**SYLLABUS**

**Fall semester 2023-2024 academic year**

**Educational program "Electrochemical transducers of energy"**

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| **ID** **and name** **of course** | **Independent work** **of the student****(IWM)** | **Number of credits** | **General****number** **of credits** | **Independent work** **of the student****under the guidance** **of a teacher (IWMT)** |
| **Lectures (L)** | **Practical classes (PC)** | **Lab. classes (LC)** |
| **ID 1474814,****Electrochemical transducers of energy** | 3 | 15 | 30 | - | 7,5 | 5 |
| **ACADEMIC INFORMATION ABOUT THE COURSE** |
| **Learning Format** | **Cycle,****component** | **Lecture** **types** | **Types** **of practical classes** | **Form and platform final control** |
| *Offline* |  | Problematic, analytical, educational | Problem-solving | Exam (project)СДО Moodle |
| **Lecturer - (s)** | PhD Malchik Fyodor |
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| **Phone :** | +77072442236 |
| **Assistant - (s)** |  |
| **e-mail :** |  |
| **Phone :** |  |
| **ACADEMIC COURSE PRESENTATION** |
| **Purpose****of the course** | **Expected Learning Outcomes (LO) \***  | **Indicators of LO achievement (ID)** |
| to form the ability to think and design products/processes/apparatus within the framework of the course about battery technology and battery components chemical and physical-chemical engineering. | 1. Understand the world's demand for electrical energy resources. Estimate and know the world's energy problem and ways to solve it.
 | * 1. Ability to estimate energy demand in different countries.
 |
| 1.2 Understand the trajectory of the development of energy resources. Classify energy converter system. |
| 2. Systematize and explain the types of electrochemical energy converters. | 2.1 Classify the difference between batteries supercapacitors and fuel cells.  |
| 2.2 Understand the pros and cons of different electrochemical energy converters. |
| 3. Classify the characteristics of electrochemical energy converters. Understand the methods of their calculation and evaluation. | 3.1 Understand the difference between power and energy densities.  |
| 3.1 Describes and explains the main approaches of calculation and evaluation of characteristics of electrochemical energy converters |
| 4. Systematize the main components of the electrochemical energy device. Define the chemical stability of components in different electrolyte environments (organic and water-based electrolytes). | 4.1 Distinguish components of the electrochemical energy device and the ability to select them for certain systems. |
| 4.2 Understand the necessity of chemical/electrochemical stability of all components as the main factor for material selection. |
| 5. To be able to implement Electrochemical characterization methods for batteries (cyclic voltammetry, impedance spectroscopy chronopotentiometry). Undersend and know the basics of these methods. | 5.1 Explains the main features of applicability cyclic voltammetry, impedance spectroscopy chronopotentiometry methods. |
| 5.2 Explains and understands the main features of diffusion coefficient calculation using the cyclic voltammetry method and Randles-Sevcik equation.  |
| 6. Understand the working principles of Li-ion batteries. Estimate the market of Li-ion batteries. | 6.1 Understand the difference between the intercalation mechanism (in Li-ion batteries) and bulk Red/Ox reaction (like in lead acid batteries) |
| 6.2 Explains the main features and working principles of Li-ion batteries. |
| **Prerequisites** | Undergraduate studies in Chemistry or Chemical Engineering are of benefit |
| **Postrequisites** | Execution of the final thesis. |
| **Learning Resources** | **Literature:** main, additional. 1. Modern Battery Engineering A Comprehensive Introduction // Kai Peter Birke (Editor), 2019, World Scientific Publishing Co. Pte. Ltd., P. 281
2. Thomas Wenzel «Electrochemical Methods of Analysis» <https://asdlib.org/activelearningmaterials/files/2015/08/electrochemical_text.pdf>
3. Cheng, F, “Functional Materials for Rechargeable Batteries”, Advanced Materials, 2011, 23, 1695-1715.
4. Kim, H. et al. Aqueous rechargeable Li and Na ion batteries. Chem. Rev. 114, 11788–11827 (2014).
5. Yang, Z. et al. Electrochemical energy storage for green grid. Chem. Rev. 111, 3577–3613 (2011).
6. Kar, K. K. Handbook Materials I Supercapacitor of Nanocomposite. Springer Series in Materials Science vol. 300 (2020).
7. Administration, U. S. E. I. International Energy Outlook 2019 with projections to 2050. Choice Rev. Online 85 (2019) doi:10.5860/CHOICE.44-3624.
8. Abdel Maksoud, M. I. A. et al. Advanced materials and technologies for supercapacitors used in energy conversion and storage: a review. Environmental Chemistry Letters vol. 19 (Springer International Publishing, 2021).
9. May, G. J., Davidson, A. & Monahov, B. Lead batteries for utility energy storage: A review. J. Energy Storage 15, 145–157 (2018).
10. Dubal, D. P., Ayyad, O., Ruiz, V. & Gómez-Romero, P. Hybrid energy storage: The merging of battery and supercapacitor chemistries. Chem. Soc. Rev. 44, 1777–1790 (2015).
11. Li, P. et al. Rechargeable Micro‐Batteries for Wearable and Implantable Applications. Small Struct. 3, 2200058 (2022).

