

MINISTRY OF HEALTH OF UKRAINE
BOGOMOLETS NATIONAL MEDICAL UNIVERSITY

GUIDELINES
to practical classes

Academic discipline	Fundamentals of chemical metrology in medicine
Branch of knowledge	22 “Health care”
Specialty	222 “Medicine”
Department	Analytical, physical and colloid chemistry

Approved at the meeting of Analytical, Physical and Colloid Chemistry Department
Proceedings N 29 dated 24 June 2024

Considered and approved by cyclical methodological commission in natural sciences
Proceedings N 1 dated 28 August 2024

Authors:

Yaroslava Pushkarova – Associate Professor of Analytical, Physical and Colloid
Chemistry Department, PhD in Chemistry, Associate Professor,

Galina Zaitseva – Head of Analytical, Physical and Colloid Chemistry Department,
PhD in Chemistry, Associate Professor.

CONTENTS

Topic of lesson N 1: “Significant figures. Rounding of the measurement results”	3
Topic of lesson N 2: “Estimation of the presence of outliers in results”	5
Topic of lesson N 3: “Basics of statistical analysis of the results of chemical experiment”	7
Topic of lesson N 4: “Confidence limits and estimation of their value”	9
Topic of lesson N 5: “Comparison of two methods of analysis by reproducibility”	11
Topic of lesson N 6: “Comparison of the mean values of two samples”	13
Topic of lesson N 7: “Estimation of the accuracy of measurements”	15
Topic of lesson N 8: “Estimation of the repeatability of results”	17
Topic of lesson N 9: “Calculation of linear dependence parameters. Estimation of the limit of detection”	19
Topic of lesson N 10: “Probability theory in medicine”	21
SUPPLEMENT	23

Topic of lesson N 1: “Significant figures. Rounding of the measurement results”

Competencies:

– **integral competence:** the ability to solve complex problems, including those of a research and innovation nature in the field of medicine; the ability to continue learning with a high degree of autonomy;

– **general competencies (GC):**

1. Ability for abstract thinking, analysis and synthesis (GC 01).
2. Ability to learn and master modern knowledge (GC 02).
3. Ability to apply knowledge in practical situations (GC 03).
4. Ability to make informed decisions (GC 06).

– **professional competences of the specialty (PC):**

1. Ability to develop and implement scientific and applied projects in the field of health care (PC 23).
2. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results (PC 25).

Purpose: ability to present the results of a chemical (pharmaceutical) experiment with the required accuracy.

Equipment: practical tasks (tests, calculation problems, situational problems), student’s notebook, calculator.

Lesson plan and organizational structure:

Stage	Description of the stage	Learning levels	Time
Preparatory	Organizational issues (checking the presence of students)	Familiarization	1 min.
	Formation of motivation, activation of cognitive activity	Perception	3 min.
	Control of the initial level of teaching: test control and/or individual survey, verification of the performance of tasks of extra-auditory independent work	Reproductive	10 min.
Main	Discussion of theoretical material according to the subject of the topic	Comprehension Understanding	10 min.
	Solving calculation and situational problems	Application in practice Search creative activity	25 min.
	Independent work of the student under the supervision of the teacher (auditory work of the student)	Application in practice Search creative activity	10 min.

	Generalization of knowledge	Fixing	5 min.
Final	Control of the final level of teaching (solving calculation and situational problems)	Reproduction	15 min.
	General evaluation of the student's educational activity	Familiarization	10 min.
	Informing students about the topic of the next lesson and tasks for independent work	Familiarization	1 min.

Recommended literature:

Basic

1. Taylor, J. K., Cihon, C. Statistical techniques for data analysis (second edition). Chapman and Hall/CRC, 2004, P. 66-73. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Additional

1. Statistics and Chemometrics for Analytical Chemistry (seventh edition) / J. N. Miller, J.C. Miller and R. D. Miller : Pearson, 2018, P. 29-31. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

2. Ellison S. L. R., Williams A. Eurachem/Citac Guide: Quantifying Uncertainty in Analytical Measurements (third ed, 2012). URL: https://www.eurachem.org/images/stories/Guides/pdf/QUAM2012_P1.pdf (date of access: 25.07.2024).

Information resources

1. <https://nmuofficial.com/en/zagalni-vidomosti/kafedri/department-medical-general-chemistry/>
2. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224>

Questions for the student's self-preparation for the practical lesson:

1. Accuracy of presentation of results. Number of significant figures.
2. Determining the significance of the result due to various mathematical operations.

The methodical instruction is developed by:

Yaroslava Pushkarova – Associate Professor of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor,

Galina Zaitseva – Head of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor.

