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

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)		
91427 - Modern research methods in electrochemistry	2	1.7	3.3	-	5	7

ACADEMIC INFORMATION ABOUT THE COURSE

Learning Format	Cycle, component	Lecture types	Types of practical classes	Form and platform final control
offline	MD. Elective component	Traditional lecture on the board	Problems, discussion	Writing exam, IS Univer
Lecturer - (s)	Avchukir Khaisa, PhD, Acting Associate Professor			
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ACADEMIC COURSE PRESENTATION

Purpose of the course	Expected Learning Outcomes (LO) *	Indicators of LO achievement (ID)
	Learning Outcome 1: Demonstrate understanding of fundamental principles and processes in electrochemistry.	1.1 Explain key concepts such as charge transfer, electrode/solution interface, and mass transfer.
		1.2 Solve problems related to electrochemical thermodynamics and kinetics.
		1.3 Interpret data from potentiostatic and linear sweep voltammetry measurements.
	Learning Outcome 2: Apply advanced electrochemical methods for investigating reaction mechanisms.	2.1 Design experiments using cyclic voltammetry and chronoamperometry.
		2.2 Analyze and interpret Nyquist plots and impedance data.
		2.3 Evaluate reaction mechanisms based on experimental results.
	Learning Outcome 3: Utilize state-of-the-art techniques for electrochemical research.	3.1 Demonstrate the use of EIS in battery and sensor research.
		3.2 Apply quartz crystal microbalance for studying mass changes during reactions.
		3.3 Assess material stability using electrochemical online ICP-MS.
	Learning Outcome 4: Critically evaluate and report on electrochemical research.	4.1 Review and discuss scientific literature on electrochemical methods.
		4.2 Write detailed reports on experimental findings, including data processing.
		4.3 Present comparisons between different electrochemical techniques.
	Learning Outcome 5: Integrate modeling approaches with electrochemical processes.	5.1 Simulate corrosion processes in electrochemical systems.
		5.2. Analyze the limitations and benefits of modeling in electrochemical research.
Prerequisites	Advanced chapters of analytical chemistry, Data analysis in chemistry	
Post requisites	Dissertation Writing, Publication in the Proceedings of International Conferences	

Learning Resources	**Literature:** 1. Bard A. J., Faulkner L. R., White H. S. Electrochemical methods: fundamentals and applications. – John Wiley & Sons, 2022. 2. Scholz F. et al. Electroanalytical methods. – Berlin : Springer, 2010. – T. 1. 3. Mandler D. Fritz Scholz (Ed.): Electroanalytical methods. Guide to experiments and applications. – 2010. 4. Bagotsky V. S. (ed.). Fundamentals of electrochemistry. – John Wiley & Sons, 2005. 5. Orazem M. E., Tribollet B. Electrochemical impedance spectroscopy //New Jersey. – 2008. – T. 1. – №. 906. – C. 383-389. 6. Bard A. J., Inzelt G., Scholz F. (ed.). Electrochemical dictionary. – Berlin, Heidelberg : Springer Berlin Heidelberg, 2012. **Scientific articles:** 1. Scholz F. Electrochemistry and education //Journal of Solid State Electrochemistry. – 2024. – T. 28. – №. 3. – C. 635-640. 2. Scholz F. Thermodynamics of electrochemical reactions //Electroanalytical Methods: Guide to Experiments and Applications. – 2010. – C. 11-31. 3. Avchukir K. et al. The kinetics of indium electroreduction from chloride solutions //Russian Journal of Electrochemistry. – 2018. – T. 54. – C. 1096-1103. 4. Avchukir K. et al. Influence of tetrabutylammonium chloride on the electrodeposition of indium from chloride solution on a glassy carbon electrode //Journal of Electroanalytical Chemistry. – 2019. – T. 842. – C. 176-183. 5. Avchukir K. et al Influence of LiCl on the kinetics of Mg^{2+} insertion into TiO_2 prepared by solid-state chemical reaction //Journal of Solid State Electrochemistry. – 2024. – T. 28. – №. 7. – C. 2151-2162. **Professional scientific databases** 1. Science Direct 2. Scopus **Internet resources** (at least 3-5) 1 . http://elibrary.kaznu.kz/ru 2. https://www.metrohm.com/en/service/software-center/nova.html 3. http://scholar.google.com 4. https://www.biologic.net/learning-center-topics/ **Software** (optionally) 1. https://www.metrohm.com/en/service/software-center/nova.html
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 . Documents are available on the main page of IS Univer . **Integration of science and education.** The research work of undergraduate and doctoral students is a deepening of the educational process. It is organized directly at the university's departments, laboratories, scientific and design departments, 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, and IWS, which are reflected in the syllabus and are responsible for the relevance of the topics of training sessions and assignments. **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. **Academic honesty.** Practical/laboratory classes, IWS develop the student's independence, critical thinking, and creativity. Plagiarism, forgery, the use of cheat sheets, and fraud at all stages of completing tasks are unacceptable. 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". Documents are available on the main page of IS Univer . **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. All students, especially those with disabilities, can receive counselling assistance by phone/mail avchukir.khaisa@kaznu.edu.kz

