Approved

At the meeting of the Council of Faculty of Pharmacy
Minutes No. 4 of 12.06.2014

Dean of the Faculty of Pharmacy
PhD, associate professor _____ N. Ciobanu

Approved

At the meeting of the chair of General Chemistry
Minutes No. 11 of 06.06.2014

Head of the chair,
PhD, associate professor _____ C. Cheptănaru

SYLLABUS FOR STUDENTS OF

FACULTY OF PHARMACY

Name of the course: **Analytical Chemistry**

Code of the course: **F03O026; F04O035**

Type of course: **compulsory**

Total number of hours – 153

lectures - 51 hours, practical lessons - 102 hours

Number of credits provided for the course: **12**

Lecturers teaching the course: **PhD, associate professor – Budu Grigore**

PhD, associate professor – Melnic Silvia

Chisinau 2014

I. Aim of the discipline:

The main goal of the course is to strengthen each student's knowledge of fundamental principles of Analytical Chemistry and to give students the opportunity to become familiar with the methods of qualitative and quantitative analysis of chemical substances.

II. Objectives obtained in teaching the discipline:

- <u>At the level of knowledge and understanding</u>

the course should enhance the student's ability

- 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).

- <u>At the level of application</u>

the course should enhance the student's ability

- 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).

- <u>At the level of integration</u>

the course should enhance the student's ability

- 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.

III. Provisional terms and conditions:

This is a lecture course 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, equilibria (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.

IV. Main theme of the course:

Analytical Chemistry is a 2-semester credit class that introduces the major aspects of qualitative and quantitative chemical analysis.

A. Lectures:

№	***Themes***	Hours
	Semester III	
1	Analytical chemistry and chemical analysis. Fundamentals, basic concepts, principles and methods of qualitative chemical analysis. The nature of aqueous solutions. Strong and weak electrolytes. Solvent classification.	2
2	Acid-base reversible reactions. Protolytic theory of acids and bases. The pH scale of hydrogen ion activity in water and non-aqua solutions. Law of mass actions for acid-base reversible reactions. Method for the calculations of pH.	2
3	Buffered solutions. Mechanism of the buffered solutions action. pH of buffered solutions. Protolytic equilibrium for aqua salt solutions. Hydrolysis constant and grade. Method for the calculations of aqua salt solutions pH.	2
4	Amphoteric substances in chemical analysis. Equilibrium in heterogenic «solid-solution» systems. Solubility product (K_{sp}). Precipitation. Relation between solubility (S, mol/l) and K_{sp}. Factors that influence solubility.	2
5	Selective precipitation. Solubility of slightly soluble electrolytes. Colloids in chemical analysis. Coagulation and peptisation.	2
6	Equilibrium in redox systems. Reduction potentials. Nernst equation. Equilibrium constant for redox reactions. Direction of redox reactions. Redox reactions in chemical analysis.	2
7	Coordination complexes reactions in chemical analysis. Organic solvents in analysis.	2
8	Chemical methods of separation and concentration. Physical-chemical methods of separation and concentration. Qualitative analysis of solid inorganic salts.	2
9	Introduction in quantitative analysis. Gravimetric analysis.	1
	Semester IV	
10	Introduction to volumetric analysis: fundamentals, basic concepts, principles and methods of volumetric analysis. Errors in quantitative analysis.	2

11	Introduction to volumetric analysis: measuring glassware, the composition of solutions, preparation of a standard solution, analysis data handling.	2
12	Acid-base titration: basic concepts, classification, acid-base indicators.	2
13	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
14	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
15	Acid-base titration: indicator errors, non-aqueous titration. Examples of acid-base determinations.	2
16	Oxidation-reduction (redox) titration: basic concepts, classification, indicators, titration curves.	2
17	Permanganatometry.	2
18	Iodimetry.	2
19	Redox titration: chloroiodimetry, iodatometry, bromatometry, bromometry.	2
20	Redox titration: cerimetry, nitritometry.	2
21	Precipitation titration: basic concepts, classification, indicators, titration curves.	2
22	Precipitation titration: argentometry (Mohr's method, Fajans-Hodakov's method), rodanometry.	2
23	Precipitation titration: mercorometry, sulfatometry, hexacianoferratometry.	2
24	Complexometry: basic concepts, classification, peculiarities. Argentometry, mercurimetry.	2
25	Complexonometry: basic concepts, peculiarities. Complexones. Specific and metalocromic indicators.	2
26	Complexonometry: titration curves, examples of determinations.	2