Topic of lesson N 2: “Estimation of the presence of outliers in results”

Competencies:

– **integral competence:** the ability to solve complex problems, including those of a research and innovation nature in the field of medicine; the ability to continue learning with a high degree of autonomy;

– **general competencies (GC):**

1. Ability for abstract thinking, analysis and synthesis (GC 01).
2. Ability to learn and master modern knowledge (GC 02).
3. Ability to apply knowledge in practical situations (GC 03).
4. Ability to make informed decisions (GC 06).

– **professional competences of the specialty (PC):**

1. Ability to develop and implement scientific and applied projects in the field of health care (PC 23).
2. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results (PC 25).

Purpose: ability to classify measurement errors and assess the presence of outliers.

Equipment: practical tasks (tests, calculation problems, situational problems), student’s notebook, calculator, tables of critical values of Q -criterion and G -criterion.

Lesson plan and organizational structure:

Stage	Description of the stage	Learning levels	Time
Preparatory	Organizational issues (checking the presence of students)	Familiarization	1 min.
	Formation of motivation, activation of cognitive activity	Perception	3 min.
	Control of the initial level of teaching: test control and/or individual survey, verification of the performance of tasks of extra-auditory independent work	Reproductive	10 min.
Main	Discussion of theoretical material according to the subject of the topic	Comprehension Understanding	10 min.
	Solving calculation and situational problems	Application in practice Search creative activity	25 min.
	Independent work of the student under the supervision of the teacher (auditory work of the student)	Application in practice Search creative activity	10 min.
	Generalization of knowledge	Fixing	5 min.

Final	Control of the final level of teaching (solving calculation and situational problems)	Reproduction	15 min.
	General evaluation of the student's educational activity	Familiarization	10 min.
	Informing students about the topic of the next lesson and tasks for independent work	Familiarization	1 min.

Recommended literature:

Basic

1. Taylor, J. K., Cihon, C. Statistical techniques for data analysis (second edition). Chapman and Hall/CRC, 2004, P. 100-107. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Additional

1. Statistics and Chemometrics for Analytical Chemistry (seventh edition) / J. N. Miller, J.C. Miller and R. D. Miller : Pearson, 2018, P. 49-52. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Information resources

1. <https://nmuofficial.com/en/zagalni-vidomosti/kafedri/department-medical-general-chemistry/>
2. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224>

Questions for the student's self-preparation for the practical lesson:

1. Classification of errors.
2. Exclusion of outliers using the Q-test.
3. Exclusion of outliers using the Grubb's test.
4. Exclusion of outliers using the rule of the huge error.

The methodical instruction is developed by:

Yaroslava Pushkarova – Associate Professor of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor,

Galina Zaitseva – Head of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor.

Topic of lesson N 3: “Basics of statistical analysis of the results of chemical experiment”

Competencies:

– **integral competence:** the ability to solve complex problems, including those of a research and innovation nature in the field of medicine; the ability to continue learning with a high degree of autonomy;

– **general competencies (GC):**

1. Ability for abstract thinking, analysis and synthesis (GC 01).
2. Ability to learn and master modern knowledge (GC 02).
3. Ability to apply knowledge in practical situations (GC 03).
4. Ability to make informed decisions (GC 06).

– **professional competences of the specialty (PC):**

1. Ability to develop and implement scientific and applied projects in the field of health care (PC 23).

2. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results (PC 25).

Purpose: ability to correctly carry out statistical processing of the results of chemical analysis and to be able to interpret their calculations.

Equipment: practical tasks (tests, calculation problems, situational problems), student’s notebook, calculator.

Lesson plan and organizational structure:

Stage	Description of the stage	Learning levels	Time
Preparatory	Organizational issues (checking the presence of students)	Familiarization	1 min.
	Formation of motivation, activation of cognitive activity	Perception	3 min.
	Control of the initial level of teaching: test control and/or individual survey, verification of the performance of tasks of extra-auditory independent work	Reproductive	10 min.
Main	Discussion of theoretical material according to the subject of the topic	Comprehension Understanding	10 min.
	Solving calculation and situational problems	Application in practice Search creative activity	25 min.
	Independent work of the student under the supervision of the teacher (auditory work of the student)	Application in practice Search creative	10 min.

		activity	
	Generalization of knowledge	Fixing	5 min.
Final	Control of the final level of teaching (solving calculation and situational problems)	Reproduction	15 min.
	General evaluation of the student's educational activity	Familiarization	10 min.
	Informing students about the topic of the next lesson and tasks for independent work	Familiarization	1 min.

