**SYLLABUS**
**Spring semester 2024-2025 academic year**
**Educational program 7M05301 - Chemistry**

| ID and name of course | Independent work of the student (IWS) | Number of credits | | | General number of credits | Independent work of the student under the guidance of a teacher (IWST) |
|---|---|---|---|---|---|---|
| | | Lectures (L) | Practical classes (PC) | Lab. classes (LC) | | |
| 85315 Modern methods of analysis of environmental objects | 4 | 1.7 | 3.3 | - | 5 | 5 |

**ACADEMIC INFORMATION ABOUT THE COURSE**

| Learning Format | Cycle, component | Lecture types | Types of practical classes | Form and platform final control |
|---|---|---|---|---|
| Offline | MD. Elective component | Oral presentation | Seminars | Written (Univer) |

| | |
|---|---|
| **Lecturer - (s)** | Madi Abilev<br>PhD, Associate professor |
| **e-mail :** | madi.abilev@kaznu.edu.kz |
| **Phone :** | 8 (727) 221-15-07 |
| **Assistant - (s)** | - |
| **e-mail :** | - |
| **Phone :** | - |

**ACADEMIC COURSE PRESENTATION**

| Purpose of the course | Expected Learning Outcomes (LO) *<br>As a result of studying the discipline the student will be able to: | Indicators of LO achievement (ID) |
|---|---|---|
| To form the ability to assess and use methods to control environmental pollution, modern rapid methods for the analysis of pollutants, regulatory documents for environmental analysis. | 1.explain the principles and applications of modern analytical methods used in environmental analysis | 1.1 Student can accurately describe the theoretical principles underlying key analytical methods such as spectroscopy, chromatography, and electrochemical analysis |
| | | 1.2 Student can provide specific examples of real-world environmental applications for each analytical method, such as pollutant detection in air, water, or soil, and explain why a particular method is the most suitable for a given scenario |
| | 2. design analytical experiments to address specific environmental problems, including pollutant identification, quantification, and monitoring | 2.1 Student can develop a detailed experimental plan that specifies the analytical methods, sample collection strategies, and preparation techniques appropriate for identifying and quantifying specific pollutants in environmental matrices |
| | | 2.2 Student can troubleshoot issues in analytical processes and suggest solutions based on theoretical knowledge and practical experience |
| | | 2.3 Student can justify the selection of analytical methods and instruments based on the nature of the pollutant, environmental conditions, and required sensitivity and accuracy, demonstrating a clear understanding of method suitability |

| | | |
|---|---|---|
| | 3. conduct independent research, utilizing modern analytical techniques, and present findings effectively through written and oral communication | 3.1 Student can independently plan and execute a research project, demonstrating the ability to apply modern analytical techniques to collect, analyze, and interpret environmental data related to a specific research question or problem |
| | | 3.2 Student can effectively communicate research findings by preparing a comprehensive scientific report or presentation that includes objectives, methodology, results, interpretation, and conclusions, using appropriate technical language and visual aids |
| | 4. implement quality assurance and quality control (QA/QC) procedures to ensure the reliability and accuracy of environmental analyses | 4.1 Student can demonstrate knowledge of international environmental standards and regulations governing analytical practices |
| | | 4.2 Student can design and apply QA/QC protocols, including calibration of instruments, use of blanks, standards, and replicates, to minimize errors and ensure the reliability of analytical results |
| | | 4.3 Student can evaluate and interpret QA/QC data, such as control charts and recovery rates, to identify inconsistencies or deviations and propose corrective actions to maintain analytical accuracy |
| **Prerequisites** | Organization and planning of scientific research, Advanced chapters of analytical chemistry, Advanced analytical chemistry, Data analysis in chemistry | |
| **Postrequisites** | Modern aspects of chromatography, Modern research methods in electrochemistry | |
| **Learning Resources** | **Literature:**<br>1. Hussain C., Kecili R. Modern Environmental Analysis Techniques for Pollutants. - Elsevier, 2020. — 410 p.<br>2. Gelfand A., Fuentes M., Hoeting J., Smith R. (Eds.). Handbook of Environmental and Ecological Statistics. - Chapman and Hall/CRC, 2019. — 876 p.<br>3. Buszewski B., Baranowska I. (eds.) Handbook of Bioanalytics. - New York: Springer, 2022. — 1091 p.<br>4. Zhang Z. Environmental Data Analysis: Methods and Applications. - De Gruyter, 2017. — 329 p.<br>5. Wilson J. Environmental Applications of Digital Terrain Modeling. - Wiley Blackwell, 2018. — 359 p.<br><br>**Research infrastructure**<br>1. Labs of the department of analytical, colloid chemistry and technology of rare elements<br><br>**Professional scientific databases**<br>1. Web of Science<br>2. Scopus<br><br>**Internet resources**<br>1. http://elibrary.kaznu.kz/ru<br>2. MOOC / video lectures.<br>3. https://www.twirpx.com/<br>4. https://www.sciencedirect.com | |

