National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

Electrochemical production technology department

Electrochemical Methods in Materials Science

Work program of the educational component (Syllabus)

Details of the educational component	
Level of higher education	***Second (Master)***
Field of knowledge	*G Chemical and bioengineering*
Specialty	*G1 Chemical technologies and engineering*
Educational program	*Chemical technologies of inorganic, electrode materials and water purification*
The status of the educational component	*Selective*
Form of education	*Full-time*
Year of education, semester	*1st year, spring semester*
The scope of the educational component	*4 credits ECTS / 120 hours (16 hours lectures; 28 hours laboratory works)*
Semester control/ control measures	*Assessment / modular control work / home test*
Class schedule	*Lectures 1 hour per week (1 pair once every 2 weeks); laboratory classes 2 hours per week (2 pairs once every 2 weeks)*
Language	*English*
Information about head of the course / teachers	Lecturer: Dr, professor Georgii Vasyliev, g.vasyliev@kpi.ua
Placement of the course	*Electronic campus*

Educational component program

1. 1. Description of the educational component, its purpose, subject of study and learning outcomes

In the modern world, there is a constant development of new materials with unique properties that allow them to be used in various fields, such as energy, medicine, transport, electronics, and others. The study of modern research methods allows us to understand the structure, properties and behaviour of these materials, which is important for their rational use and the development of new technologies.

The purpose of the educational component is the formation of the acquirers of competences:

- *Ability to generate new ideas (creativity) (ZK1);*
- *The ability to evaluate and adapt the learned scientific methods and methods of activity to the conditions of sustainable development. (ZK4);*

Professional competencies of the specialty:

- *Ability to use modern special scientific equipment and software when conducting experimental research and carrying out research and development in the field of chemical technologies and engineering (FK4);*
- *Ability to use modern research methods, conduct scientific experiments and solve actual technical problems in the field of chemical technologies and engineering (FC7);*
- *Ability to plan and carry out scientific research in the field of chemical engineering (FC8).*

Graduates of higher education at the master's level after mastering the educational component " Electrochemical Methods in Materials Science " must demonstrate knowledge of:

- Appling advanced knowledge of modern concepts, practices and methods for improving existing materials and functional coatings to determine and predict key parameters and properties of new materials and functional coatings, in laboratory or production conditions (PRN8).

- Knowledge of modern research methods, devices and equipment, software in the field of chemical technologies and engineering (PRN9).

- To be able to apply methods and approaches of advanced research in the field of chemical technologies and engineering (PRN12)

in particular knowledge of:

- understanding the nature of redox processes.

- determination of systems that can be studied by electrochemical methods.

- planning, performing and processing the results of electrochemical research.

- work on modern equipment for electrochemical research.

2. Pre-requisites and post-requisites of the educational component (place in the structural and logical scheme of training according to the relevant educational program)

The prerequisites for studying the educational component are the educational components of the first (bachelor's) level of training.

Post-requisites:	
Scientific work on the topic of the master's thesis. Part 2. Scientific work on the topic of the master's thesis, *Research practice,* *Execution of a master's thesis*	*PER1. Critically interpret scientific concepts and modern theories of chemical processes and chemical engineering, apply them in conducting scientific research and creating innovations.* *PER2. Search for the necessary information on chemical technology, processes and equipment for the production of chemical substances and materials based on them, systematize, analyse and evaluate the relevant information.* *PER3. Organize your work and the work of the team in the conditions of industrial production, design units, research laboratories, determine goals and effective ways to achieve them, motivate and train personnel.* *PER4. To evaluate the technical and economic characteristics of the results of scientific research, research and development, technologies and equipment of chemical industries.* *PER5. Communicate freely in national and foreign languages orally and in writing to discuss and present the results of professional activities, research and projects.* *PER6. Develop and implement projects in the field of chemical technologies and related interdisciplinary projects considering social, economic, environmental and legal aspects.* *PER7. Search for the necessary information in scientific and technical literature, patents, databases, and other sources on chemical technology, processes and equipment to produce chemical substances and materials based on them, systematize, and analyse and evaluate the relevant information.* *PER8. Apply advanced knowledge of modern concepts, practices and methods for improving existing materials and functional coatings to determine*

	and predict key parameters and properties of new materials and functional coatings, in laboratory or production settings. *PER9. Knowledge of modern research methods, devices and equipment, software in the field of chemical technologies and engineering.* *PER10. Plan and carry out experimental and theoretical research in the field of chemical technologies and engineering, formulate and test hypotheses, argue conclusions, present research results.* *PER11. Develop and teach special disciplines in chemical technologies and engineering in institutions of higher education.* *PER12. Be able to apply methods and approaches of advanced research in the field of chemical technologies and engineering.* *PER13. Solve problems in the field of chemical technology and engineering using both standard approaches and own original methods.*