Recommended literature:

Basic

1. Statistics and Chemometrics for Analytical Chemistry (seventh edition) / J. N. Miller, J.C. Miller and R. D. Miller : Pearson, 2018, P. 16-25. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Additional

1. European Pharmacopoeia / European Directorate for the Quality of Medicines & HealthCare of the Council of Europe. – tenth edition, volume 1. Strasbourg : Council of Europe, 2019. Section 5.3. Statistical analysis of results of biological assays and tests. P. 683-713. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Information resources

1. <https://nmuofficial.com/en/zagalni-vidomosti/kafedri/department-medical-general-chemistry/>
2. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224>

Questions for the student's self-preparation for the practical lesson:

1. Specificity of chemical analysis as a metrological discipline.
2. Calculation of the main metrological characteristics of the analysis method.

The methodical instruction is developed by:

Yaroslava Pushkarova – Associate Professor of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor,
Galina Zaitseva – Head of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor.

Topic of lesson N 4: “Confidence limits and estimation of their value”

Competencies:

– **integral competence:** the ability to solve complex problems, including those of a research and innovation nature in the field of medicine; the ability to continue learning with a high degree of autonomy;

– **general competencies (GC):**

1. Ability for abstract thinking, analysis and synthesis (GC 01).
2. Ability to learn and master modern knowledge (GC 02).
3. Ability to apply knowledge in practical situations (GC 03).
4. Ability to make informed decisions (GC 06).

– **professional competences of the specialty (PC):**

1. Ability to develop and implement scientific and applied projects in the field of health care (PC 23).

2. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results (PC 25).

Purpose: ability to correctly calculate the confidence limits and be able to interpret their calculations.

Equipment: practical tasks (tests, calculation problems, situational problems), student’s notebook, calculator, table of critical values of t -test.

Lesson plan and organizational structure:

Stage	Description of the stage	Levels of assimilation	Time
Preparatory	Organizational issues (checking the presence of students)	Familiarization	1 min.
	Formation of motivation, activation of cognitive activity	Perception	3 min.
	Control of the initial level of teaching: test control and/or individual survey, verification of the performance of tasks of extracurricular independent work	Reproductive	10 min.
Main	Discussion of theoretical issues according to the subject of the class	Comprehension Understanding	10 min.
	Solving calculation and situational problems	Application in practice Search creative activity	25 min.
	Independent work of the student under the supervision of the teacher (auditory work of the student)	Application in practice Search creative activity	10 min.

	Generalization of knowledge	Fixing	5 min.
Final	Control of the final level of teaching (solving calculation and situational problems)	Reproduction	15 min.
	General evaluation of the student's educational activity	Familiarization	10 min.
	Informing students about the topic of the next lesson and tasks for independent work	Familiarization	1 min.

Recommended literature:

Basic

1. Statistics and Chemometrics for Analytical Chemistry (seventh edition) / J. N. Miller, J.C. Miller and R. D. Miller : Pearson, 2018, P. 26-30. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

2. Introduction to Statistics in Metrology / S. Crowder et al. Cham : Springer International Publishing, 2020, P. 166-169. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Additional

1. European Pharmacopoeia / European Directorate for the Quality of Medicines & HealthCare of the Council of Europe. – tenth edition, volume 1. Strasbourg : Council of Europe, 2019. Section 5.3. Statistical analysis of results of biological assays and tests. P. 683-713. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Information resources

1. <https://nmuofficial.com/en/zagalni-vidomosti/kafedri/department-medical-general-chemistry/>

2. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224>

Questions for the student's self-preparation for the practical lesson:

1. Calculation of the confidence limits.
2. Presentation of the results of quantitative analysis.

The methodical instruction is developed by:

Yaroslava Pushkarova – Associate Professor of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor,

Galina Zaitseva – Head of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor.

Topic of lesson N 5: “Comparison of two methods of analysis by reproducibility”

Competencies:

– **integral competence:** the ability to solve complex problems, including those of a research and innovation nature in the field of medicine; the ability to continue learning with a high degree of autonomy;

– **general competencies (GC):**

1. Ability for abstract thinking, analysis and synthesis (GC 01).
2. Ability to learn and master modern knowledge (GC 02).
3. Ability to apply knowledge in practical situations (GC 03).
4. Ability to make informed decisions (GC 06).

– **professional competences of the specialty (PC):**

1. Ability to develop and implement scientific and applied projects in the field of health care (PC 23).

2. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results (PC 25).

Purpose: ability to compare two methods of analysis for reproducibility and to be able to interpret their calculations.

