FACULTY OF PHARMACY

STUDY PROGRAM 0916.1 PHARMACY

CHAIR OF GENERAL CHEMISTRY

APPROVED
at the meeting of the Commission for Quality Assurance and Evaluation of the Curriculum faculty of Pharmacy
Minutes No. 2 of 22.12.2017

Chairman, PhD, associate professor

Uncu Livia _____

APPROVED
at the Council meeting of the Faculty of Pharmacy
Minutes No. 2 of 22.12.2017

Dean of Faculty, PhD, associate professor

Ciobanu Nicolae _____

APPROVED
approved at the meeting of the chair of
General chemistry
Minutes No.4 of 30.10.2017
Head of chair, PhD, associate professor

Cheptanaru Constantin _____

SYLLABUS

DISCIPLINE **ANALYTICAL CHEMISTRY**

Integrated studies

Type of course: **Compulsory**

Chisinau, 2017

I. INTRODUCTION

- **General presentation of the discipline: place and role of the discipline in the formation of the specific competences of the professional / specialty training program**

  Analytical Chemistry curriculum for pharmacist qualification is a normative pedagogical document and a didactic tool for the efficient organization of the educational process. At the Nicolae Testemitanu State University of Medicine and Pharmacy the curriculum development is based on several normative regulatory documents: Framework Program for Pharmaceutical Higher Education in the Republic of Moldova, based on the University Charter of PI Nicolae Testemitanu SUMPh, Regulations for organization of studies in higher education based on the National Credit Studies System, no. 1/8 of 06.04.2017, Regulation for evaluation and academic performance in State University of Medicine and Pharmacy "Nicolae Testemitanu", no. 5/4 of 12.10.2016, coordinated with the curriculum of pharmaceutical disciplines (pharmaceutical chemistry, pharmaceutical biochemistry, drug technology, pharmacology and clinical pharmacy).

  Analytical chemistry is a brunch of chemistry that deals with the analysis of the chemical composition of different substances. Analytical chemistry has wide application in medical diagnosis, in determining the quality and wholesomeness of drugs. Various experimental techniques and instrumentation are used to separate deferent chemical species, determine their concentrations and define their molecular formulas. Analytical chemistry is divided into qualitative analytical chemistry to detect the presence of specific elements in the sample and qualitative analytical chemistry, which determines the amount of these substances and elements. It is important to learn and study about some methods used in the classical techniques both qualitative and quantitative analysis, because these classical methods are the root of the modern analytical chemistry. These traditional methods still are in use today even though the high-tech instrumentation exists. Pharmacy students need a solid foundation in analytical chemistry knowledge. Analytical chemistry teaches students techniques they can use for their career within pharmaceutical testing laboratories as well as manufacturing facilities. Analytical chemistry provide the fundamental knowledge and overview off all core topics related to chemical analysis, relate this knowledge to the better understanding of drug molecules and their development and meet demand of the fundamental disciplines studied at faculty of Pharmacy (pharmaceutical and toxicological chemistry, drugs technology etc.)

  Mission of the curriculum (aim) in professional training

  Chemical analysis is very important. As all drugs are chemicals, and pharmacy is mainly about the study of various aspects of drugs, including manufacture, storage, actions and toxicities, analytical chemistry plays a vital role in pharmacy education. In the context of

pharmaceutical science, analytical chemistry is the branch of science that provides knowledge of compound separation, identification and quantification that can be useful for measuring bioavailability of drugs, purifying drugs during synthesis, and identifying drug metabolic pathways. The main aim of this discipline is to enable students to develop and use chemical methods in connection with development of drug substances, as well as identification and quality assessment of drug. It is devoted to provide students with a sound theoretical back ground in chemical principles that is essential to practice chemical analysis. It enables students to understand the importance of judging the accuracy and precision of experimental data and techniques of qualitative and quantitative analysis. Besides the above mentioned direct objective, the education of analytical chemistry significantly influences the formation of logical train of thought of incoming pharmacist and orientation in the field. Experimentally skilled student becomes familiar with a wide scale of important substances and their properties. Students acquire creativity and principles of a good laboratory practice. Validation of analytical methods is included.

- Languages of the course: Romanian, Russian, English;
- Beneficiaries: students of the II year, faculty of Pharmacy.