**Research infrastructure**1. The lectures will be carried out in 401 room at the center of physical-chemical methods of research and analysis. The practical work, IMS and IMST will be in 212 room in the laboratory Electrochemical productions**Professional scientific databases**1. https://www.scopus.com/search/form.uri?display=basic#basic**Internet resources** 1. [https://www.youtube.com/@echemchannel9316/videos](https://www.youtube.com/%40echemchannel9316/videos)
2. <https://asdlib.org/activelearningmaterials/files/2015/08/electrochemical_text.pdf>
3. <http://chemistry-chemists.com/Uchebniki/Chemistry-books-UnChem.html>
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| **Academic****course policy** | The academic policy of the course is determined by [the Academic Policy](https://univer.kaznu.kz/Content/instructions/%D0%90%D0%BA%D0%B0%D0%B4%D0%B5%D0%BC%D0%B8%D1%87%D0%B5%D1%81%D0%BA%D0%B0%D1%8F%20%D0%BF%D0%BE%D0%BB%D0%B8%D1%82%D0%B8%D0%BA%D0%B0.pdf) and [the Policy of Academic Integrity of Al-Farabi Kazakh National University .](https://univer.kaznu.kz/Content/instructions/%D0%9F%D0%BE%D0%BB%D0%B8%D1%82%D0%B8%D0%BA%D0%B0%20%D0%B0%D0%BA%D0%B0%D0%B4%D0%B5%D0%BC%D0%B8%D1%87%D0%B5%D1%81%D0%BA%D0%BE%D0%B9%20%D1%87%D0%B5%D1%81%D1%82%D0%BD%D0%BE%D1%81%D1%82%D0%B8.pdf) Documents are available on the main page of IS Univer .**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 IMST, IMS, which are reflected in the syllabus and are responsible for the relevance of the topics of training sessions andassignments.**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.**Аcademic honesty.** Practical/laboratory classes, IMS 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.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"](https://univer.kaznu.kz/Content/instructions/%D0%9F%D1%80%D0%B0%D0%B2%D0%B8%D0%BB%D0%B0%20%D0%BF%D1%80%D0%BE%D0%B2%D0%B5%D0%B4%D0%B5%D0%BD%D0%B8%D1%8F%20%D0%B8%D1%82%D0%BE%D0%B3%D0%BE%D0%B2%D0%BE%D0%B3%D0%BE%20%D0%BA%D0%BE%D0%BD%D1%82%D1%80%D0%BE%D0%BB%D1%8F%20%D0%9B%D0%AD%D0%A1%202022-2023%20%D1%83%D1%87%D0%B3%D0%BE%D0%B4%20%D1%80%D1%83%D1%81%D1%8F%D0%B7%D1%8B%D0%BA%D0%B5.pdf) , ["Instructions for the final control of the autumn / spring semester of the current academic year"](https://univer.kaznu.kz/Content/instructions/%D0%98%D0%BD%D1%81%D1%82%D1%80%D1%83%D0%BA%D1%86%D0%B8%D1%8F%20%D0%B4%D0%BB%D1%8F%20%D0%B8%D1%82%D0%BE%D0%B3%D0%BE%D0%B2%D0%BE%D0%B3%D0%BE%20%D0%BA%D0%BE%D0%BD%D1%82%D1%80%D0%BE%D0%BB%D1%8F%20%D0%B2%D0%B5%D1%81%D0%B5%D0%BD%D0%BD%D0%B5%D0%B3%D0%BE%20%D1%81%D0%B5%D0%BC%D0%B5%D1%81%D1%82%D1%80%D0%B0%202022-2023.pdf) , "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 counseling assistance by phone +77072442236/ e- mail Frodo-007@mail.ru or via video link in MS.**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** | **Assessment Methods** |
| **Grade** | **Digital****equivalent****points** | **points,****% content** | **Assessment according to the traditional system** | **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 IMS. 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. |
| A | 4.0 \_ | 95-100 | Great |
| A- | 3.67 | 90-94 |
| B+ | 3.33 | 85-89 | Fine |
| B | 3.0 | 80-84 | **Formative and summative assessment** | **Points % content** |
| B- | 2.67 | 75-79 | Activity at lectures | 5 |
| C+ | 2.33 | 70-74 | Work in practical classes | 20 |
| C | 2.0 | 65-69 | Satisfactorily | Independent work | 25 |
| C- | 1.67 | 60-64 | Design and creative activity | 10 |
| D+ | 1.33 | 55-59 | Final control (exam) | 40 |
| D | 1.0 | 50-54 | TOTAL | 100 |
| FX | 0.5 | 25-49 | Unsatisfactory |
| F | 0 | 0-24 |
| **Calendar (schedule) for the implementation of the content of the course. Methods of teaching and learning.** |