Equipment: practical tasks (tests, calculation problems, situational problems), student’s notebook, calculator, table of critical values of F -test.

Lesson plan and organizational structure:

Stage	Description of the stage	Learning levels	Time
Preparatory	Organizational issues (checking the presence of students)	Familiarization	1 min.
	Formation of motivation, activation of cognitive activity	Perception	3 min.
	Control of the initial level of teaching: test control and/or individual survey, verification of the performance of tasks of extra-auditory independent work	Reproductive	10 min.
Main	Discussion of theoretical material according to the subject of the topic	Comprehension Understanding	10 min.
	Solving calculation and situational problems	Application in practice Search creative activity	25 min.
	Independent work of the student under the supervision of the teacher (auditory work of the student)	Application in practice Search creative activity	10 min.

	Generalization of knowledge	Fixing	5 min.
Final	Control of the final level of teaching (solving calculation and situational problems)	Reproduction	15 min.
	General evaluation of the student's educational activity	Familiarization	10 min.
	Informing students about the topic of the next lesson and tasks for independent work	Familiarization	1 min.

Recommended literature:

Basic

1. Statistics and Chemometrics for Analytical Chemistry (seventh edition) / J. N. Miller, J.C. Miller and R. D. Miller : Pearson, 2018, P. 45-48. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

2. Taylor, J. K., Cihon, C. Statistical techniques for data analysis (second edition). Chapman and Hall/CRC, 2004, P. 91-93. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Additional

1. European Pharmacopoeia / European Directorate for the Quality of Medicines & HealthCare of the Council of Europe. – tenth edition, volume 1. Strasbourg : Council of Europe, 2019. Section 5.3. Statistical analysis of results of biological assays and tests. P. 683-713. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Information resources

1. <https://nmuofficial.com/en/zagalni-vidomosti/kafedri/department-medical-general-chemistry/>

2. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224>

Questions for the student's self-preparation for the practical lesson:

1. Definition of the terms “precision”, “reproducibility”.
2. Comparison of two methods of analysis by reproducibility (comparison of variances).

The methodical instruction is developed by:

Yaroslava Pushkarova – Associate Professor of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor,

Galina Zaitseva – Head of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor.

Topic of lesson N 6: “Comparison of the mean values of two samples”

Competencies:

– **integral competence:** the ability to solve complex problems, including those of a research and innovation nature in the field of medicine; the ability to continue learning with a high degree of autonomy;

– **general competencies (GC):**

1. Ability for abstract thinking, analysis and synthesis (GC 01).
2. Ability to learn and master modern knowledge (GC 02).
3. Ability to apply knowledge in practical situations (GC 03).
4. Ability to make informed decisions (GC 06).

– **professional competences of the specialty (PC):**

1. Ability to develop and implement scientific and applied projects in the field of health care (PC 23).

2. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results (PC 25).

Purpose: ability to compare the mean values of experimental data obtained by two different methods or for two different objects, and to be able to interpret their calculations.

Equipment: practical tasks (tests, calculation problems, situational problems), student’s notebook, calculator, tables of critical values of t -test and F -test.

Lesson plan and organizational structure:

Stage	Description of the stage	Learning levels	Time
Preparatory	Organizational issues (checking the presence of students)	Familiarization	1 min.
	Formation of motivation, activation of cognitive activity	Perception	3 min.
	Control of the initial level of teaching: test control and/or individual survey, verification of the performance of tasks of extra-auditory independent work	Reproductive	10 min.
Main	Discussion of theoretical material according to the subject of the topic	Comprehension Understanding	10 min.
	Solving calculation and situational problems	Application in practice Search creative activity	25 min.
	Independent work of the student under the supervision of the teacher (auditory work of the student)	Application in practice Search creative	10 min.

		activity	
	Generalization of knowledge	Fixing	5 min.
Final	Control of the final level of teaching (solving calculation and situational problems)	Reproduction	15 min.
	General evaluation of the student's educational activity	Familiarization	10 min.
	Informing students about the topic of the next lesson and tasks for independent work	Familiarization	1 min.

Recommended literature:

Basic

1. Statistics and Chemometrics for Analytical Chemistry (seventh edition) / J. N. Miller, J.C. Miller and R. D. Miller : Pearson, 2018, P. 37-44. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).
2. Taylor, J. K., Cihon, C. Statistical techniques for data analysis (second edition). Chapman and Hall/CRC, 2004, P. 87-90. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Additional

1. European Pharmacopoeia / European Directorate for the Quality of Medicines & HealthCare of the Council of Europe. – tenth edition, volume 1. Strasbourg : Council of Europe, 2019. Section 5.3. Statistical analysis of results of biological assays and tests. P. 683-713. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Information resources

1. <https://nmuofficial.com/en/zagalni-vidomosti/kafedri/department-medical-general-chemistry/>
2. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224>

Questions for the student's self-preparation for the practical lesson:

1. Comparison of the average results of two samples for cases:
 - 1.1. The difference in variances is statistically insignificant.
 - 1.2. The difference in variances is statistically significant.