II. MANAGEMENT OF THE DISCIPLINE

Code of discipline		**F.03.O.028;** **F.04.O.039**	
Name of the discipline		**Analytical chemistry**	
Person in charge of the discipline		**Melnic Silvia,** PhD, associate professor	
Year	**II**	Semesters	**III and IV**
Total number of hours, including:			**270**
Lectures	**51**	Practical/laboratory hours	**102**
Seminars		Self-training	**117**
Clinical internship			
Form of assessment	**CD and E**	Number of credits	**9**

III. TRAINING AIMS WITHIN THE DISCIPLINE

At the end of the discipline study the student will be able to:

- ***at the level of knowledge and understanding:***
  - to specify the study object of the discipline;
  - to explain the objectives of the qualitative and quantitative analysis of chemical substances organisation;
  - to develop an understanding of the basic ideas of solutions and solution properties;
  - to develop an understanding of the qualitative and quantitative analysis of chemical substances;
  - to know reactions of identification and separation of inorganic ions;
  - to know chemical methods of quantitative analysis (gravimetry and volumetry).
- ***at the application level:***
  - to use the principles of ion (cations and anions) identification for qualitative analysis of inorganic medicinal substances;
  - to use the methods of gravimetric analysis for the investigation of medicinal materials and various medicinal plants;
  - to use the methods of volumetric analysis for the quantitative investigation of various inorganic and organic medicinal materials;
  - to chose correctly the appropriate method of chemical analysis taking in consideration different aspects (precision, economic, rationalism)
- ***at the integration level:***
  - to know pharmacopoeia reactions – analytical reactions that are recommended for qualitative analysis of medicinal substances;
  - to be able to carry out a qualitative analysis of a mixture of inorganic medicinal substances;
  - to be able to suggest the most rational method of chemical quantitative analysis of inorganic or organic medicinal substances.

IV. PROVISIONAL TERMS AND CONDITIONS

This is a discipline that emphasizes qualitative and quantitative chemical analysis and underlying principles, with the objective to introduce fundamental concepts to develop the necessary skills to perform chemical analysis of specific chemical components in a given sample. The topics to be discussed include analytical measurements and data handling, equilibrium (emphasizing acid-base, red-ox chemistry) and solution chemistry.

The study of analytical chemistry requires some level of mathematics and physics. These disciplines are a part of the language of chemistry, and a lack of familiarity with that language can become a barrier to success in understanding analytical chemistry. The course assumes previous knowledge of chemistry. It is designed to provide students whose background includes a year of high school chemistry with stimulation and some new material.

V. THEMES AND ESTIMATE ALLOCATION OF HOURS

Lectures, practical hours/ laboratory hours/seminars and self-training

No. d/o	THEME	Number of hours		
		Lectures	Practical hours	Self-training
1.	Analytical chemistry and chemical analysis. Fundamentals, basic concepts, principles and methods of qualitative chemical analysis.	1	3	3
2.	The nature of aqueous solutions. Strong and weak electrolytes. Solvent classification. Analytical reactions and qualitative analysis of the I^{st} analytical group of cations.	1	3	5
3.	Acid-base reversible reactions. Protolytic theory of acids and bases. The pH scale of hydrogen ion activity in water and non-aqua solutions. Analytical reactions and qualitative analysis of the II^{nd} analytical group of cations.	1	3	5
4.	Law of mass actions for acid-base reversible reactions. Method for the calculations of pH. Analytical reactions and qualitative analysis of the III^{rd} analytical group of cations.	1	3	5
5.	Buffered solutions. Mechanism of the buffered solutions action. pH of buffered solutions. Qualitative analysis of a mixture of cations from the I^{st} - III^{rd} analytical groups.	1	3	5
6.	Protolytic equilibrium for aqua salt solutions. Hydrolysis constant and grade. Method for the calculations of aqua salt solutions pH. Quiz 1.	1	3	5
7.	Amphoteric substances in chemical analysis. Equilibrium in heterogenic «solid-solution» systems. Solubility product (K_{sp}). Analytical reactions and qualitative analysis of the IV^{th} analytical group of cations.	1	3	5
8	Precipitation. Relation between solubility (S, mol/l) and K_{sp}. Factors that influence solubility. Analytical reactions and qualitative analysis of the V^{th} analytical group of cations.	1	3	5
9	Selective precipitation. Solubility of slightly soluble electrolytes. Analytical reactions and qualitative analysis of the VI^{th} analytical group of cations.	1	3	5
10	Colloids in chemical analysis. Coagulation and peptization. Qualitative analysis of a mixture of cations from the IV^{th} - VI^{th} analytical groups.	1	3	5
11	Equilibrium in redox systems. Reduction potentials. Nernst equation. Quiz 2.	1	3	5
12	Equilibrium constant for redox reactions. Direction of redox reactions. Redox reactions in chemical analysis. Analytical reactions and qualitative analysis of the I^{st} analytical group of anions.	1	3	5
13	Coordination complexes reactions in chemical analysis. Analytical reactions and qualitative analysis of the II^{nd} and III^{rd} analytical groups of anions.	1	3	5
14	Organic reagents in analysis. Chemical methods of separation and concentration. Physical-chemical methods of separation and	1	3	5