	https://teams.microsoft.com/l/meetup-join/19%3ameeting_NGRlOTQwZjktYTk4OS00NTQ0LWJiOTAtYzNkODE1YWViNGE4%40thread.v2/0?context=%7b%22Tid%22%3a%22b0ab71a5-75b1-4d65-81f7-f479b4978d7b%22%2c%22Oid%22%3a%22c9d46eed-b202-40b2-8fb5-91d635ae3243%22%7d **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. **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, and timely correct the educational process for the teacher. The performance of tasks, and the activity of work in the classroom during lectures, seminars, and practical exercises (discussions, quizzes, debates, round tables, laboratory work, etc.) are evaluated. Acquired knowledge and competencies are assessed.

Summative assessment - the 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 The teacher introduces his own types of assessment or uses the proposed option	**Points % content** The teacher enters his score into points in accordance with the calendar (schedule). The exam does not change and the final score in the course.
Activity at lectures	5
Work in practical classes	20
Independent work	25
Design and creative activity	10
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: Fundamentals of electrochemical processes		
1	**L 1.** Lecture 1. Principles of electrochemical measurements, apparatus, and definitions	1	0
	PC 1. Seminar 1. Types of electrochemical equipment and introduction to Nova 1.11 Software interface	2	0
2	**L 2.** Lecture 2. Fundamentals of processes occurring in the electrode/solution interface. A charge transfer	1	0
	PC 2. Seminar 2. The thermodynamics of electrode processes. Solving the problems.	2	10
3	**L 3.** Lecture 3. Fundamentals of mass transfer in electrochemical reactions	1	0
	PC 3. Seminar 3. Potentiostatic current transients of reversible systems. Processing the results of chronoamperometric measurements in the Nova 1.11 Software.	2	10
	IWST 1: Resolving problems of IWS 1 and IWS 2, time 30 min.		
4	**L 4.** Lecture 4. Introduction to the kinetics of electrochemical reactions, the slow-discharge theory	1	0
	PC 4. Seminar 4. Linear sweep voltammograms (LSV) of reversible systems. Processing the results of LSV measurements in the Nova 1.11 Software.	2	10
5	**L 5.** Lecture 5. Mechanism of the electrochemical reactions	1	0
	PC 5. Seminar 5. Chronoamperometric study of electrochemical discharge of metal complexes. Processing the chrono-amperometric data in the Nova 1.11 Software.	2	10
	MODULE 2: Fundamentals of basic electrochemical methods		