The methodical instruction is developed by:

Yaroslava Pushkarova – Associate Professor of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor,
Galina Zaitseva – Head of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor.

Topic of lesson N 7: “Estimation of the accuracy of measurements”

Competencies:

– **integral competence:** the ability to solve complex problems, including those of a research and innovation nature in the field of medicine; the ability to continue learning with a high degree of autonomy;

– **general competencies (GC):**

1. Ability for abstract thinking, analysis and synthesis (GC 01).
2. Ability to learn and master modern knowledge (GC 02).
3. Ability to apply knowledge in practical situations (GC 03).
4. Ability to make informed decisions (GC 06).

– **professional competences of the specialty (PC):**

1. Ability to develop and implement scientific and applied projects in the field of health care (PC 23).

2. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results (PC 25).

Purpose: ability to evaluate the accuracy of measurements obtained experimentally and to be able to interpret their calculations.

Equipment: practical tasks (tests, calculation problems, situational problems), student’s notebook, calculator, table of critical values of *t*-test.

Lesson plan and organizational structure:

Stage	Description of the stage	Learning levels	Time
Preparatory	Organizational issues (checking the presence of students)	Familiarization	1 min.
	Formation of motivation, activation of cognitive activity	Perception	3 min.
	Control of the initial level of teaching: test control and/or individual survey, verification of the performance of tasks of extra-auditory independent work	Reproductive	10 min.
Main	Discussion of theoretical material according to the subject of the topic	Comprehension Understanding	10 min.
	Solving calculation and situational problems	Application in practice Search creative activity	25 min.
	Independent work of the student under the supervision of the teacher (auditory work of the student)	Application in practice Search creative activity	10 min.

	Generalization of knowledge	Fixing	5 min.
Final	Control of the final level of teaching (solving calculation and situational problems)	Reproduction	15 min.
	General evaluation of the student's educational activity	Familiarization	10 min.
	Informing students about the topic of the next lesson and tasks for independent work	Familiarization	1 min.

Recommended literature:

Basic

1. Introduction to Statistics in Metrology / S. Crowder et al. Cham : Springer International Publishing, 2020, P. 19-28. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

2. Taylor, J. K., Cihon, C. Statistical techniques for data analysis (second edition). Chapman and Hall/CRC, 2004, P. 112-115. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Additional

1. European Pharmacopoeia / European Directorate for the Quality of Medicines & HealthCare of the Council of Europe. – tenth edition, volume 1. Strasbourg : Council of Europe, 2019. Section 5.3. Statistical analysis of results of biological assays and tests. P. 683-713. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Information resources

1. <https://nmuofficial.com/en/zagalni-vidomosti/kafedri/department-medical-general-chemistry/>

2. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224>

Questions for the student's self-preparation for the practical lesson:

1. Assessment of the accuracy of measurements using confidence limits.
2. Assessment of the accuracy of measurements using the *t*-criterion.

The methodical instruction is developed by:

Yaroslava Pushkarova – Associate Professor of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor,

Galina Zaitseva – Head of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor.

Topic of lesson N 8: “Estimation of the repeatability of results”

Competencies:

– **integral competence:** the ability to solve complex problems, including those of a research and innovation nature in the field of medicine; the ability to continue learning with a high degree of autonomy;

– **general competencies (GC):**

1. Ability for abstract thinking, analysis and synthesis (GC 01).
2. Ability to learn and master modern knowledge (GC 02).
3. Ability to apply knowledge in practical situations (GC 03).
4. Ability to make informed decisions (GC 06).

– **professional competences of the specialty (PC):**

1. Ability to develop and implement scientific and applied projects in the field of health care (PC 23).

2. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results (PC 25).

Purpose: ability to evaluate the repeatability of results and to be able to interpret their calculations.

Equipment: practical tasks (tests, calculation problems, situational problems), student’s notebook, calculator, table of critical values of *L*-test.

