**SYLLABUS**

**Fall semester 2022-2023 academic years**

**on the educational program “****6B07102 - Chemical Engineering”**

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| **Discipline’s code** | **Discipline’s title** | **Independent work of students (IWS)** | **Number of credits** | | | | | **Number of credits** | **Independent work of student with teacher (IWST)** |
| **Lectures (L)** | **Practical training (PT)** | | **Laboratory (Lab)** | |
| HKE 2302 | Chemical Kinetics and Electrochemistry | 82 | 1,5 | 1,5 | | 3 | | 6 | 8 |
| **Academic course information** | | | | | | | | | |
| **Form of education** | **Type of course** | **Types of lectures** | | | **Types of practical training** | | **Form of final control** | | |
| Full-time | Blended | Problematic,  review and analytical | | | To solve problems, carry out laboratory work | |
| Lecturer | Supiyeva Zhazira | | | | | | Written/offline | | |
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| **Aim of course** | **Expected Learning Outcomes (LO)\***  As a result of studying the discipline the undergraduate will be able to: | **Indicators of LO achievement (ID)**  (for each LO at least 2 indicators) |
| To form the  student's ability to  define the main  terms of chemical kinetics, electrochemistry to solve specific problems of physico-chemical processes. | 1. Explain the content of the basic rules and laws of chemical kinetics, catalysis and electrochemistry | 1.1. Learns terms and definitions of formal kinetics, electrochemistry and catalysis;  1.2. Formulates basic laws, rules and principles of chemical kinetics of simple and complex reactions, electrochemistry and catalysis;  1.3. Basic formulas describing kinetic and electrochemical laws and work;  1.4. Carries out classification of processes and their characteristics;  1.5. Describes kinetic and electrochemical parameters. |
| 2. Calculation of kinetic and electrochemical parameters of physico-chemical processes | 2.1. Determines the data needed to calculate the indicated kinetic and electrochemical process;  2.2. Select the equation and its type to calculate the indicated kinetic parameter and thermodynamic and kinetic characteristics of electrochemical reactions;  2.3. Chooses the most appropriate method (analytical, graphical) for calculating the indicated kinetic parameter;  2.4. Based on the choice of the method of calculating the indicated kinetic parameter;  2.5. Describes the main methods and parameters of Lewis and Debye-Hückel theory of strong electrolytes. |
| 3. Application of basic methods of determination of kinetic, thermodynamic and electrochemical parameters of chemical reactions | 3.1. Calculates the rate of chemical reactions, rate constant, activation energy;  3.2. To determine the order of the reaction, integral differential methods are used;  3.3. Using the predictions of Lewis and Debye-Hückel theory, he uses methods of calculating activity and activity coefficient;  3.4. Evaluates specific and equivalent electrical conductivity of electrolyte solutions;  3.5. Create diagrams of galvanic circuits and calculate parameters. |
| 4. Summary and analysis of experimental and theoretical calculation results | 4.1. Analyzes the effect of temperature on kinetic, thermodynamic and electrochemical characteristics;  4.2. Justifies the effect of catalyst on rate in homogeneous and heterogeneous catalysis;  4.3. Explains the reasons for the deviation of electrochemical characteristics in real and ideal solutions;  4.4. Formulates the main goal and conclusion of the theoretical or practical implementation of the student's own work;  4.5. Make a presentation on a practical or theoretical task, give a report. |
| 5. Carrying out a physical and chemical experiment independently (according to the prepared methodology), analyzing, explaining and drawing conclusions from the obtained results | 5.1. Understands the basic safety rules of work in a chemical laboratory;  5.2. Performs processing of experimental results and evaluates errors;  5.3. Determines the system / process parameter based on the measurement data of physical quantities;  5.4. Based on the obtained experimental data, the dependencies of the studied systems are drawn;  5.5. Analyzes and interprets experimental data based on knowledge of basic laws of kinetics and electrochemistry. |
| **Prerequisites** | Physics, maths, general and inorganic chemistry, Physical chemistry. | |
| **Post requisites** | Chemical physic, Colloidal chemistry, Kinetics of complex processes. | |
| **Information resources** | **Literature:**  1. Elements of Physical Chemistry: 6th Edition / P. Peter. Atkins. - Oxford: Oxford University Press, 2013. - 591 p.  2. Physical chemistry: a modern introduction: second Edition / updated and revised by W.M.Davis. - USA: CRC Press, 2012. - 501 p.  3. David W. Ball. Physical Chemistry. USA, Thomson Learning, 2011. 840 p.  4. Peter Atkins,Julio de Paula. Physical Chemistry, Eighth Edition. Oxford University Press, 2006. 1050 p.  5. Robert J. Silbey, Robert A. Alberty, Moungi G. Bawendi. Physical Chemistry. Hamilton Printing, 2005. 944 p.  6. Стромберг А.Г., Семченко Д.П. Физическая химия. М.: Высшая школа,-2003, 527 с.  7. Краснов Г.С., Воробьев Н.К., Годнев И.Н. и др. Физическая химия: в 2-х книгах. М.: Высш.школа, 1995. Кн.1,2.  8. Ira N. Levine. Physical Chemistry. Sixth Edition. New York: McGraw-Hill, 2009. 995 p.  9. Еремин В.В., Каргов С.И., Успенская И.А. и др. Задачи по физической химии. М.: Экзамен, 2005, 318 с.  **Internet resources:**  1. <http://elibrary.kaznu.kz/ru>  2. <https://www.coursera.org/learn/physical-chemistry>  3. <https://teach-in.ru/lecture/09-02-Korobov> | |