No. d/o	THEME	Number of hours		
		Lectures	Practical hours	Self-training
	concentration. Qualitative analysis of a mixture of anions from the Ist - IIIrd analytical groups.			
15	Qualitative analysis of solid inorganic salts. Quiz 3.	1	3	5
16	Introduction in quantitative analysis. Gravimetric analysis.	1	3	5
17	Errors in quantitative analysis.	1	3	5
18	Introduction to volumetric analysis: fundamentals, basic concepts, principles and methods of volumetric analysis.	2	3	2
19	Introduction to volumetric analysis: measuring glassware, the composition of solutions, preparation of a standard solution, analysis data handling.	2	3	2
20	Acid-base titration: basic concepts, classification, acid-base indicators. Quiz 4.	2	3	2
21	Titration curve for the acid-base titration: a) titration of a strong acid with a strong base, б) titration of a weak acid with a strong base.	2	3	2
22	Titration curve for the acid-base titration: a) titration of a weak base with a strong acid, б) titration of a mixture of acids, в) titration of an aqua salt solution.	2	3	2
23	Acid-base titration: indicator errors, non-aqueous titration. Examples of acid-base determinations.	2	3	2
24	Oxidation-reduction (redox) titration: basic concepts, classification, indicators, titration curves.	2	3	2
25	Permanganatometry.	2	3	2
26	Iodimetry. Quiz 5.	2	3	2
27	Redox titration: chloroiodimetry, iodatometry, bromatometry, bromometry.	2	3	2
28	Redox titration: cerimetry, nitritometry.	2	3	2
29	Precipitation titration: basic concepts, classification, indicators, titration curves.	2	3	2
30	Precipitation titration: argentometry (Mohr's method, Fajans-Hodakov's method), rodanometry.	2	3	2
31	Precipitation titration: mercorometry, sulfatometry, hexacianoferratometry. Quiz 6.	2	3	2
32	Complexometry: basic concepts, classification, peculiarities. Argentometry, mercurimetry.	2	3	2
33	Complexonometry: basic concepts, peculiarities. Complexones. Specific and metalocromic indicators.	2	3	2
34	Complexonometry: titration curves, examples of determinations. Quiz 7.	2	3	2
Total		**51**	**102**	**117**