6	**L 6.** Lecture 6. Basic concepts of potentiostatic measurement	1	0
	PC 6. Seminar 6. Using the fast-chrono method in studying the reaction kinetics. Processing the fast-chronoamperometry data in the Nova 1.11 Software.	2	10
7	**L 7.** Lecture 7. Potentiostatic current transients of a new-phase formation	1	0
	PC 7. Seminar 7. The determination of the mechanism of electrochemical nucleation. Data processing in the Nova 1.11 Software.	2	10
	IWS 1. Data Processing and Interpretation. (Processing the potentiostatic current transients of metal electrodeposition). A report.		**40**
	IWST 2: Resolving problems of IWS 1 (Processing the potentiostatic current transients of metal electrodeposition)		
Midterm control 1			**100**
8	**L 8.** Lecture 8. Fundamentals of the polarization methods. Potential sweep methods.	1	0
	PC 8. Seminar 8. Using the cyclic voltammetry (CV) in the studying of electrochemical processes.	2	10
	IWST 3. Individual project. Prepare a report of 3 pages also containing an analysis of the experimental current transients. Send the report to Professor.		
9	**L 9.** Lecture 9. Methods involving forced convection-hydrodynamic methods.	1	0
	PC 9. Seminar 9. Electrochemistry of rotating disc electrode. Discussing an article DOI: https://doi.org/10.1016/j.jelechem.2019.04.078	2	10
10	**L 10.** Lecture 10. Electrochemistry of micro-disk electrode. Limiting stage of electrochemical reaction.	1	0
	PC 10. Seminar 10. Processing an experimental CV and LSV data obtained using micro-disk electrode in the Nova 1.11 Software.	2	10
	MODULE 3: Advanced state-of-the-art electrochemical research methods		
11	**L 11.** Lecture 11. Techniques based on concepts of impedance	1	0
	PC 11. Seminar 11. The Nyquist plots of the metal ion electroreduction, electrochemical reactions coupled with chemical step. Discussing an article DOI: https://doi.org/10.1134/S1023193518120042	2	10
	IWST 4. Consultation on the implementation of IWS 2		
12	**L12.** Lecture 12. The impedance of complex electrochemical systems. Benefits of electrochemical impedance spectroscopy (EIS).	1	0
	PC 12. Seminar 12. Application of EIS in battery and electrochemical sensor research. Discussing of articles DOI: https://doi.org/10.1007/s10008-023-05742-0 and https://doi.org/10.1007/s12678-024-00914-6	2	10
	IWST 5 Consultation on the implementation of IWS 2		
13	**L 13.** Lecture 13. Basics of electrochemical quartz crystal microbalance method.	1	0
	PC 13. Seminar 13. In-situ studying of mass change of electrochemical reaction. Discussion an article DOI: https://doi.org/10.18321/ectj885	2	10
	IWST 6. Discussion about the submitting of IWS 2.		
14	**L 14.** Lecture 14. Electrochemical On-line ICP-MS in electrocatalysis research	1	0
	PC 14. Seminar 14. Application of the electrochemical online ICP-MS method in studying the stability of materials. Discussing an article DOI: https://doi.org/10.1002/tcr.201800162	2	10
15	**L 15.** Lecture 15. Fundamentals of modeling electrochemical processes.	1	0
	PC 15. Seminar 15. Modeling the corrosion of steel in carbon dioxide environment. Discussion an article DOI: https://doi.org/10.18321/ectj991	2	0
	IWS 2. Processing the data of RDE, EIS, EQCM methods).		**30**
	IWST 7. Workshop and discussion about the IWS 2		
Midterm control 2			**100**
Final control (exam)			**100**
TOTAL for course			**300**

RUBRICATOR OF THE SUMMATIVE ASSESSMENT
CRITERIA EVALUATION OF LEARNING OUTCOMES

Criterion	"Excellent" 20-25%	"Good" 15-20%	"Satisfactory" 10-15%	"Unsatisfactory" 0-10%
Solving Electrochemical Problems (IWS 1 & IWS 2)	Demonstrates a deep understanding of electrochemical equations and problem-solving techniques. Applies theoretical	Demonstrates good understanding and applies correct methods, with minor calculation errors.	Shows a basic understanding with occasional mistakes in calculations or interpretation.	Lacks understanding of fundamental concepts and makes multiple errors in problem-solving.

	knowledge to real-world scenarios with accuracy.			
Data Processing and Interpretation (IWS 1)	Processes experimental data effectively, using correct software tools (e.g., Nova 1.11). Provides accurate analysis and meaningful conclusions.	Uses appropriate tools with minimal errors in data interpretation. Some conclusions could be improved.	Demonstrates limited ability to analyze data; misinterprets key aspects but attempts to provide insights.	Fails to process or interpret experimental data correctly; lacks effort in analysis.
Critical Review of Scientific Literature (IWS 1)	Critically evaluates research articles, demonstrating strong comprehension and synthesis of key findings. Draws relevant comparisons between techniques.	Provides a thorough review with logical reasoning but lacks depth in comparisons.	Shows basic understanding of articles but lacks critical insights and synthesis.	Superficial or incorrect understanding of scientific literature; lacks coherence in discussion.
Experimental Design and Practical Application (IWS 2)	Designs a well-structured experimental plan, explaining methodology clearly. Provides an in-depth discussion of expected results and limitations.	Outlines a sound experimental approach with reasonable justifications. Some aspects lack clarity.	Provides a basic experimental design but misses key details or rationale.	Experimental plan is vague, incomplete, or incorrect, showing little understanding.
Comprehensive Understanding of Electrochemical Techniques (Additional Criterion)	Demonstrates mastery of electrochemical techniques such as CV, EIS, and EQCM. Explains their application to specific research areas.	Understands major electrochemical techniques but struggles with advanced applications.	Has a basic grasp of electrochemical methods but cannot fully explain their applications.	Lacks understanding of core electrochemical techniques and their relevance.

Dean _____ A.K. Galeyeva

Chair of the Academic Committee on the Quality of Teaching and Learning _____ Bektemisova A.

Head of Department _____ A.M. Argimbayeva

Lecturer _____ K. Avchukir