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|---|---|
| **Academic course policy** | The academic policy of the course is determined by the Academic Policy and the Policy of Academic Integrity of Al-Farabi Kazakh National University .<br>Documents are available on the main page of IS Univer.<br>**Integration of science and education.** The research work of students, undergraduates and doctoral students is a deepening of the educational process. It is organized directly at the departments, laboratories, scientific and design departments of the university, in student scientific and technical associations. Independent work of students at all levels of education is aimed at developing research skills and competencies based on obtaining new knowledge using modern research and information technologies. A research university teacher integrates the results of scientific activities into the topics of lectures and seminars (practical) classes, laboratory classes and into the tasks of the IWST, IWS, which are reflected in the syllabus and are responsible for the relevance of the topics of training sessions and assignments.<br>**Attendance.** The deadline for each task is indicated in the calendar (schedule) for the implementation of the content of the course. Failure to meet deadlines results in loss of points.<br>**Academic honesty.** Practical/laboratory classes, IWS develop the student's independence, critical thinking, and creativity. Plagiarism, forgery, the use of cheat sheets, cheating at all stages of completing tasks are unacceptable.<br>Compliance with academic honesty during the period of theoretical training and at exams, in addition to the main policies, is regulated by the "Rules for the final control" , "Instructions for the final control of the autumn / spring semester of the current academic year" , "Regulations on checking students' text documents for borrowings".<br>Documents are available on the main page of IS Univer.<br>**Basic principles of inclusive education.** The educational environment of the university is conceived as a safe place where there is always support and equal attitude from the teacher to all students and students to each other, regardless of gender, race / ethnicity, religious beliefs, socio-economic status, physical health of the student, etc. All people need the support and friendship of peers and fellow students. For all students, progress is more about what they can do than what they can't. Diversity enhances all aspects of life.<br>All students, especially those with disabilities, can receive counseling assistance by e-mail madi.abilev@kaznu.edu.kz or https://us05web.zoom.us/j/84794521363?pwd=sWcQIkFjxnvv0aBoCpCAeX48txwxoF.1<br>**Integration MOOC (massive open online course).** In the case of integrating MOOC into the course, all students need to register for MOOC. The deadlines for passing MOOC modules must be strictly observed in accordance with the course study schedule.<br>**ATTENTION!** The deadline for each task is indicated in the calendar (schedule) for the implementation of the content of the course, as well as in the MOOC. Failure to meet deadlines results in loss of points. |

## INFORMATION ABOUT TEACHING, LEARNING AND ASSESSMENT

**Score-rating letter system of assessment of accounting for educational achievements**

| Grade | Digital equivalent points | Points, % content | Assessment according to the traditional system |
|---|---|---|---|
| A | 4.0 _ | 95-100 | Great |
| A- | 3.67 | 90-94 | |
| B+ | 3.33 | 85-89 | Fine |
| B | 3.0 | 80-84 | |
| B- | 2.67 | 75-79 | |
| C+ | 2.33 | 70-74 | |
| C | 2.0 | 65-69 | Satisfactorily |
| C- | 1.67 | 60-64 | |
| D+ | 1.33 | 55-59 | |
| D | 1.0 | 50-54 | |
| FX | 0.5 | 25-49 | Unsatisfactory |
| F | 0 | 0-24 | |

**Assessment Methods**

**Criteria-based assessment** is the process of correlating actual learning outcomes with expected learning outcomes based on clearly defined criteria. Based on formative and summative assessment.