VI. REFERENCE OBJECTIVES OF CONTENT UNITS

Objectives	Content units
Chapter 1. Analytical chemistry and chemical analysis. Fundamentals, basic concepts, principles and methods of qualitative chemical analysis. Analytical reactions and qualitative analysis of the I, II and III analytical groups of cations.	
• to know fundamentals of qualitative chemical analysis; • to define analytical properties of chemical compounds; • to know analytical tests and reagents ; • to know principles of ion classifications; • to know the basic concepts of strong and weak electrolytes; • to define equilibrium in chemical analysis; • to demonstrate main properties of the I-III analytical groups of cations (according acid-base classification of ions); • to know chemical methods of separation and identification of cation; • to apply qualitative tests for identification of the following cations: group I (K^+, Na^+, Li^+, NH_4^+), groupa II (Ag^+, Pb^{2+}), group III (Ca^{2+}, Ba^{2+}).	**1.** Fundamentals, basic concepts, principles and methods of qualitative chemical analysis. Analytical properties of chemical compounds. Analytical tests and reagents. Qualitative chemical analysis of inorganic compounds. Ions classification. Acid-base classification of ions. **2**. Solutions. The low of mass action. Types of electrolytes. Strong electrolytes. Autoionization of water. pH scale. **3.** Brønsted–Lowry acid–base theory. Strength of acids and bases. Base and acid ionization constant. Calculating the pH and pOH of acid and base solutions. **4.** Classification of common cations into analytical groups. Acid-base classification. The I, II and III analytical groups of cations. Detection and separation analytical reactions.
Chapter 2. Buffered solutions. Protolytic equilibrium for aqua salt solutions. Analytical reactions and qualitative analysis of the IV - VI analytical groups of cations.	
• to know basic concepts of buffer solutions; • to know principles and general mechanism of the hydrolysis of salts; • to demonstrate main properties of the IV-VI analytical groups of cations (according acidic-base classification of ions); • to have adequate practical and theoretical knowledge of analytical techniques to perform qualitative detections of cations using relevant analytical methods; • to apply qualitative tests for identification of the following cations: group IV (Al^{3+}, Cr^{3+}, As(III,V), Zn^{2+}), group V (Fe^{3+}, Fe^{2+}, Mn^{2+}, Bi^{3+}, Mg^{2+}), group VI (Cu^{2+}, Co^{2+}, Ni^{2+}).	**1.** Buffer solutions. Types of buffers. Mechanism of buffer solutions. Calculating the pH of buffer solutions. Uses of buffers. Amphoteric compounds. **2.** Acid-base properties of salts. Quantitative aspect of hydrolysis. Calculating the pH of salt solutions. Application of hydrolysis in analytical chemistry. **3.** Acid-base classification. The IV, V and VI analytical groups of cations. Test reactions.
Chapter 3. Equilibrium in heterogenic «solid-solution» systems. Equilibrium in redox systems. Coordination complexes reactions in chemical analysis. Chemical methods of separation and concentration. Qualitative analysis of solid inorganic salts.	
• to know principles and general mechanism of	**1.** Solubility and solubility product. The

Objectives	Content units
precipitate formation; • to know the basic concepts of redox reactions; application of redox reactions in chemical analysis; • to know principles and general mechanism of complex compound formation; • to have adequate practical and theoretical knowledge of analytical techniques to perform qualitative detections of anions using relevant analytical methods; • to apply qualitative tests for identification of the following anions: SO_4^{2-}, CO_3^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, PO_4^{3-}, $C_2O_4^{2-}$, $B_4O_7^{2-}$, AsO_3^{3-}, AsO_4^{3-}, Cl^-, Br^-, S^{2-}, I^-, SCN^-, IO_3^-, BrO_3^-, NO_3^-, NO_2^-, CH_3COO^-; • to have adequate practical and theoretical knowledge of analytical techniques to perform qualitative analyses of a solid inorganic salt.	relationship between solubility and solubility product. Factors that affect solubility. Fractional (or selective) precipitation. Factors that affect precipitation. Colloidal solutions. **2.** Redox equilibrium and feasibility of a reaction. Standard reduction potentials. Predicting the direction of redox reactions. The Nernst equation. Equilibrium constants for redox reactions. Application of redox reactions in chemical analysis. **3.** Formation of complexes. Types of complexes. Complex ion equilibria. Formation (stability) constant. Instability (dissociation) constant. Factors affecting the stability of complexes. Application of complexes in analysis. Application of organic reagents in analysis. **4.** Ways to separate mixtures. Chemical and physicochemical ways. Extraction. Chromatography. **5.** Qualitative analyses of a solid inorganic salt. Analysis of unknown sample.
Chapter 4. Introduction in quantitative analysis. Gravimetric analysis. Errors in quantitative analysis.	
• to know the basic concepts of quantitative analysis; • to assess the reliability of analytical data; • to understand the importance of judging the accuracy and precision of experimental data and techniques of quantitative analysis; • to know principles of gravimetric analysis; • to be able to chose correctly the appropriate gravimetric method of chemical analysis; • to have adequate practical and theoretical knowledge of gravimetry to perform quantitative analysis of a drug; • to perform quantitative calculations in connection with the analytical methods applied.	**1.** Fundamentals, basic concepts, principles and methods of quantitative chemical analysis. Quantitative analytical methods. Errors in quantitative analysis. Absolute and relative errors. Accuracy and precision of experimental data and techniques of quantitative analysis. **2.** Principles and types of gravimetric analysis. Precipitation gravimetry. Types of precipitates. Favourable conditions for precipitation. Impurities encountered in gravimetric analysis. The main operations of a precipitation gravimetry. Properties of the precipitate and gravimetric forms. Calculations in gravimetry. Use gravimetry in the pharmaceutical analysis.
Chapter 5. Volumetric analysis: fundamentals, basic concepts, principles and methods. Acid-base titration.	
• to know principles of volumetric analysis; • to be able to chose correctly the appropriate volumetric method of chemical analysis; • to know different ways of expressing concentration and to be able to prepare solutions of different concentrations;	**1.** Introduction to volumetric analysis: fundamentals, basic concepts, principles and methods of volumetric analysis. Requirements to chemical reaction used in titrimetric methods of analysis. Direct and indirect titrations. Measuring glassware. The composition of solutions, preparation of a standard solution, analysis data