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| **Academic policy of the course in the context of university moral and ethical values** | **Academic Behavior Rules:**  All students are required to register for the MOOC. The deadlines for completing the modules of the online course must be strictly observed in accordance with the schedule for studying the discipline. Leave in case of current MOOC or SPOC courses.  **ATTENTION!** Failure to meet deadlines results in loss of points! The deadline for each task is indicated in the calendar (schedule) for the implementation of the content of the training course, as well as in the MOOC. Leave in case of current MOOC or SPOC courses.  **Academic values:**  - Practical trainings/laboratories, IWS should be independent, creative.  - Plagiarism, forgery, cheating at all stages of control are unacceptable.  - Students with disabilities can receive counseling at e-mail Supiyeva.Zhazira@kaznu.kz. |
| **Evaluation and attestation policy** | **Criteria-based evaluation:**  assessment of learning outcomes in relation to descriptors (verification of the formation of competencies in midterm control and exams).  **Summative evaluation:** assessment of work activity in an audience (at a webinar); assessment of the completed task. |

**CALENDAR (SCHEDULE) THE IMPLEMENTATION OF THE COURSE CONTENT:**

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| Week | Topic name | Number of hours | Max.  score |
| **Module 1**  **Chemical Kinetics** | | | |
| 1 | **Lec 1.** Basic concepts of chemical kinetics. The rate of chemical reaction, the effect of various factors on the rate. The main postulate of chemical kinetics. Average and instantaneous speeds. Rate constant, its physical value. Mechanism of chemical reaction, elementary stages, elementary action of chemical reaction. | 1 |  |
| 1 | **Sem 1.** Calculation of chemical reaction rates: average and instantaneous rates. | 1 | 5 |
| 1 | **Lab 1.** Introductory lesson. Safety rules when working in a chemical laboratory. The procedure for submitting laboratory work and providing its results. Elements of statistical processing of measurement results. | 4 | 5 |
| 2 | **Lec 2.** Kinetic analysis of simple irreversible reactions of the first, second, nth (with equal concentrations of reactants) and zero order. Half-life. A measure of the rate constant for various order reactions. | 1 |  |
| 2 | **Sem 2.** Calculation of rate constants of different order of chemical reaction and determination of half period. | 1 | 5 |
| 2 | **Lab 2.** The task of the theoretical part of the laboratory work No. 1 «Spectrophotometric measurement of the decomposition rate of complex manganese oxalate». | 4 | 5 |
| 2 | **IWST 1.** Consultation on the implementation of the IWS 1 on the topic: «Chemical Kinetics I. The Basic Ideas Rate Constants and Order of Reaction. Temperature Dependence. Collision Theory and Transition-State Theory. Ionic-Strength Effects.». | 1 |  |
| 3 | **Lec 3.** Methods of determining the order of reactions and determining the rate constant of reactions in closed systems: substitution method, graphical method, Ostwald-Noyes-Rakovsky method, Ostwald's excess method and Van't-Hoff's differential method. | 1 |  |
| 3 | **Sem 3.** Determination of order for simple and formal-simple reactions in closed systems. | 1 | 5 |
| 3 | **Lab 3.** Рerformance of laboratory work No. 1. «Spectrophotometric measurement of the decomposition rate of complex manganese oxalate». Tasks of laboratory work No. 2 «Study of the kinetics of the oxidation reaction of thiourea with hexacyanoferrate (III) in an alkaline environment». | 4 | 5 |
| 3 | **IWS 1.** Completion of the IWS 1 on the topic: «Chemical Kinetics I. The Basic Ideas Rate Constants and Order of Reaction. Temperature Dependence. Collision Theory and Transition-State Theory. Ionic-Strength Effects.». | 1 | 5 |