**Formative assessment is** a type of assessment that is carried out in the course of daily learning activities. It is the current measure of progress. Provides an operational relationship between the student and the teacher. It allows you to determine the capabilities of the student, identify difficulties, help achieve the best results, timely correct the educational process for the teacher. The performance of tasks, the activity of work in the classroom during lectures, seminars, practical exercises (discussions, quizzes, debates, round tables, laboratory work, etc.) are evaluated. Acquired knowledge and competencies are assessed.

**Summative assessment** - type of assessment, which is carried out upon completion of the study of the section in accordance with the program of the course. Conducted 3-4 times per semester when performing IWS. This is the assessment of mastering the expected learning outcomes in relation to the descriptors. Allows you to determine and fix the level of mastering the course for a certain period. Learning outcomes are evaluated.

| Formative and summative assessment | Points % content |
|---|---|
| Activity at lectures | 7 |
| Work on seminars | 22 |
| Independent work | 18 |
| Colloquium | 13 |
| Final control (exam) | 40 |
| TOTAL | 100 |

## Calendar (schedule) for the implementation of the content of the course. Methods of teaching and learning.

| A week | Topic name | Number of hours | Max. ball |
|---|---|---|---|
| | **MODULE 1. Foundations of environmental analysis** | | |
| 1 | **Lec 1.** Introduction to environmental systems and analysis | 1 | 2 |
| | **Sem 1.** The role of environmental analysis in sustainable development | 2 | 5 |
| 2 | **Lec 2.** Environmental chemistry and pollutants | 1 | 2 |
| | **Sem 2.** Emerging environmental pollutants | 2 | 6 |
| | **IWST 1.** Consultation on the implementation of IWS1 | 1 | - |
| 3 | **Lec 3.** Principles of sampling and monitoring | 1 | 2 |
| | **Sem 3.** Advanced sampling strategies | 2 | 5 |