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| **A week** | **Topic name** | **Number of hours** | **Max.****ball** |
| **MODULE 1** **The need for electrochemical systems (electrochemical energy converters) and the theoretical basis of their functioning** |
| **1** | **L 1. The world energy problem and ways to solve it** | **1** | **4** |
| **Seminar 1. Need for energy production and storage** | 1 | 4 |
| **Seminar 2. Energy as a universal equivalent and basis for development** | 1 | 4 |
| **2** | **L 2. Energy resources and the trajectory of their development** | 1 | 4 |
| **Seminar 3. Physical methods of accumulation** | 1 | 4 |
| **Seminar 4. Components of electrochemical energy converters** | 1 | 4 |
| **3** | **L 3. Energy conversion as the basis of energy** | **1** | **4** |
| **Seminar 5. Analysis of the design of current sources** | 1 | 4 |
| **Seminar 6. Basic schemes of electrochemical energy converters** | 1 | 4 |
| **IMST 1. Consultations on the implementation of IMST 1** | **1** | 2 |
| **4** | **L 4. Characteristics of batteries** | **1** | **4** |
| **Seminar 7. Potential, resistance and energy densities** | 1 | 4 |
| **Seminar 8. Current, capacity, the power densities** | 1 | 4 |
|  | **IMS 1. Electrochemical methodology for battery evaluation** | 1 | 10 |
| **5** | **L 5. Thermodynamics of electrochemical transformation and kinetic barriers to its path** | **1** | **4** |
| **Seminar 9. Types of charge storage mechanisms** | 1 | 4 |
| **Seminar 10. Difference between batteries and capacitors/supercapacitors.** | 1 | 4 |
| **MODULE 2 Title Types of electrochemical systems for practice application** |
| **6** | **L 6. Batteries and their varieties based on high-energy electrochemical systems** | **1** | **4** |
| **Seminar 11. Intercalation type systems** | 1 | **4** |
| **Seminar 12. Charge/discharge curve characterization** | 1 | **4** |
| **IMST 2. Consultations on the implementation of IMS 2**  | 1 | **2** |
| **7** | **L 7. Rechargeable and non-rechargeable batteries** | **1** | **4** |
| **Seminar 13. New generation of metal Ion batteries** | **1** | **4** |
| **Seminar 14. Electrochemical reaction reversibility** | **1** | **4** |
| **Midterm control 1** | **100** |
| **8** | **L 8. Lead acid batteries** | **1** | **3** |
| **Seminar 15. Charge/discharge characterization of lead acid batteries** | **1** | **3** |
| **Seminar 16. Drawbacks of lead acid batteries** | **1** | **3** |
| **IMS 2. Practical work with battery charge/discharge evolution using AAA battery type. Repor** | **1** | **7** |
| **9** | **L 9. Capacitors and supercapacitors** | **1** | **3** |
| **Seminar 17. Difference between batteries and supercups** | **1** | **3** |
| **Seminar 18. Charge/discharge characterization of supercapacitors** | **1** | **4** |
| **IMST 2.** | **1** | **3** |
| **10** | **L 10. Fuel cells – types and application** | **1** | **4** |
| **Seminar 19. Drawbacks of fuel cells** | **1** | **3** |
| **Seminar 20. Calculation of energy and power densities.** | **1** | **3** |
| **IMST 4. Disassembling of standard AAA battery to investigate its composition.** | **1** | **1** |
| **MODULE 3 Electrochemical characterization of batteries** |
| **11** | **L 11. Calculation of energy and power densities.** | **1** | **3** |
| **Seminar 21. Main electrochemical characterization techniques** | **1** | **4** |
| **Seminar 22. Main physical-chemical characterization techniques of battery components. characterization techniques** | **1** | **4** |
| **IMST 5. Consultations on the implementation of IMS 3**  | **1** | **1** |
| **12** | **L12. Cyclic voltammetry (CV) as battery characterization techniques.** | **1** | **4** |
| **Seminar 23. Characterization CV curves for batteries and supercapacitors** | **1** | **3** |
| **Seminar 24. Electrode material and membrane characterization by CV** | **1** | **3** |
| **13** | **L 13. Chronopotentiometry** | **1** | **3** |
| **Seminar 25. Charge discharge rate (C-rate)** | **1** | **3** |
| **Seminar 26. Potentiostat/galvanostat system for CV and chronopotentiometry measurements**  | **1** | **4** |
| **IMS 3. Coin cell assembling. Report preparation** | **1** | **7** |
| **14** | **L 14. Battery resistance and methods of its determination** | **1** | **3** |
| **Seminar 27. Electrochemical impedance spectroscopy** | **1** | **4** |
| **Seminar 28. Tasks for EIS** | **1** | **3** |
| **15** | **L 15. Lithium-ion battery** | **1** | **4** |
| **Seminar 29. Market of Li-ion batteries** | **1** | **3** |
| **Seminar 30. Micro battery application** | **1** | **4** |
| **IMST 6. Exam task preparation and discussion**  | **1** | **0** |
| **Midterm control 2** | **100** |
| **Final control (exam)** | **100** |
| **TOTAL for course** | **100** |