B. Practical lessons:

№	***Themes***	Hours
	Semester III	
1	Quantitative techniques for analysis.	3
2	Analytical reactions and qualitative analysis of the I^{st} analytical group of cations.	3
3	Analytical reactions and qualitative analysis of the II^{nd} analytical group of cations. Working problems on theme:"Ion strength of solutions, ion activity."	3
4	Analytical reactions and qualitative analysis of the III^{rd} analytical group of cations. Working problems on theme: "Acid-base equilibrium."	3
5	Qualitative analysis of a mixture of cations from the I^{st} - III^{rd} analytical groups – practical quiz.	3
6	Quiz: "Analytical reactions and qualitative analysis of the I-III analytical groups of cations ."	3
7	Analytical reactions and qualitative analysis of the IV^{th} analytical group of cations. Working problems on theme: "Buffered solutions equilibria."	3
8	Analytical reactions and qualitative analysis of the V^{th} analytical group of cations	3
9	Analytical reactions and qualitative analysis of the VI^{th} analytical group of cations Working problems on theme: "Hydrolysis".	3
10	Qualitative analysis of a mixture of cations from the IV^{th} - VI^{th} analytical groups – practical quiz.	3

11	Quiz: ”Analytical reactions and qualitative analysis of the IV-VI analytical groups of cations .”	3
12	Analytical reactions and qualitative analysis of the I^{st} analytical group of anions. Working problems on theme: ”Equilibrium in heterogenic «solid-solution» systems.”.	3
13	Analytical reactions and qualitative analysis of the II^{nd} and III^{rd} analytical groups of anions. Working problems on theme: ”Complex compounds equilibrium”.	3
14	Qualitative analysis of a mixture of anions from the I^{st} - III^{rd} analytical groups – practical quiz.	3
15	Seminar: ”Analytical reactions and qualitative analysis of the II^{nd} and III^{rd} analytical groups of anions.”	3
16	Analysis of a solid salt (inorganic medicinal substances).	3
17	Qualitative analysis – Colloquim.	3
	IV Semester	
18	Gravimetric analysis: the mass percent determination (%) of cinder in medicinal plan and humidity in medicinal substances (or crystallization water in barium chloride).	3
19	Gravimetric analysis: determination of sodium sulfate in an analyzed sample (or the mass percent determination (%) of iron(II) sulfate in a sample of iron salt), determination of other salts.	3
20	Gravimetric analysis. Working problems. Quiz (seminar).	3
21	Volumetric analysis. Measuring glassware. Calibration of measuring glassware.	3
22	Acid-base titration. Acidemetry. Steps involved in the preparation and standardization of a hydrochloric acid standard (titrant) solution.	3
23	Acidemetry. Determination of bases (NaOH, NH_3 et.)	3
24	Acidemetry. Determination of $NaHCO_3$ and Na_2CO_3 in presence of each other. Determination NaOH and Na_2CO_3 in presence of each other.	3
25	Alcalimetry. Preparation and standardization of NaOH (or KOH) titrant solution. Determination of ammonia salts.	3
26	Quiz: ”Acid-base titration”.	3
27	Oxidation-reduction (redox) titration. Permanganatometry. Preparation and standardization of $KMnO_4$ titrant. Determination of the mass of iron(II) sulfate in an analyzed sample (or mass percent of hydrogen peroxide in a sample).	3
28	Iodometry. Steps involved in the preparation and standardization of the titrant sodium thiosulfate. Determination of oxidants (H_2O_2, $KMnO_4$, $CuSO_4$ et.)	3
29	Iodimetry. Steps involved in the preparation and standardization of the titrant iodine. Determination of reductions ($Na_2S_2O_3$, ascorbic acid, As_2O_3 et.).	3
30	Bromatometry. Determination of reductions. Bromometry. Determination of streptocidum or salicylic acid.	3
31	Quiz: ”Oxidation-reduction (redox) titration ”.	3
32	Precipitation titration. Preparation and standardization of $AgNO_3$ titrant (Mohr’s method) and NH_4SCN titrant (Wolhard’s method). Determination of mass of KBr in a sample by Wolhard’s method.	3
33	Complexonometry. Steps involved in the preparation and standardization of the titrant of Complexon III. Determination of salts: $CaCl_2$, $MgSO_4$, $CuSO_4$ et. (or Mg^{2+} or Ca^{2+} in a mixture).	3
34	Quiz: ”Precipitation and complexometric titration”.	3

V. Recommended literature:

- *A. compulsory:*

1. Budu Grigore V. Chimie analitică calitativă. "Ştiinţa", Chişinău, 1994.
2. Vasiliev V. P. Chimia analitică, V.1 "Universitas", Chişinău 1991.
3. Толстоусов, Эфрос С. М. Задачник по количественному анализу, "Химия". Л. 1986.
4. В. П. Васильев. Аналитическая химия. Физико-химические методы анализа. М. "Высшая школа", т.1, 1989.
5. Г. В. Буду, «Пособие по аналитической химии», CEP, Medicina, Chişinău, 2007.
6. Grigore Budu, Silvia Melnic, Chimie analitică. Probleme şi teste. CEP, Medicina, Chişinău, 2009.
7. Budu, G.; Melnic, S. Indicaţii metodice la lucrările practice şi de laborator la chimia analitică cantitativă. Ch.: CEP Medicină, 2011.

- *B. additional:*

1 Posipaico V. S., Kozirieva N. A., Logacieva I. P. Metode chimice de analiză, „Universitas", Chişinău, 1992.
2 Dorneanu Vasile, Stan Maria, Miftode Maria. Chimia analitică: lucrări practice. Iaşi, 1990.
3 Лурье Ю.Ю. Справочник по аналитической химии, «Химия», Москва, 1989.