3. 3. Content of the educational component

CHAPTER 1. Subject and content of the course
Topic 1.1. Introduction to the course
1.1.1. The main purpose, tasks and general content of the course. Structure and grid of hours. Control tasks, terms and requirements for the quality of their execution.
1.1.2. The value of the course in the master's training system.

CHAPTER 2. Fundamentals of electrochemistry
Topic 2.1. Structure of electrolytes, phase separation boundaries under equilibrium conditions
2.1.1. Ions and dissociation.
2.1.2. Double electric layer.
2.1.3. Electrode potential, Nernst equation.
2.1.4. Structure of electrodes.

Topic 2.2. Passage of current through the electrolyte, interphase boundary
2.2.1. Current transfer in solution.
2.2.2. Current transfer across the interphase boundary.
2.2.3. Faraday's laws.
2.2.4. Electrochemical cell.
2.2.5. Devices for static polarization.

Topic 2.3. Electrochemical kinetics
2.3.1. Staging of electrode processes.
2.3.2. Transport, chemical, electrochemical restrictions.
2.3.3. Devices for dynamic polarization.

CHAPTER 3. Electrochemical research methods
Topic 3.1. Electrochemical methods using static polarization
3.1.1. Potentiometry.
3.1.2. Potentiostatic polarization.
3.1.3. Galvanostatic polarization.

Topic 3.2. Electrochemical methods using dynamic polarization

3.2.1. Direct potentiostatic polarization.
3.2.2. Cyclic polarization.
3.2.3. Determination of the window of electrochemical stability.
3.2.4. Determination of electrochemical activity.

Topic 3.3. Electrochemical methods using alternating current polarization
3.3.1. Electrochemical impedance method.
3.3.2. Analysis of electrical conductivity of systems.

Topic 3.4. Electrochemical methods of research of chemical current sources
3.4.1. Charge/discharge curves.
3.4.2. Determination of capacity and power of current sources.

Topic 3.5. Electrochemical methods of corrosion resistance research
3.5.1. Determination of corrosion potential.
3.5.2. Determination of corrosion current.
3.5.3. Determination of the rate of corrosion in various corrosion systems.

Topic 3.6. Polarography
3.6.1. Analysis of the composition of solutions by the method of polarography.

4. Educational materials and resources

The educational materials listed below are available in the university library and in the library of the Department of Electrochemical Production Technology. Basic literature is mandatory for study, other materials are optional. Sections and topics with which student must familiarize oneself, the teacher notes in lectures.

BASIC:

1. *Plieth, W., 2008. Electrochemistry for materials science. Elsevier.*
2. *Scholz F. Electroanalytical Methods Guide to Experiments and Applications / Fritz Scholz. – Berlin: Springer-Verlag, 2010. – 366 c. – (Springer). – (Second, Revised and Extended Edition).*
3. *Bard A. Electrochemical methods. Fundamentals and Applications / A. Bard, L. Faulkner. – New York: John Wiley & Sons, Inc, 2001. – 850 c. – (Wiley). – (Second Edition).*

Educational content

5. Methods of learning the educational component

Lecture classes

Lectures are conducted in parallel with consideration of issues submitted for self-education work. During lectures, video conferencing tools (Google Meet, Zoom, etc.) and illustrative material in the form of presentations are used, which are placed on the Sikorsky-distance platform. After each lecture, it is recommended to familiarize yourself with the materials recommended for independent study, and before the next lecture, repeat the material of the previous one.