**Dean \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Head of Department \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Lecturer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**RUBRICATOR OF THE SUMMATIVE ASSESSMENT**

**CRITERIA EVALUATION OF LEARNING OUTCOMES**

**. Written assignment "Electrochemical methodology for battery evaluation" (25% of 100% MC)**

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| --- | --- | --- | --- | --- |
| **Criterion**  | **"Excellent"**20-25% | **"Good"**15-20% | **"Satisfactory"**10-15% | **"Unsatisfactory"**0-10% |
| **Understanding Theories** **and concepts of professional identity and professionalism of a teacher**   | Full methodology for one of the electroanalytical methods for 6-8 pages. Fully described issues for determination of given electroactive component. Presence of an introduction part with a background of the given electroanalytical method. The main body must be supplied by adequate graphs/tables/illustrations. Adequate references should be given..  | Written short methodology for one of the electroanalytical methods for 5-6 pages. Fully described issues for determination of given electroactive component. Presence of an introduction part with a background of the given electroanalytical method. The main body must be supplied by adequate graphs/tables/illustrations. | Written short methodology for one of the electroanalytical methods for 3-4 pages. Fully described issues for determination of given electroactive component. Presence of an introduction part with a background of the given electroanalytical method. | Existed replica on the methodology for one of the electroanalytical methods (potentiometry, coulometry, impedance cyclic voltammetry) for some electroactive material. |
| Clearness of the methodology and given suggestions | A comparison between other physical/chemical methods of analysis with the given electroanalytical method for determination of some electroactive component should be discovered.  | Presence of an introduction part with a background of the given electroanalytical method. | Limited connection of the concepts of between existed methodology  | There is little or no connection between the existed methodology  |
| **Scientific stile and English grammar** | The methodology must be written in Scientific style following appropriate English grammar and scientifically meaningful | The letter demonstrates clarity, conciseness and correctness. Basically follows the APA style.  | The letter has some key errors and clarity needs to be improved. There are mistakes in following the APA style.  | The writing is unclear, it is difficult to follow the content. Lots of mistakes in following the APA style.  |