Objectives	Content units
• to be competent in handling laboratory equipment • to be able to prepare and to determine the unknown concentration of a solution of an acid or a base; • to know principles of acid-base titration; • to be competent to apply acid-base titration for drug analysis; • to perform calculations of titration results.	handling. **2.** Principles of acid - base titration. Titrants, standard compounds. Acid base indicators. Theory of indicators. pH range of an indicator. Titration curves. Non-aqueous titration. Indicator errors. Examples of acid-base determinations.
Chapter 6. Oxidation- Reduction Titration	
• to know principles of redox titration; • to be able to prepare and to determine the unknown concentration of a solution of a reducing agent or an oxidizing agent; • to be competent to apply redox titration for drug analysis; • to have adequate practical and theoretical knowledge of volumetry to perform quantitative analysis of a drug.	**1.** Principles of oxidation- reduction titration. Redox indicators. Titration curves. Redox methods of analysis: permanganatometry, iodometry, cloriodometry, iodatometry, bromatometry, bromometry, dicromatometry, cerimetry, nitritometry.
Chapter 7. Precipitation Titration. Complexation Titration.	
• to know principles of precipitation titration; • to know principles of complexation titration; • to be competent to apply precipitation titration for drug analysis; • to be competent to apply complexation titration for drug analysis.	**1.** Precipitation titration: basic concepts, classification, indicators, titration curves. Precipitation titration methods: argentometry, tiocyanatometry, mercurometry, sulphatometry, hexacianoferatometry. **2**. Complexation titration: basic concepts, classification, indicators, titration curves. Complexation titration methods: mercurimetry, argentometry. Titration methods based on the chemical reactions with multidentate ligands. Complexometry. Metallochromic indicators. Examples of complexometric determinations.

VII. PROFESSIONAL (SPECIFIC (SC)) AND TRANSVERSAL (TC) COMPETENCES AND STUDY OUTCOMES

✓ Professional (specific) (SC) competences

- PC1. An in-depth knowledge and understanding of analytical chemistry. Ability to demonstrate knowledge of essential facts and principles relating to the classical methods of chemical analysis. Adequate use of chemical terminology.
- PC2. Ability to apply chemistry knowledge and understanding to the qualitative and quantitative analysis of an unknown compound. Competence in the execution of chemical analysis of given inorganic drug compounds. The ability to select appropriate techniques with regard to their use in qualitative and quantitative determination and identification. Skills in the safe handling of chemical materials as well experience in the handling of different chemical glassware and laboratory equipment.
- PC3. Skills at applying theoretical knowledge of analytical chemistry for the practical pharmaceutical purposes. Skills at using computer and communication techniques applied to pharmaceutical practice. Information skills, in relation to a large variety of sources, including information through on-line computer searches. Numeracy and calculation skills, including such aspects as errors analysis, correct use of units, etc. Ability to interpret data from laboratory experiments in terms of their significance. Ability to participate effectively in transdisciplinary teams working on research related to chemical qualitative and quantitative analysis.

✓ Transversal competences (TC)

- TC1. Formation of professional and civic attitudes, allowing students to be honest, non-conflicted, cooperative, available to help people, interested in community development; to know and apply ethical principles related to medical-pharmaceutical practice; ability to recognize and analyze problems and plans strategies for their solution.
- TC2. Practical skills needed for application of chemical methods in pharmaceutical practice as well as for continuing professional development. Interpersonal skills, relating to the ability to interact with other people and to engage in team-working.
- TC3. To have openness to lifelong learning; to become aware of the need for individual study as a basis for personal autonomy and professional development; to capitalize optimally and creatively on their own potential in collective activities; to use information and communication technology.