№	***Date***	*The name of the topic of the lecture and a list of main questions*
1	*1 week*	*Introduction to the course* *The main purpose, tasks and general content of the course. Structure and grid of hours. Control tasks, terms and requirements for the quality of their execution. The value of the course in the master's training system.* *Structure of electrolytes, phase separation boundaries under equilibrium conditions*

		Ions, dissociation, electrical conductivity, PES, electrode potential, structure of electrodes
2	*3 week*	*Passage of current through the electrolyte, interphase boundary* *Transfer of current in solution, through the interphase boundary, Faraday's laws, electrochemical cell, devices for static polarization*
3	*5 week*	*Electrochemical kinetics* *Phases of electrode processes, transport, chemical, electrochemical limitations, devices for dynamic polarization*
4	*7 week*	*Electrochemical methods that use static polarization* *Potentiometry, potentiostatic, galvanostatic polarization. Charge/discharge curves, determination of capacity and power of current sources*
5	*9 week*	*Electrochemical methods that use dynamic polarization* *Direct potentiostatic polarization, cyclic polarization, determination of the window of electrochemical stability, electrochemical activity*
6	*11 week*	*Electrochemical methods using alternating current polarization* *Electrochemical impedance method, analysis of electrical conductivity of systems*
7	*13 week*	*Electrochemical methods of corrosion resistance research* *Determination of corrosion potential, corrosion current, corrosion rate in various corrosion systems*
8	*15 week*	*Polarography* *Analysis of the composition of solutions by the method of polarography.*

Laboratory classes

The main tasks of the cycle of laboratory classes are the use of knowledge gained at lectures, familiarization with the technical implementation of processes known from the lecture course, and consolidation of theoretical material.

№	*The name of the laboratory work*	*Description of planned work*	*Number of aud. hours*
0	*Introductory lesson*	*Introductory briefing on the rules of staying in the laboratory and safety techniques*	*2*
1	*Determination of electrode potentials*	*Measurement of electrode potentials and verification of the validity limits of the Nernst equation*	*4*
2	*Chemical effect of electric current*	*Experimental verification of Faraday's law and determination of the current output of electrochemical processes*	*6*
3	*Establishing the nature of the limiting stage of the electrochemical process*	*Determining the current-voltage characteristics of electrochemical processes and determining the nature of the limiting stage*	*6*
4	*Determination of electrical conductivity*	*Investigation of the system by the electrochemical impedance method and determination of resistance components: ohmic and polarization components*	*6*
5	*Determining the kinetics of scale formation by the chronoamperometry method*	*Study of the process of deposition of calcium carbonate on the metal surface during cathodic polarization*	*6*

6	*Determination of metal corrosion rate*	*Application of electrochemical methods to determine the rate of corrosion of metals that corrode by different mechanisms: uniform, local corrosion.*	*6*

6. Self-studying

Self-studying during the semester includes repetition of lecture material, calculations and preparation of laboratory work reports; performance of calculation work. The recommended number of hours allocated to preparation for the specified types of work::

Type of self-studying	*Number of hours*
Preparation for classroom classes: repetition of lecture material, calculations and preparation of laboratory work reports.	*4 hours per week x 15 weeks = 45 hours.*
Performing homework control work	*19 hours*
Preparation for the test	*12 hours*

Policy and control

7. The policy of the educational component

In the normal mode of work of the university, lectures and laboratory classes are held in classrooms. In a mixed mode, lecture and laboratory classes are conducted through the Sikorsky distance learning platform. In remote mode, all classes are conducted through the Sikorsky distance learning platform. Attending lectures and laboratory classes is mandatory.

Rules for assigning incentive and penalty points

- *Incentive points can be awarded by the teacher exclusively for the performance of creative works from the educational component or additional completion of online specialized courses with the receipt of the appropriate certificate. Their sum cannot exceed 25% of the rating scale.*
- *Penalty points are not provided for within the educational component.*

The policy of deadlines and rescheduling: determined by clause 8 of the Regulation on current, calendar and semester control of study results at Igor Sikorsky KPI.

Academic Integrity Policy: Determined by the Academic Integrity Policy and other provisions of the University's Honor Code.

8. Types of control and rating system for evaluating learning outcomes

Current control: performance of modular control work, home control work, performance and protection of laboratory work.

A rating system for evaluating learning outcomes

Student rating the credit module is calculated based on a 100-point scale. A student's rating must be at least 60 points to receive a credit. The rating during the semester consists of points that the student receives for:

- *execution and defence of 6 laboratory works - in the usual, mixed and remote modes of work of the University.*
- *performing home control work.*

***Scoring criteria**:*

1. ***Laboratory work***

in regular, mixed and remote modes of university work

Weight score – 12 points. Points for laboratory work are calculated as the sum of points for the performance of individual stages of work - admission and actual performance (6 points), quality of the prepared protocol (2 point) and protection of work (4 points). A total of 6 works are performed.