| | | | |
|---|---|---|---|
| | **IWS 1.** Experimental plan for analyzing specific pollutants in water samples using modern analytical techniques | | 15 |
| **MODULE 2. Analytical techniques in environmental science** | | | |
| **4** | **Lec 4.** Spectroscopic techniques in environmental analysis | 1 | 2 |
| | **Sem 4.** Innovations in spectroscopic analysis | 2 | 6 |
| **5** | **Lec 5.** Chromatographic methods: GC and HPLC | 1 | 2 |
| | **Sem 5.** Chromatographic technologies: beyond basics | 2 | 5 |
| | **IWST 2.** Consultation on the implementation of IWS2 | 1 | - |
| **6** | **Lec 6.** Mass spectrometry in environmental studies | 1 | 2 |
| | **Sem 6.** Mass spectrometry applications in trace analysis | 2 | 6 |
| | **IWS 2.** A report comparing the effectiveness of spectroscopy, chromatography, and mass spectrometry for monitoring a specific environmental matrix (air, water, soil) | | 15 |
| **7** | **Lec 7.** Remote sensing and GIS in environmental analysis | 1 | 2 |
| | **Sem 7.** Modern remote sensing techniques applied in environmental analysis | 2 | 5 |
| | **IWST 3.** Colloquium (written) | 1 | 18 |
| **Midterm control 1** | | | **100** |
| **MODULE 3. Emerging techniques and technologies** | | | |
| **8** | **Lec 8.** Nanotechnology in environmental analysis | 1 | 1 |
| | **Sem 8.** Nanomaterials in pollution mitigation | 2 | 5 |
| | **IWST 4.** Consultation on the implementation of the IWS3 | 1 | |
| **9** | **Lec 9.** Molecular biology techniques for environmental monitoring | 1 | 1 |
| | **Sem 9.** DNA-based techniques in monitoring ecosystems | 2 | 5 |
| **10** | **Lec 10.** Real-time environmental monitoring | 1 | 2 |
| | **Sem 10.** Real-time data collection and analysis in environmental monitoring | 2 | 5 |
| | **IWS 3.** Review on innovative nanotechnology applications in environmental monitoring | | 15 |
| **MODULE 4. Case studies and applications** | | | |
| **11** | **Lec 11.** Climate change and atmospheric monitoring | 1 | 2 |
| | **Sem 11.** Impact of climate change on air quality monitoring | 2 | 5 |
| **12** | **Lec 12.** Water quality assessment | 1 | 2 |
| | **Sem 12.** Integrated water quality monitoring systems | 2 | 5 |
| **13** | **Lec 13.** Soil pollution and remediation monitoring | 1 | 1 |
| | **Sem 13**. Bioremediation and soil health monitoring | 2 | 5 |
| | **IWST 5.** Consultation on the implementation of the IWS4 | | |
| **MODULE 5. Challenges and future directions** | | | |
| **14** | **Lec 14**. Data analysis and interpretation in environmental studies | 1 | 1 |
| | **Sem 14.** Quality assurance in environmental analysis | 2 | 5 |
| **15** | **Lec 15.** Ethics, regulations, and global perspectives in environmental analysis | 1 | 1 |
| | **Sem 15.** Colloquium (written) | 2 | 24 |
| | **IWS 4.** A detailed QA/QC protocol for an environmental monitoring project, including calibration and error minimization strategies | 1 | 15 |
| | **IWST 6.** Consultation on preparation for the exam | 1 | |
| **Midterm control 2** | | | **100** |
| **Final control (exam)** | | | **100** |
| **TOTAL for course** | | | **100** |

**Dean ____________________________________ A. Galeyeva**

**Chair of the Academic Committee**

**on the Quality of Teaching and Learning___________ Bektemissova A.U.**

**Head of Department ______________________ A. Argimbayeva**

**Lecturer ____________________________________ M. Abilev**

**SUMMATIVE ASSESSMENT RUBRICATOR**
**Criteria for assessment of learning outcomes**

**IWS 1**
**Experimental plan for analyzing specific pollutants in water samples using modern analytical techniques (15% out of 100%)**

| Criterion | "Very good" 13-15% | "Good" 10-12% | "Satisfactory" 5-9% | "Unsatisfactory" 0-4% |
|---|---|---|---|---|
| **Technical feasibility and completeness** | The experimental plan includes all necessary steps. Modern analytical techniques are appropriately selected based on the nature of the pollutant. Details on equipment, materials, and protocols are well-defined and aligned with the objectives. | The experimental plan includes most necessary steps. Analytical techniques are selected appropriately but may lack detailed justification for their suitability to the pollutant. Equipment, materials, and protocols are provided but may miss minor details or alignment with all objectives. | The experimental plan includes some necessary steps, but key elements such as sample preparation or data analysis are incomplete or unclear. The selection of analytical techniques may be appropriate but lacks alignment with the pollutant's characteristics or is insufficiently justified. Details on equipment, materials, and protocols are present but lack specificity or thoroughness. | The experimental plan is incomplete or poorly organized, with significant gaps in essential steps. Analytical techniques are either inappropriately chosen, not aligned with the pollutant's nature, or entirely absent. Details on equipment, materials, and protocols are vague, incorrect, or missing entirely. |
| **Rationale and justification** | The choice of analytical methods is justified with scientific reasoning, considering factors such as the pollutant's chemical properties, required sensitivity, and expected accuracy. Environmental and practical considerations, such as cost-effectiveness, availability of resources, and regulatory compliance, are clearly addressed. | The choice of analytical methods is supported by reasonable scientific reasoning, addressing some relevant factors like the pollutant's chemical properties or required sensitivity. Environmental and practical considerations, such as cost-effectiveness and resource availability, are mentioned but lack depth or thorough analysis. | The choice of analytical methods is partially justified, with minimal consideration of scientific reasoning. Few factors, such as the pollutant's properties or required accuracy, are addressed, and the reasoning may be unclear or incomplete. Environmental and practical considerations are mentioned briefly or are overly general. | The choice of analytical methods is unjustified or lacks scientific reasoning entirely. Key factors, such as the pollutant's chemical properties or required sensitivity, are ignored. Environmental and practical considerations, such as cost-effectiveness or regulatory compliance, are missing or irrelevant. |
| **Innovation and problem-solving** | Demonstrates originality or creative approaches in designing the experiment, including novel techniques or integration of emerging technologies. Anticipates potential challenges (e.g., sample contamination, interferences) and provides practical solutions or alternatives. | The experimental design shows some originality or creative approaches, incorporating established techniques with minor innovative elements. Potential challenges are identified, but the solutions or alternatives provided are basic or lack depth in addressing complex issues. | The experimental design demonstrates limited originality, relying primarily on standard techniques without incorporating novel elements or emerging technologies. Challenges are only partially identified, and proposed solutions are vague, impractical, or incomplete. | The experimental design lacks originality or creativity, using only conventional approaches without any consideration for innovation. Challenges are ignored, or those mentioned lack relevance, and no viable solutions or alternatives are provided. |