VI. Teaching and learning methods:

The course of Analytical chemistry is taught in a classical manner, which includes theoretical lectures and practical lessons. 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 course include sample preparation, equilibrium, titrations (e.g. acid–base, precipitation, complexation, and redox), and separations. This course focuses on the qualitative and quantitative procedures of chemical analysis. 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.

VII. Suggestions for individual activity:

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 is more effective, than the simple reading about task execution, and even more effective when teaching somebody else.

It is necessary to point out some of the discipline's features, along with some suggestions about how to achieve the greatest advantage.

1. It is recommended to begin the study by examining the material of each practical lesson. Always come prepared! Whenever possible, read the material as soon as it is assigned and before the topic is discussed in the lecture. Read carefully, taking time to study the worked-out examples, which provide further illustration of the ideas explained in text. A worthwhile tactic is to attempt to answer the question in the example before looking at the solution. Prepare your own set of instructions prior to arriving in the laboratory. People who are unprepared make more mistakes, waste time (including the instructors'), and get poor results.
2. Read assigned material from your textbook. If you do this, you will be amazed by the amount of material you understand. In general, it is good practice in all science courses to go over the material covered in the course at least three times. The first is a quick scan to survey the topics and concepts being covered. The second is for comprehension to understand the fundamental idea. The third, but by no means the last, is to review and reflect on the concepts that you had just covered. If you need to review a concept go back and read the material again or seek outside help. If you use this study habit approach, you will achieve a level of understanding that will allow you to be successful in this course.
3. Come to class prepared to listen. Listen to the lecture. Attempt the in-class problems. Write notes of the important points not covered in the book. Ask questions. Fact, that you put questions, means that you try to understand the investigated topic, and it is welcomed.
4. Do the assigned homework problems before coming to the next lecture. If you have difficulties, then ask questions at the beginning of the next class. If you want good grades in your exams, do the homework and if you have to, do extra problems at the end of the chapter. By taking time to work on extra problems before the exam, you will be better prepared for the exam problems. Working problems in the book and other sources (i.e., sample test) is an ideal way to prepare for this course. When you have trouble with a problem, see your teacher immediately - if you have to wait the day before an exam then it is too late!!
5. For preparation to practical lessons, quizzes, seminars and final exam discuss new material in groups. As a rule working in group you better catch and understand a material. Besides the skills of explanation of a theme to friends will be useful to you in the future.
6. Use time rationally. The course of analytical chemistry shows the high demands, as well as many other disciplines taught in this educational year. There for, it is necessary to you to attain the proper balance between study, other duties and personal life. According to fixed schedule, the students one hour work with the teacher and 1-2 hours by themselves. In other words, to succeed in a course of Analytical chemistry students should work by themselves 5 hours per week.

VIII. Methods of assessment:

There are 4 in-class quizzes and 3 seminars on dates to be announced. 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.

The quizzes are spent in written form, as following: a theoretical question, practical question, problem and tests with one and several answers. Each question is worth some points. The final mark is based on total points earned for the quiz.

Seminars are composed of both oral and writing section. Tests and problems should be done in written form and theoretical and practical questions - in oral.

A total of seven (7) quizzes and seminars are given throughout the semester: 3 in the III semester and 4 in the IV semester. Each quiz or seminar is worth 10. During the semester students are given 2 opportunities to redo the quizzes. The final average mark for the semester will be based on total points earned for quizzes and seminars.

The midterm exam on qualitative analysis emphasizes the third semester and is held during final semester week. The final exam is at the end of the IV semester and it comprises only material on the quantitative analysis.

The midterm exam on qualitative analysis is composed of two sections: writing (10 tests in 15 minutes) and oral section (30 minutes for answer preparing). During the oral section a student should answer 3 questions: theoretical, practical and a problem. Both sections are worth from 0 to 10.

Exams designed to reward understanding of the material and the ability to work problems independently and correctly (not memorization). Achieving final answers that are completely correct is important. The final exam is composed of two sections: writing (20 tests) and oral section (a theoretical question, practical question and a problem). It covers new material not covered on the midterm exam. The exam is limited to 20 and 30-minutes period for each section respectively and time limits are strictly enforced. Both sections are worth from 0 to 10.

The questions for exams are always approved by the head of department and are given to the students one month before exams.

The final exam mark is based on total points earned for the oral exam section (coefficient 0,3), writing exam section (coefficient 0,2) and the average mark for the semester (coefficient 0,5).

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.

Methods of mark rounding

The average of current and final marks	Final mark
5	**5**
5,1-5,5	**5,5**
5,6-6,0	**6**
6,1-6,5	**6,5**
6,6-7,0	**7**
7,1-7,5	**7,5**
7,6-8,0	**8**
8,1-8,5	**8,5**
8,6-9,0	**9**
9,1-9,5	**9,5**
9,6-10	**10**

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

IX. Language of study:

Romanian, Russian, English