Performing laboratory work (LW)

- *full implementation of LW tasks without comments from the teacher regarding unjustified deviation from methodical instructions or compliance with safety requirements - 6 points;*
- *failure to complete LR tasks in full within the allotted time in the presence of comments from the teacher regarding the faithfulness of the work or compliance with safety requirements - 0 points.*

Quality of protocol and defence of laboratory work

- *the presence of confident knowledge and acquired skills from the tasks of the completed LW; flawless execution of the protocol and other materials - 6 points (at least 90% of the required information);*
- *not quite complete mastery of knowledge and skills as a result of the implementation of LW; comments on the completeness and quality of the protocol - 4-5 points (at least 75% of the required information);*
- *the presence of significant comments regarding completeness, literacy and neatness when preparing materials from the completed LW – 1-3 point (at least 60% of the required information);*
- *significant comments regarding the completeness and design of the protocol; inability to give an answer on the work performed - 0 points.*

2. ***Home test work***

in normal, mixed and remote modes of work of the University, it is carried out in electronic form, after verification, a printed version is issued.

The task is issued on the 14th week, it is necessary to pass it on the 18th week.

Weight score – 28 points. The points for the estimated work are calculated as the sum of the points for the performance of the work (14 points), the quality of the design (7 points) and the defence of the work (7 points).

Performance of work

- *performance of work tasks in full with no comments from the teacher regarding unjustified deviation from methodical instructions (at least 90% of the required information) - 14 points;*
- *incomplete performance of work tasks in the presence of comments from the teacher regarding unjustified deviation from methodical instructions (at least 60% of the required information) - 7 points.*
- *failure to complete the work tasks in full within the allotted time in the presence of comments from the teacher regarding the accuracy of the work (less than 60% of the required information) - 0 points.*

Quality of the protocol and defence of the work

- *the presence of reliable knowledge and acquired skills from the tasks of the completed work; flawless execution of the protocol and other materials - 14 points.*
- *incomplete mastery of knowledge and skills because of the implementation of the work; comments on the completeness and quality of the protocol - 10 points.*
- *the presence of significant comments regarding completeness, literacy and neatness when preparing materials from the completed work - 6 points.*

- significant comments regarding the completeness and design of the protocol; inability to give an answer on the work performed - 0 points.

Calendar control: conducted twice a semester as a monitoring of the current state of fulfilment of the syllabus requirements. A condition for receiving a positive grade from the calendar control is a student's rating of 50% of the maximum possible at the time of the calendar control. At the first calendar control (8th week), the student of higher education receives "attested" if his current rating is at least 10 points. At the second calendar control (14th week), the student of higher education receives " attested " if his current rating is at least 20 points.

3. Semester control: test.

In the test, persons who scored 60 or more points have the opportunity:

1) receive a passing grade in accordance with the obtained rating

2) to perform credit control work to increase the rating. In the case of receiving a grade higher than "automatically" from the rating, the student receives a grade based on the results of the credit test. In case of receiving a grade lower than "automatically" from the rating, the student receives a grade according to the previous rating.

Credit control work is performed in the form of a test on the g-suite platform. The test contains 20 questions, the weight of each question is 2 points. The grade for the performance of the credit work consists of the sum of the points scored for the correct answers.

The maximum number of points a student can earn during the semester is 100 points:

$$RC = r_{LW} + r_{HCW} = 72 + 28 = 100 \text{ points.}$$

The condition for admission to the credit is the enrolment of all laboratory work, the completion of the HCW and the number of rating points at least 60.

Table of correspondence of rating points to grades on the university scale:

Number of points	*Rating*
100-95	*Excellent*
94-85	*Very good*
84-75	*Good*
74-65	*Poor*
64-60	*Very poor*
Lower 60	*Fail*
Admission conditions not met	*Not admitted*

9. Additional information on the educational component

- *List of materials that are allowed to be used during the assessment - during the assessment, the student of higher education is prohibited from using any auxiliary materials and literature. Students who violate the requirements are removed from the course.*
- *• During the defence of laboratory works, the student has the right to use his own works to clarify the physical parameters of the processes.*

Working program of the educational component (syllabus):

Compiled by the professor of the Department of Electrochemical Production Technology, Dr. Georgii Vasyliev.

Approved by the Department of Electrochemical Production Technology (23.06.2025 protocol № 15)

Agreed by the Methodical Commission of the faculty (26.06.2025 protocol № 10)