**IWS 2**

**A report comparing the effectiveness of spectroscopy, chromatography, and mass spectrometry for monitoring a specific environmental matrix (air, water, soil) (15% out of 100%)**

| Criterion | "Very good"<br>13-15% | "Good"<br>10-12% | "Satisfactory"<br>5-9% | "Unsatisfactory"<br>0-4% |
|---|---|---|---|---|
| **Depth of comparison and analysis** | The report provides an in-depth, well-structured comparison of spectroscopy, chromatography, and mass spectrometry, clearly explaining their principles, advantages, limitations, and suitability for the selected environmental matrix. The analysis is supported by relevant examples and evidence from credible sources. | The report includes a detailed comparison of the techniques with sufficient explanation of their principles, advantages, and limitations. However, some aspects may lack depth or specific examples. | The report offers a basic comparison of the techniques but lacks comprehensive analysis. Explanations are superficial, and the use of examples is minimal or absent. | The report fails to provide a meaningful comparison of the techniques, with little to no explanation of their principles, advantages, or limitations. There is no evidence or examples to support claims. |
| **Relevance to the environmental matrix** | The report effectively links each technique to its applicability for the specific environmental matrix (air, water, or soil), clearly justifying why a technique is suitable or unsuitable based on the matrix's characteristics. | The report relates the techniques to the environmental matrix, but the justifications for their suitability or limitations are general or not well-developed. | The report mentions the environmental matrix but does not effectively connect it to the choice of analytical techniques or provides weak justifications. | The report does not address the relevance of the techniques to the environmental matrix or fails to justify the connections altogether. |
| **Clarity, structure, and use of sources** | The report is well-organized, with a logical structure that enhances readability. Arguments are clear and concise, supported by accurate data from reliable and up-to-date sources. Citations and references are properly formatted. | The report is organized and mostly clear, but some arguments may lack coherence or conciseness. Sources are generally reliable but may lack variety or recency. Citations and references are present but may have minor formatting issues. | The report is somewhat organized but includes unclear arguments or repetitive information. Few sources are cited, or they may not be credible or relevant. Citation formatting is inconsistent. | The report lacks structure, clarity, and coherence. Sources are absent, unreliable, or irrelevant, and citations are missing or incorrectly formatted. |