| 4 | **Lec 4.** Dependence of reaction rate on temperature. Van't-Hoff rule, temperature coefficient. Arrhenius law, equations, assumptions about the effect of temperature on the rate of chemical reactions. Activation energy, physical meaning, experienced and real activation energy. Methods of determining activation energy. | 1 |  |
| 4 | **Sem 4.** Application of Van't Hoff's rule, Arrhenius law. Calculation of activation energy. | 1 | 5 |
| 4 | **Lab 4.** Delivery of the theoretical part of the laboratory work No. 2 «Study of the kinetics of the oxidation reaction of thiourea with hexacyanoferrate (III)  in an alkaline environment». | 4 | 5 |
| 4 | **IWST 2.** Colloquium. Write essay on the topic «The Importance Of Chemical Kinetics». | 1 | 5 |
| 5 | **Lec 5.** Elementary reactions, detailed equilibrium and postulates about the independence of the limiting period. Kinetic analysis of reversible and parallel first-order reactions. | 1 |  |
| 5 | **Sem 5.** Сontrol work on lecture materials. | 1 | 5 |
| 5 | **Lab 5.** The task of the theoretical part of the laboratory work No. 3 «Study of the rate of sapagenation of acetetethyl ether with alkaline». | 4 | 5 |
| 6 | **Lec 6.** Kinetic analysis of chain reactions. Analysis of kinetic relationships in chain reactions. Approximate methods of chemical kinetics. Bodenstein's principle of quasistationary concentration. | 1 |  |
| 6 | **Sem 6.** Calculation of rate constants of reversible and parallel first-order reactions. | 1 | 5 |
| 6 | **Lab 6.** Рerformance of laboratory work No. 3. «Study of the rate of sapagenation of acetetethyl ether with alkaline». | 4 | 5 |
| 7 | **Lec 7.** Homogeneous catalysis. The main properties of the catalyst. Catalytic activity and selectivity. Kinetics of homogeneous catalytic reactions. | 1 |  |
| 7 | **Sem 7.** Calculation of kinetic characteristics of chain reactions. | 1 | 5 |
| 7 | **Lab 7.** Defense of laboratory work No. 3 «Study of the rate of sapagenation of acetetethyl ether with alkaline»  Examination and colloquium based on the materials of lectures 1-6. | 4 | 25 |
| 7 | **IWST 3.** Consultation on the implementation of the IWS 2 on the topic: «Chemical Kinetics II. Composite Mechanisms and Rate Equations. Photochemistry and Radiation Chemistry.» | 1 |  |
|  | **LEVEL CONTROL 1** |  | **100** |
| 8 | **Lec 8.** Heterogeneous catalysis. Adsorption on the catalyst surface. The main stages of the heterogeneous catalytic reaction. Kinetics of heterogeneous catalytic reactions, Langmuir adsorption theory. | 1 |  |
| 8 | **Sem 8.** Application of the Bodenstein principle of quasi-stationary concentration. | 1 | 5 |
| 8 | **Lab 8.** Delivery of the theoretical part of the laboratory work No. 4 «Determination of the pH of hydrate formation and the product of the solubility (PoS) of metal hydroxide». | 4 | 5 |
| 8 | **IWS 2.** Completion of the IWS 2 on the topic: «Chemical Kinetics II. Composite Mechanisms and Rate Equations. Photochemistry and Radiation Chemistry.» | 1 | 5 |
| **Module 2**  **Electrochemistry** | | | |
| 9 | **Lec 9.** Basic characteristics of electrochemical reactions. Causes of electrostatic dissociation. Pros and cons of Arrhenius theory of electrostatic dissociation. Solvation and hydration in electrolyte solutions. | 1 |  |
| 9 | **Sem 9.** Application of thermodynamic theory of strong electrolytic solutions to calculate activity | 1 | 5 |
| 9 | **Lab 9.** Рerformance of laboratory work No. 4 «Determination of the pH of hydrate formation and the product of the solubility (PoS) of metal hydroxide». | 4 | 5 |
| 9 | **IWST 4.** Consultation on the implementation of the IWS 3 on the topic: «Faraday’s Laws, Molar Conductivity, and Weak Electrolytes.» | 1 |  |
