium salt (in MOLECULAR form):
$Mg(NO_3)_2$ + $(NH_4)_2HPO_4$ + $NH_3\cdot H_2O$ = _____

2.2. Write the equation of the dissolving of obtained sediment in the Acetic acid CH_3COOH:
_____↓ + CH_3COOH= _____

Question 3. Propose the reagent for the separation of cations:



Write the molecular equation of the precipitation reaction.

TEST QUESTIONS FOR FINAL ASSESSMENT

Екзаменаційні питання

1. pH calculations of strong acids and bases, weak acids and bases. Examples.

2. Write the equation of the chemical reaction of group reagent $(NH_4)_2HPO_4$ (in the presence of ammonia $NH_3 \cdot H_2O$) and soluble Strontium soluble salt (for example, $Sr(NO_3)_2$) in molecular from. Write the equation of the dissolving of obtained sediment in the Acetic acid CH_3COOH.

Тестові завдання різних типів

1. Point the correspondence of the compound formulas and type of the analytical reagents (ammonium-phosphate classification):*(possible more than one true variant)*

A	Group	1	$K_4[Fe(CN)_6]$
B	Specific	2	$NaBiO_3 + HNO_3$ (diluted)
C	Selective	3	HCl
		4	$K_3[Fe(CN)_6]$
		5	NaOH
		6	H_2SO_4

2. Calculate ionic strength I of solution contained 17,43 g K_2SO_4 (M=174,26 g/mol) per 1 L.

A	0, 10 mol/L	B	0,20 mol/L	C	0,30mol/L	D	0,50mol/L

3. Note types of analytical tools used for mass analysis (gravimetry):


A


B


C


D


E


F

4. Note the characteristic analytical test of Molybdate MoO_4^{2-} anions:

A	Action of Hydrogen peroxide H_2O_2 and water ammonia $NH_3 \cdot H_2O$	C	Action of Silver nitrate $AgNO_3$ and the following dissolving of isolated sediment in water ammonia $NH_3 \cdot H_2O$
B	Action of $FeSO_4$ (saturated) and H_2SO_4 (concentrated)	D	Action of Potassium Permanganate $KMnO_4$ in presence of H_2SO_4 (diluted)

Write the correspondent equation(s) of reaction(s) in molecular form.

5. Note mixtures used as buffer solutions *(possible more that one true variant):*

A	NaCl + HCl	C	$NH_4OH + NH_4Cl$
B	$CH_3COONa + CH_3COOH$	D	NaOH + NaCl

6. Equivalent mass of Bi^{3+} cation (A=208,98 g/mol) in reaction with Trilon B is, g-eq/g :

A	104,49	B	208,98	C	52,25	D	69,66

7. Calculate gravimetric factor *f* for the quantitative determination of Magnesium content in the form MgO (M=40,31 g/mol), if the weighted form of the sediment is $Mg_2P_2O_7$ (M=222,57 g/mol).

8. Put in the sentence missing word: *The reaction of group reagent is realized in presence of mixture $NH_4OH + NH_4Cl$ named _____ mixture, which keeps pH of solution equal to 10.*

9. Note the absorption indicator for redox method of volumetric method:

A	Eriochrome black T	C	Methyl orange
B	Starch	D	Phenolphthalein

10. Calculate ppt (‰) concentration of solution contains 0,01 g of solute per 50 g of solution.

A	0, 200	B	1,000	C	0,500	D	0,001

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 grade	Grade according to national system	Percentage score
Passed	Excellent	90-100
	Very good	82-89
	Good	74-81
	Satisfactory	64-73
	Satisfactoty enough	60-63
Non-passed	Unsatisfactory	35-59
	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

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

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

n − кількість змістових модулів;

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

$\mathbf{К_{ДИС} = К^{(1)}_{ЗМ} + \ldots + К^{(n)}_{ЗМ}}$ − кількість кредитів ECTS, передбачених робочим навчальним планом для дисципліни у поточному семестрі;

$\mathbf{R_{ДР}}$ − рейтинг з додаткової роботи;

$\mathbf{R_{ШТР}}$ − рейтинг штрафний.