**IWS 3**
**Review on innovative nanotechnology applications in environmental monitoring (15% out of 100%)**

| Criterion | "Very good" 13-15% | "Good" 10-12% | "Satisfactory" 5-9% | "Unsatisfactory" 0-4% |
|---|---|---|---|---|
| **Coverage of nanotechnology applications** | The review provides a comprehensive and detailed overview of innovative nanotechnology applications in environmental monitoring. It covers a diverse range of examples and explains their principles, advantages, and limitations in depth. | The review discusses several nanotechnology applications with adequate detail, but some examples may lack depth or diversity. Explanations of principles, advantages, and limitations are present but not fully developed. | The review mentions a few nanotechnology applications but lacks depth or misses key examples. Explanations of principles, advantages, and limitations are minimal or superficial. | The review fails to adequately address nanotechnology applications or provides irrelevant, incomplete, or incorrect information. Explanations are absent or insufficient. |
| **Analysis and critical thinking** | The review critically evaluates the effectiveness of nanotechnology applications, discussing their environmental impact, scalability, and potential challenges. The analysis is well-supported by credible evidence and thoughtful insights. | The review includes some critical evaluation but may not address all aspects, such as environmental impact or scalability. The analysis is supported by evidence but lacks depth or originality in some areas. | The review demonstrates limited analysis or critical thinking, offering basic commentary on nanotechnology applications without deeper exploration of challenges or implications. Evidence is minimal or not well-integrated. | The review lacks critical evaluation or analysis, presenting information without assessing its significance or providing supporting evidence. |
| **Structure, clarity, and use of sources** | The review is well-organized with a logical flow and clear sections (e.g., introduction, main discussion, conclusion). Arguments are concise and well-articulated. It cites a wide range of credible and up-to-date sources, with proper formatting. | The review is organized and clear but may have minor structural issues or repetitive arguments. Sources are generally credible but may lack variety or completeness, and citations are mostly correct. | The review is somewhat organized but lacks clarity or coherence in places. Few sources are cited, or they may not be highly credible or relevant. Citation formatting may be inconsistent. | The review is poorly organized, with unclear or incoherent arguments. Sources are absent, unreliable, or irrelevant, and citations are missing or incorrect. |

**IWS 4**

**A detailed QA/QC protocol for an environmental monitoring project, including calibration and error minimization strategies (15% out of 100%)**

| Criterion | "Very good" 13-15% | "Good" 10-12% | "Satisfactory" 5-9% | "Unsatisfactory" 0-4% |
|---|---|---|---|---|
| **Completeness and accuracy of the QA/QC protocol** | The protocol is comprehensive and meticulously detailed, covering all critical components, including calibration procedures, error minimization strategies, quality control checks, and documentation practices. Steps are accurate and align with international standards. | The protocol is detailed and includes most critical components but may lack depth or thoroughness in some areas. Calibration and error minimization strategies are accurate but not extensively described. Alignment with standards is evident but not explicitly emphasized. | The protocol includes some key components but is incomplete or lacks sufficient detail. Calibration and error minimization strategies are addressed superficially or inconsistently. Alignment with standards is minimal or unclear. | The protocol is missing essential components, lacks accuracy, or is poorly organized. Calibration and error minimization strategies are absent or incorrect. There is no consideration of standards or best practices. |
| **Practicality and feasibility** | The protocol is highly practical and feasible, with clear and realistic steps for implementation. It anticipates potential challenges (e.g., equipment malfunctions, human errors) and provides effective solutions. Instructions are actionable and easily replicable. | The protocol is practical but may lack consideration of some potential challenges or solutions. Steps are feasible and mostly realistic, but minor adjustments may be needed for smooth implementation. | The protocol is somewhat practical but includes vague or impractical steps. Potential challenges are minimally addressed, and solutions are generic or unclear. | The protocol is impractical or unrealistic, with steps that are poorly defined or difficult to implement. Potential challenges are ignored, and no solutions are provided. |
| **Clarity, organization, and use of supporting data** | The protocol is well-organized with a logical structure, using clear headings and concise language. Supporting data (e.g., calibration curves, control charts) are accurate, relevant, and effectively integrated into the document. | The protocol is organized and mostly clear, though some sections may lack coherence or detail. Supporting data are present but may lack variety or integration into the document. | The protocol has a basic structure but lacks clarity or coherence in places. Supporting data are minimal, unclear, or not well-connected to the text. | The protocol is poorly organized and difficult to follow. Supporting data are absent, irrelevant, or incorrect, further detracting from the document's utility. |