✓ Study outcomes

- To have adequate theoretical and practical knowledge of a classical analytical methods
- To know the principles of the qualitative and quantitative chemical analysis
- To explain the principle of the analytical techniques, their areas of application and potential sources of errors
- To understand the classification of ions into analytical groups
- To be able to use analytical tests in fulfilling variable qualitative analysis of given drag compounds and their mixtures
- To be able to use experience and theoretical knowledge in fulfilling variable quantitative analysis of drug compounds
- To take responsibility for the laboratory instruments and equipment operations
- To perform quantitative calculations and to assess the reliability of analytical data

Note. Study outcomes (are deduced from the professional competencies and formative valences of the informational content of the discipline).

VIII. STUDENT'S SELF-TRAINING

No.	Expected product	Implementation strategies	Assessment criteria	Implementation terms
1.	Working with information sources	Careful reading of the assigned material before of each theoretical and practical lesson. Read the text-book in order to participate in class discussion, better follow the lecture, and ask meaningful questions. Reflect on the content as you read and take notes. Study worked out examples, which provide further illustration the ideas explained in text. Answer the questions. Prepare some instructions, notes as well as questions prior to arriving in the lab or in the class. Make acquaintance with supplementary bibliography units from the field of the studied discipline. Summarize and take notes in your own words to help you understand and retain information. Don't rely on highlighting as your main method of note-taking	Ability to extract the essentials, ability to survey the topics and concepts being studied; ability to review and reflect on the concepts that studied.	Throughout the semester
2.	Working problems	Solve the assigned problems. Working on problems in the book and other sources is an ideal way to prepare for chemistry disciplines.	Ability to work problems independently and correctly (not memorization). Achieving final answers that are completely correct is important.	Throughout the semester
3.	Working scientific essay	Select the topic and analyze it. The essay purpose should be unambiguously defined. Prepare a detailed outline of the essay and basic bibliography. Write definitions for each of the key terms. Start on the reading list, tacking the more general textbooks first and moving on the more specialized books, review articles etc. Take notes when reading. Working of the essay. Once the essay is finished it should be submitted to the lecturer.	The primary function of an assessment essay is to document what a student has learned. The higher quality student's essay the greater the progress the student will make in the session. Assessment student understanding; judgment about student achievement at certain relevant points in the learning process of study.	Throughout the semester

IX. METHODOLOGICAL SUGGESTIONS FOR TEACHING-LEARNING-ASSESSMENT

- ***Teaching and learning methods used***

The discipline of Analytical chemistry is taught in a classical manner, which includes theoretical lectures and practical lessons. This discipline focuses on the qualitative and quantitative procedures of chemical analysis. At lectures students study in detail the analytical process including the techniques and methods used to isolate and quantify specific analytes in samples of materials. Major topics that are discussed in this discipline include sample preparation, equilibrium, titrations (e.g. acid–base, precipitation, complexation, and redox), and separations. Practical lessons, which are three hours a week, are essential to the course. The laboratory grade counts much of student's grade in the course. Practical lessons include definitions, equipment identification, instrumentation, data analysis, data interpretation, calculations, lab notebook questions, questions regarding analytical methods used, experimental questions, theory, and lab safety. Seven (7) quizzes and seminars are given throughout the semesters: 3 in the III semester and 4 in the IV semester. Quizzes and seminars test student knowledge of central concepts, ability to synthesize information, and quantitative analysis skills. They are intended to test student understanding of the course material before the exams. According to fix schedule, the students five hour per week work with the teacher and 1-2 hours by themselves. Main practical oriented skills and abilities are retained only due to students hard individual work while doing tasks in solving problems, exercises, etc. To succeed in a discipline of analytical chemistry students should work by themselves 5 hours per week.

- ***Applied teaching strategies / technologies****(specific to the discipline)*

It is necessary to point out some of the discipline's features, along with some suggestions about how to achieve the greatest advantage in Analytical chemistry. Here are some ways that may help students to study.

If you 'think around' the subject you can generate the answer or more easily understand the topic. Brainstorming is a group creativity technique by which efforts are made to find a conclusion for a specific problem by gathering a list of ideas spontaneously contributed by its members. In other words, brainstorming is a situation where a group of people meet to generate new ideas and solutions around a specific domain of interest by removing inhibitions. People are able to think more freely and they suggest many spontaneous new ideas as possible. All the ideas are noted down and are not criticized and after brainstorming session the ideas are evaluated.