Lesson plan and organizational structure:

Stage	Description of the stage	Learning levels	Time
Preparatory	Organizational issues (checking the presence of students)	Familiarization	1 min.
	Formation of motivation, activation of cognitive activity	Perception	3 min.
	Control of the initial level of teaching: test control and/or individual survey, verification of the performance of tasks of extra-auditory independent work	Reproductive	10 min.
Main	Discussion of theoretical material according to the subject of the topic	Comprehension Understanding	10 min.
	Solving calculation and situational problems	Application in practice Search creative activity	25 min.
	Independent work of the student under the supervision of the teacher (auditory work of the student)	Application in practice Search creative activity	10 min.

	Generalization of knowledge	Fixing	5 min.
Final	Control of the final level of teaching (solving calculation and situational problems)	Reproduction	15 min.
	General evaluation of the student's educational activity	Familiarization	10 min.
	Informing students about the topic of the next lesson and tasks for independent work	Familiarization	1 min.

Recommended literature:

Basic

1. Introduction to Statistics in Metrology / S. Crowder et al. Cham : Springer International Publishing, 2020, P. 19-28. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

2. Statistics and Chemometrics for Analytical Chemistry (seventh edition) / J. N. Miller, J.C. Miller and R. D. Miller : Pearson, 2018, P. 6-12. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Additional

1. B. Magnusson and U. Örnemark (eds.). Eurachem Guide: The Fitness for Purpose of Analytical Methods – A Laboratory Guide to Method Validation and Related Topics, (2nd ed. 2014). URL: www.eurachem.org/images/stories/Guides/pdf/MV_guide_2nd_ed_EN.pdf (date of access: 25.07.2024).

Information resources

1. <https://nmuofficial.com/en/zagalni-vidomosti/kafedri/departament-medical-general-chemistry/>

2. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224>

Questions for the student's self-preparation for the practical lesson:

1. Evaluation of repeatability of results.
2. Validation of analytical methods and tests: basic terms and concepts.

The methodical instruction is developed by:

Yaroslava Pushkarova – Associate Professor of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor,

Galina Zaitseva – Head of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor.

Topic of lesson N 9: “Calculation of linear dependence parameters. Estimation of the limit of detection”

Competencies:

– **integral competence:** the ability to solve complex problems, including those of a research and innovation nature in the field of medicine; the ability to continue learning with a high degree of autonomy;

– **general competencies (GC):**

1. Ability for abstract thinking, analysis and synthesis (GC 01).
2. Ability to learn and master modern knowledge (GC 02).
3. Ability to apply knowledge in practical situations (GC 03).
4. Ability to make informed decisions (GC 06).

– **professional competences of the specialty (PC):**

1. Ability to develop and implement scientific and applied projects in the field of health care (PC 23).

2. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results (PC 25).

Purpose: ability to determine parameters of linear dependence and estimate the limit of detection.

Equipment: practical tasks (tests, calculation problems, situational problems), student’s notebook, calculator.

Lesson plan and organizational structure:

Stage	Description of the stage	Learning levels	Time
Preparatory	Organizational issues (checking the presence of students)	Familiarization	1 min.
	Formation of motivation, activation of cognitive activity	Perception	3 min.
	Control of the initial level of teaching: test control and/or individual survey, verification of the performance of tasks of extra-auditory independent work	Reproductive	10 min.
Main	Discussion of theoretical material according to the subject of the topic	Comprehension Understanding	10 min.
	Solving calculation and situational problems	Application in practice Search creative activity	25 min.
	Independent work of the student under the supervision of the teacher (auditory work of the student)	Application in practice Search creative	10 min.

		activity	
	Generalization of knowledge	Fixing	5 min.
Final	Control of the final level of teaching (solving calculation and situational problems)	Reproduction	15 min.
	General evaluation of the student's educational activity	Familiarization	10 min.
	Informing students about the topic of the next lesson and tasks for independent work	Familiarization	1 min.

Recommended literature:

Basic

1. Statistics and Chemometrics for Analytical Chemistry (seventh edition) / J. N. Miller, J.C. Miller and R. D. Miller : Pearson, 2018, P. 120-137. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Additional

1. Introduction to Statistics in Metrology / S. Crowder et al. Cham : Springer International Publishing, 2020, P. 227-240. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Information resources

1. <https://nmuofficial.com/en/zagalni-vidomosti/kafedri/department-medical-general-chemistry/>
2. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224>

Questions for the student's self-preparation for the practical lesson:

1. Linear and non-linear regressions.
2. Statistical estimation of the limit of detection.

The methodical instruction is developed by:

Yaroslava Pushkarova – Associate Professor of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor,

Galina Zaitseva – Head of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor.