| 10 | **Lec 10** Thermodynamic theory of electrolyte solutions. Activity and activity ratio. Ionic strength of a solution, Lewis Randall's rule. Debye-Hückel theory of strong electrolytes. Basic concepts of electrostatic theory of electrolytic solutions. Equations of the first and second activity coefficients and the third approach, concentration limits for their application. | 1 |  |
| 10 | **Sem 10.** Control work on the materials of lectures 6-10. | 1 | 5 |
| 10 | **Lab 10.** Defense of laboratory work No. 4 «Determination of the pH of hydrate formation and the product of the solubility (PoS) of metal hydroxide». | 4 | 5 |
| 11 | **Lec 11** Electrical conductivity of electrolyte solutions. Specific and molar electrical conductivity. Dependence of electrical conductivity of weak and strong electrolytes on their concentration. Kohlrausch, Debye-Onsager laws. Electrophoretic and relaxation effects of inhibition. | 1 |  |
| 11 | **Sem 11.** Calculation of activity coefficients in the first, second and third approximation of the Debye-Hückel theory of strong electrolytes and their analysis. | 1 | 5 |
| 11 | **Lab 11.** The task of the theoretical part of the laboratory work No. 5 «Electrical conductivity of electrolyte solutions». | 4 | 5 |
| 11 | **IWST 5.** Completion of the IWS 3 on the topic: «Faraday’s Laws, Molar Conductivity, and Weak Electrolytes.» | 1 | 5 |
| 12 | **Lec 12** Mobility and transport numbers, methods of their determination. Electrolysis. Laws of electrolysis. The Gittorf method. | 1 |  |
| 12 | **Sem 12.** Calculation of electrical conductivity of electrolyte solutions: specific and molar electrical conductivity. Application of Kohlrausch, Debye-Onsager laws. | 1 | 5 |
| 12 | **Lab 12.** Delivery of the theoretical part of the laboratory work No. 5 «Electrical conductivity of electrolyte solutions». | 4 | 5 |
| 12 | **IWS 3.** Consultation on the implementation of the IWS 4 on the topic: «Debye-Hückel Theory and Transport of Electrolytes.» | 1 |  |
| 13 | **Lec 13** Electromotive force (EMF) of a galvanic cell. Nernst equation. Equilibrium and standard electrode potentials. Types of electrodes. Electrodes of the first and second type. Redox electrodes. Luther's rule. Amalgam and gas electrodes. | 1 |  |
| 13 | **Sem 13.** Making reports on the laws of electrolysis. Calculation of transport number of ions. | 1 | 5 |
| 13 | **Lab 13.** Performance of the laboratory work No. 5 «Electrical conductivity of electrolyte solutions». | 4 | 5 |
| 13 | **IWST 6.** Completion of the IWS 4 on the topic: «Debye-Hückel Theory and Transport of Electrolytes.» | 1 | 5 |
| 14 | **Lec 14** Types of electrochemical cells. Chemical chains. Thermodynamics of an electrochemical cell. Determination of standard thermodynamic functions and equilibrium constants of electrochemical reactions using the EMF method. | 1 |  |
| 14 | **Sem 14.** Composition of chemical circuits (galvanic element). EMF of the galvanic element. Nernst equation. Thermodynamics of an electrochemical cell, determination of standard thermodynamic functions and equilibrium constants of electrochemical reactions using the EMF method. | 1 | 5 |
| 14 | **Lab 14.** Defense of the laboratory work No. 5 «Electrical conductivity of electrolyte solutions». Рerformance of laboratory work No. 6 «Measurement of the galvanic elements' EMF». | 4 | 5 |
| 14 | **IWST 7.** Consultation on the implementation Control work | 1 | 5 |
| 15 | **Lec 15** Concentration chains with and without charge transfer. Diffusion potential. | 1 |  |
| 15 | **Sem 15.** Control work on the materials of lectures 8-14. | 1 | 5 |
| 15 | **Lab 15.** Defense of the laboratory work No. 6. «Measurement of the galvanic elements' EMF». Examination and colloquium based on the materials of lectures 8-14. | 4 | 10 |
| 15 | **IWST 8.** Consultation on examination issues | 1 |  |
|  | **LEVEL CONTROL 2** |  | **100** |

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Head of Department Ye.A.Aubakirov

Lecturer Zh.A.Supiyeva