Working on problems in the book and other sources is an ideal way to prepare for chemistry disciplines. Problem solving requires application of a previously learned theory by the students. This requires analytical capacity and a capacity to analyze a problem and to solve it. Problem solving also plays an important role in developing some important skills like observing the problem, questioning, hypothesizing, investigating; analyzing and interpreting data, communicating results.

From the pedagogical point of view one of most pure methods of education is the passive listening of a course, even in case of its careful structuring and illustration. Carrying out of practical lesson as well as laboratory experiments is more effective, than the simple reading about task execution, and even more effective when teaching somebody else. The science learning goals of laboratory experiences include enhancing mastery of science subject matter, developing scientific reasoning abilities, developing practical skills, increasing understanding of the nature of science, cultivating interest in science and science learning, and improving teamwork abilities. The research suggests that laboratory experiences will be more likely to achieve these goals if they are designed with clear learning outcomes in mind, are thoughtfully sequenced into the flow of classroom science instruction, integrate learning of science content and process, and incorporate ongoing student reflection and discussion.

- ***Methods of assessment****(including the method of final mark calculation)*

Current: front and / or individual control via

1. applying the tests,
2. solving problems / exercises,
3. analysis of practical problems,
4. quizzes.

Final*:* Differentiated colloquium (semester III), exam (semester IV).

The differentiated colloquium on qualitative analysis emphasizes the third semester and is held during final semester week. The midterm exam on qualitative analysis is composed of two sections: writing (tests) and oral section.

The final exam is at the end of the IV semester and it comprises only material on the quantitative analysis. The final exam is composed of two sections: writing (tests) and oral section. It covers new material not covered on the midterm exam.

The final colloquium mark as well as exam mark is based on total points earned for the oral exam section, writing exam section and the average mark for the semester. The final average mark for the semester will be based on total points earned for quizzes.

Exams designed to reward understanding of the material and the ability to work problems independently and correctly (not memorization).The questions for exams are always approved by the head of department and are given to the students one month before exams.

Only a student whose average mark is 5.0 or better on the semester is allowed for the midterm or final exams. Attendance at all lectures is mandatory if students wish to be allowed to the exams.

Method of mark rounding at different assessment stages

Intermediate marks scale (annual average, marks from the examination stages)	National Assessment System	ECTSEquivalent
1,00-3,00	**2**	**F**
3,01-4,99	**4**	**FX**
5,00	**5**	**E**
5,01-5,50	**5,5**	
5,51-6,0	**6**	
6,01-6,50	**6,5**	**D**
6,51-7,00	**7**	
7,01-7,50	**7,5**	**C**
7,51-8,00	**8**	
8,01-8,50	**8,5**	**B**
8,51-8,00	**9**	
9,01-9,50	**9,5**	**A**
9,51-10,0	**10**	

The average annual mark and the marks of all stages of final examination (computer assisted, test, oral) - are expressed in numbers according to the mark scale (according to the table), and the final mark obtained is expressed in number with two decimals, which is transferred to student's record-book.

Absence on examination without good reason is recorded as "absent" and is equivalent to 0 (zero). The student has the right to have two re-examinations.

X. RECOMMENDED LITERATURE:

A. Compulsory:

1. STEVEN S. ZUMDAHL. *Chemistry.* Lexington, Massachusetts, Toronto, 1986/
2. FRANCIS MARION MILLER. *Chemistry, Structure and dynamics.* McGraw-Hill book company, USA., 1984/

B. Additional

1. БУДУ Г. *Пособие по аналитической химии*. Ch.: CEP „Medicina”, 2007.
2. BUDU G. *Curs de chimie Analitică. Partea I. Analiza chimică calitativă.* Ch.: USMF ”Nicolae Testemițanu”, Biblioteca electronică, 2015.
http://library.usmf.md/images/files/ebooks/Curs%20de%20chimia%20analitica%20part%201.pdf
3. BUDU G. *Curs de chimie Analitică. Partea I. Analiza chimică cantitativă.* Ch.: USMF ”Nicolae Testemițanu”, Biblioteca electronică, 2015.
http://library.usmf.md/images/Curs%20de%20chimie%20analitica%20part%202.pdf