Topic of lesson N 10: “Probability theory in medicine”

Competencies:

– **integral competence:** the ability to solve complex problems, including those of a research and innovation nature in the field of medicine; the ability to continue learning with a high degree of autonomy;

– **general competencies (GC):**

1. Ability for abstract thinking, analysis and synthesis (GC 01).
2. Ability to learn and master modern knowledge (GC 02).
3. Ability to apply knowledge in practical situations (GC 03).
4. Ability to make informed decisions (GC 06).

– **professional competences of the specialty (PC):**

1. Ability to develop and implement scientific and applied projects in the field of health care (PC 23).

2. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results (PC 25).

Purpose: ability of correct application of the main theorems of probability theory, estimate the probability of a random event and calculate the probability of consecutive independent events according to Bernoulli's formula.

Equipment: practical tasks (tests, calculation problems, situational problems), student's notebook, calculator.

Lesson plan and organizational structure:

Stage	Description of the stage	Learning levels	Time
Preparatory	Organizational issues (checking the presence of students)	Familiarization	1 min.
	Formation of motivation, activation of cognitive activity	Perception	3 min.
	Control of the initial level of teaching: test control and/or individual survey, verification of the performance of tasks of extra-auditory independent work	Reproductive	10 min.
Main	Discussion of theoretical material according to the subject of the topic	Comprehension Understanding	10 min.
	Solving calculation and situational problems	Application in practice Search creative activity	20 min.
	Independent work of the student under the supervision of the teacher (auditory work of the student)	Application in practice Search creative	10 min.

		activity	
	Generalization of knowledge	Fixing	5 min.
Final	Control of the final level of teaching (solving calculation and situational problems)	Reproduction	10 min.
	General evaluation of the student's educational activity	Familiarization	10 min.
	Calculation of the sum of points for the current activity.	Familiarization	11 min.

Recommended literature:

Basic

1. Riffenburg R. H., Gillen D. L. Statistical in Medicine (fourth edition). Academic press, 2020, P. 51-64. URL: <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Additional

1. Taylor, J. K., Cihon, C. Statistical techniques for data analysis (second edition). Chapman and Hall/CRC, 2004, P. 185-187. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224> (date of access: 25.07.2024).

Information resources

1. <https://nmuofficial.com/en/zagalni-vidomosti/kafedri/department-medical-general-chemistry/>
2. <https://likar.nmu.kiev.ua/md/course/view.php?id=8224>

Questions for the student's self-preparation for the practical lesson:

1. Basic theorems of probability theory.
2. Consecutive independent tests. Bernoulli's formula.

The methodical instruction is developed by:

Yaroslava Pushkarova – Associate Professor of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor,

Galina Zaitseva – Head of Analytical, Physical and Colloid Chemistry Department, PhD in Chemistry, Associate Professor.

SUPPLEMENT

Table 1. Values for use in the Dixon Test (Q-test) for Outliers

<i>n</i>	<i>P</i> = 0,90	<i>P</i> = 0,95	<i>P</i> = 0,99
3	0,89	0,94	0,99
4	0,68	0,77	0,89
5	0,56	0,64	0,76
6	0,48	0,56	0,70
7	0,43	0,51	0,64
8	0,40	0,48	0,58
9	0,38	0,46	0,55

Table 2. Values for Use in the Grubbs Test for Outliers

<i>n</i>	<i>P</i> = 0,90	<i>P</i> = 0,95	<i>P</i> = 0,99
3	1.148	1.153	1.155
4	1.425	1.463	1.492
5	1.602	1.672	1.749
6	1.729	1.822	1.944
7	1.828	1.938	2.097
8	1.909	2.032	2.221
9	1.977	2.110	2.323

Table 3. The t-distribution

<i>v</i>	<i>P</i> = 0,90	<i>P</i> = 0,95	<i>P</i> = 0,98	<i>P</i> = 0,99
1	6,3138	12,7062	31,8205	63,6567
2	2,9200	4,3027	6,9646	9,9248
3	2,3534	3,1824	4,5407	5,8409
4	2,1318	2,7764	3,7469	4,6041
5	2,0150	2,5706	3,3649	4,0321
6	1,9432	2,4469	3,1427	3,7074
7	1,8946	2,3646	2,9980	3,4995
8	1,8595	2,3060	2,8965	3,3554
9	1,8331	2,2622	2,8214	3,2498
10	1,8125	2,2281	2,7638	3,1693
11	1,7956	2,2010	2,7181	3,1058
12	1,7823	2,1788	2,6810	3,0545
13	1,7709	2,1604	2,6503	3,0123
14	1,7613	2,1448	2,6245	2,9768
15	1,7530	2,1314	2,6025	2,9467
16	1,7459	2,1199	2,5835	2,9208
17	1,7396	2,1098	2,5669	2,8982
18	1,7341	2,1009	2,5524	2,8784
19	1,7291	2,0930	2,5395	2,8609
20	1,7247	2,0860	2,5280	2,8453
25	1,7081	2,0595	2,4851	2,7874
30	1,6973	2,0423	2,4573	2,7564
40	1,6839	2,0211	2,4233	2,7045
50	1,6759	2,0086	2,4033	2,6778
100	1,6602	1,9840	2,3642	2,6259