Наведену формулу можна спростити, якщо прийняти $\mathbf{К^{(1)}_{ЗМ} = \ldots = К^{(n)}_{ЗМ}}$. Тоді вона буде мати вигляд:

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

Навчальне навантаження студента для їх вивчення та засвоєння складає:

1-й модуль (**R_1**) – 1,0 кредит ($К_1$)

2-й модуль (**R_2**) – 1,0 кредит ($К_2$)

Критерії оцінки змістових модулів:

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 (2 частини) оцінюється від 0 до 50 балів кожна.

R_2 складається з 5 лабораторних робіт, самостійної та контрольних робіт. Захист експериментальної роботи та виконання самостійної роботи оцінюються від 5 до 10 балів кожна. Модульна контрольна робота № 2 (дві частини) оцінюється від 0 до 50 балів кожна.

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 – іспит.

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

12. REQUIRED AND RECOMMENDED LITERATURE

Basic

1. Harvey D. Modern Analytical chemistry (electron copy). McGraw-Hill Education, 2000. – 556 pp.

2. Ф.Г. Жаровський, А.Т. Пилипенко, І.В. П'ятницький. Аналітична хімія. – К.: ”Вища школа”, 1982. – 543 с.

3. Analytical Chemistry. Manual for Bachelor’s Students // Voytenko l.V., Kosmaty V.E., Kopilevich V.A. – Kyiv: NAUU publ., 2007. – 199 pp.

4.Analytical Chemistry. Workbook for Bachelor’s Students // Voitenko l.V., Kosmaty V.E., Savchenko D.A., Kopilevich V.A. – Kyiv: NUBiP Publ., 2014. – 140 pp.

Supplemental

1. Vogels’ Textbook of Macro and semimicro qualitative inorganic analysis https://archive.org/details/VogelsQantitativeChemicalAnalysis

2. Harvey D. An Ecectronic Textbook for Introductory Cources in Analytical chemistry. http://www.freebookcentre.net/chemistry-books-download/An-Electronic-Textbook-for-Introductory-Courses-in-Analytical-Chemistry.html

3. Quantitative Analysis Analytical Chemistry by Dr. Michael J. Prushan http://www.freebookcentre.net/chemistry-books-download/Quantitative-Analysis-Analytical-Chemistry.html
4. Prof. Clemens F Kaminski Analytical Chemistry Notes http://www.freebookcentre.net/chemistry-books-download/Analytical-Chemistry-Notes-(PDF-55P).html

13. NORMATIVE SOURCES

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. ISO 6058:1984. Water quality – Determination of calcium content – EDTA titrimetric method.
4. ISO 6059:1984 Water quality – Determination of the sum of calcium and magnesium – EDTA titrimetric method.

14. IT SOURCES

1.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.
5. Calculating titrating curves - http://chemwiki.ucdavis.edu/Core/Physical_Chemistry/Equilibria/Acid-Base_Equilibria/pH_Titration_Curves.
6. Acid-base indicators - http://www.ch.ic.ac.uk/vchemlib/course/indi/indicator.html
7. RedOx indicators choice - http://community.asdlib.org/imageandvideoexchangeforum/2013/07/26/selecting-an-indicator-for-8a-redox-titration/
8. Sigma-Aldrich reagents - https://www.sigmaaldrich.com/
9. Qualitative tests of anions
https://www.youtube.com/watch?v=ExB1r4m7Bb8
https://www.youtube.com/watch?v=_8jxWtYuVjg
https://www.youtube.com/watch?v=xergf70U7hQ
https://www.youtube.com/watch?v=xJFG8tozVzw
Separate anions testing:
https://www.youtube.com/watch?v=9VbQO6bv6HQ –carbonate test
https://www.youtube.com/watch?v=Mk3EDAKU_BU – borate flame test
https://www.youtube.com/watch?v=TFcAo9ktZSA– borate flame test
https://www.youtube.com/watch?v=FdVO1zX6doA – phosphate test