Table 4. Critical values for the F-test, $P=0.05$, v_1 is the number of degrees of freedom of the numerator, v_2 is the number of degrees of freedom of the denominator

$v_1 \backslash v_2$	1	2	3	4	5	6	8	12	24	∞
1	161,5	199,5	215,7	224,6	230,2	233,9	238,9	243,9	249,0	254,3
2	18,51	19,00	19,16	19,25	19,30	19,33	19,37	19,41	19,45	19,50
3	10,13	9,55	9,28	9,12	9,01	8,94	8,84	8,74	8,64	8,53
4	7,71	6,94	6,59	6,39	6,26	6,16	6,04	5,91	5,77	5,63
5	6,61	5,79	5,41	5,19	5,05	4,95	4,82	4,68	4,53	4,36
6	5,99	5,14	4,76	4,53	4,39	4,28	4,15	4,00	3,84	3,67
7	5,59	4,74	4,35	4,12	3,97	3,87	3,73	3,57	3,41	3,23
8	5,32	4,46	4,07	3,84	3,69	3,58	3,44	3,28	3,12	2,93
9	5,12	4,26	3,86	3,63	3,48	3,37	3,23	3,07	2,90	2,71
10	4,96	4,10	3,71	3,48	3,33	3,22	3,07	2,91	2,74	2,54
11	4,84	3,98	3,59	3,36	3,20	3,09	2,95	2,79	2,61	2,40
12	4,75	3,88	3,49	3,26	3,11	3,00	2,85	2,69	2,50	2,30
13	4,67	3,80	3,41	3,18	3,02	2,92	2,77	2,60	2,42	2,21
14	4,60	3,74	3,34	3,11	2,96	2,85	2,70	2,53	2,35	2,13
15	4,54	3,68	3,29	3,06	2,90	2,79	2,64	2,48	2,29	2,07
16	4,49	3,63	3,24	3,01	2,85	2,74	2,59	2,42	2,24	2,01
17	4,45	3,59	3,20	2,96	2,81	2,70	2,55	2,38	2,19	1,96
18	4,41	3,55	3,16	2,93	2,77	2,66	2,51	2,34	2,15	1,92
19	4,38	3,52	3,13	2,90	2,74	2,63	2,48	2,31	2,11	1,88
20	4,35	3,49	3,10	2,87	2,71	2,60	2,45	2,28	2,08	1,84
21	4,32	3,47	3,07	2,84	2,68	2,57	2,42	2,25	2,05	1,81
22	4,30	3,44	3,05	2,82	2,66	2,55	2,40	2,23	2,03	1,78
23	4,28	3,42	3,03	2,80	2,64	2,53	2,38	2,20	2,00	1,76
24	4,26	3,40	3,01	2,78	2,62	2,51	2,36	2,18	1,98	1,73
25	4,24	3,38	2,99	2,76	2,60	2,49	2,34	2,16	1,96	1,71
26	4,22	3,37	2,98	2,74	2,59	2,47	2,32	2,15	1,95	1,69
27	4,21	3,35	2,96	2,73	2,57	2,46	2,30	2,13	1,93	1,67
28	4,20	3,34	2,95	2,71	2,56	2,44	2,29	2,12	1,91	1,65
29	4,18	3,33	2,93	2,70	2,54	2,43	2,28	2,10	1,90	1,64
30	4,17	3,32	2,92	2,69	2,53	2,42	2,27	2,09	1,89	1,62
35	4,12	3,26	2,87	2,64	2,48	2,37	2,22	2,04	1,83	1,57
40	4,08	3,23	2,84	2,61	2,45	2,34	2,18	2,00	1,79	1,51

45	4,06	3,21	2,81	2,58	2,42	2,31	2,15	1,97	1,76	1,48
50	4,03	3,18	2,79	2,56	2,40	2,29	2,13	1,95	1,74	1,44
60	4,00	3,15	2,76	2,52	2,37	2,25	2,10	1,92	1,70	1,39
70	3,98	3,13	2,74	2,50	2,35	2,23	2,07	1,89	1,67	1,35