**SYLLABUS**

**Fall semester 2022-2023 academic years**

**on the educational program “6B05301 – Chemistry”**

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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)** | |
| FH 2213 | Physical Chemistry, 2 | 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 ability to solve practical problems in chemical kinetics and electrochemistry, to analyze the physicochemical properties of electrolyte solutions, the kinetic characteristics of chemical reactions, as well as the features of electrode processes. | 1**.** Describe the basic laws of chemical kinetics and electrochemistry; | 1.1 to formulate the basic concepts of chemical kinetics;  1.2 derive formulas for calculating the rate constant for reactions of different orders, activation energy;  1.3 demonstrate methods for determining the order of reaction;  1.4 justify the influence of temperature and catalyst on the rate of the process;  1.5 to formulate the basic concepts and laws of electrochemistry;  1.6 explain the effect of temperature, concentration on the electrical conductivity of electrolytes;  1.7 explain the processes occurring during electrolysis in chemical and concentration chains. |
| 2. Explain the basic theories, properties of strong and weak electrolytes; | 2.1 calculate the activity of electrolyte solutions based on the thermodynamic theory of activity and the electrostatic theory of Debye-Hückel;  2.2 calculate the electrical conductivity of electrolyte solutions;  2.3 calculate the main characteristics of electrolytes based on data on electrical conductivity. |
| 3. Analyze the calculated kinetic characteristics of chemical reactions; | 3.1 calculate the rate, order, rate constant, activation energy of the process under study;  3.2 draw conclusions about the advantages and disadvantages of various methods for calculating the kinetic parameters of the process. |
| 4. Analyze the calculated thermodynamic characteristics of electrode processes; | 4.1 write a diagram of electrolysis and reactions occurring on the electrodes;  4.2 make up chains and write electrode reactions, the total reaction in the chain;  4.3 calculate the EMF of the circuit;  4.4 calculate the thermodynamic characteristics of electrochemical processes. |
| 5. To evaluate the optimal conditions for carrying out chemical and electrochemical reactions; | 5.1 to establish the influence of various factors on the process under study;  5.2 choose the optimal conditions for the process under study and provide a justification. |
| **Prerequisites** | Physics, maths, general and inorganic chemistry, Physical chemistry, 1. | |
| **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.Ira N. Levine. Physical Chemistry. Sixth Edition. New York: McGraw-Hill, 2009. 995 p.  7.Ospanova A.K., Seilkhanova G.A. Chemical Kinetics and Electrochemistry [Text] // educational man. Al-Farabi Kazakh National University. - Almaty: Qazaq University, 2017. - 135 p.  8.Seilkhanova G.A., Ospanova A.K. Fundamentals of chemical kinetics and electrochemistry (theory and tests)//Учебное пособие. – Алматы: Unique Service, 2019. – 116 p.  9.Dykstra C. E. Physical chemistry: a modern introduction [Текст]: second Edition / updated and revised by W.M.Davis. - USA: CRC Press, 2012. - 501 p. -). - ISBN 978-1-4398-1077-4.  **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 chemical reaction rate, the influence of various factors on the rate. The basic postulate of chemical kinetics. Average and instant rates. Rate constant, its physical meaning. The mechanism of a chemical reaction, elementary stages, an elementary act of a chemical reaction. Molecularity and order of reaction | 1 |  |
| 1 | **Sem 1.** Solving problems. Calculation of the rate of a chemical reaction: average and instantaneous rates. | 1 | 5 |
| 1 | **Lab 1.** Organizational issues of the educational process in the discipline, providing a syllabus, explanations. Statistical processing of experimental results. Least square method. 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 | **Lec 2.** Kinetic analysis of simple irreversible reactions of the first, second, n-th (with equal concentrations of reactants) and zero orders. Half-life. Dimension of the different orders reactions rate constants. | 1 |  |
| 2 | **Sem 2.** Solving problems. Calculation of the kinetic characteristics of formally simple homogeneous one-way reactions of different orders. | 1 | 5 |
| 2 | **Lab 2.** 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 |
| 2 | **IWST 1.** Consultation on IWS No. 1task «Introduction to Physical Chemistry. Chemical Kinetics I – Introduction, Reactions I, Reactions II» | 1 |  |
| 3 | **Lec 3.** Integral and differential methods for determining the reaction order and the rate constant of formal-simple reactions in closed systems. | 1 |  |
| 3 | **Sem 3.** Determination of the order of given reaction using MS Excel Software | 1 | 5 |
| 3 | **Lab 3.** 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 |
| 3 | **IWS 1.** Completion of IWS No. 1task «Introduction to Physical Chemistry. Chemical Kinetics I – Introduction, Reactions I, Reactions II». | 1 | 5 |
| 4 | **Lec 4.** The dependence of the reaction rate on temperature. Van't Hoff's rule, temperature coefficient. Arrhenius's law. Activation energy, physical meaning, empirical and true activation energy. Methods for determining the activation energy. | 1 |  |
| 4 | **Sem 4.** Solving problems. Application of Van't Hoff's rule, Arrhenius's law. Calculation of the activation energy. | 1 | 5 |
| 4 | **Lab 4.** 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 |
|  | **IWST 2.** Consultation on IWS No. 2task «Chemical Kinetics II – Complex reactions Video II, Steady-state approximation – Using the steady-state approximation. Chemical Kinetics II – Review and Recap». | 1 | 5 |
| 5 | **Lec 5.** The postulates of the independence of the flow of elementary reactions, detailed equilibrium and the limiting stage. Kinetic analysis of a reversible and parallel first-order reaction. | 1 |  |
| 5 | **Sem 5.** Solving problems. Calculation of rate constants for reversible and parallel first-order reactions. | 1 | 5 |
| 5 | **Lab 5.** Examination and colloquium based on the materials of lectures 1-5. | 4 | 25 |
| **Module 2**  **Catalysis** | | | |
| 6 | **Lec 6.** Kinetic analysis of consequent reactions. Analysis of kinetic dependences in sequential reactions. Approximate methods of chemical kinetics. Bodenstein's principle of quasi-stationary concentrations. | 1 |  |
| 6 | **Sem 6.** Solving problems. Application of Bodenstein’s method. | 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. Basic properties of the catalyst. Catalytic activity and selectivity. Kinetics of homogeneous catalytic reactions. | 1 |  |
| 7 | **Sem 7.** Discussion of presentations on IWS 2. | 1 | 5 |
| 7 | **Lab 7.** Defense of laboratory work No. 3 «Study of the rate of sapagenation of acetetethyl ether with alkaline» | 4 | 5 |
| 7 | **IWST 3.** Completion of IWS No. 2task «Chemical Kinetics II – Complex reactions Video II, Steady-state approximation – Using the steady-state approximation. Chemical Kinetics II – Review and Recap». | 1 |  |
|  | **LEVEL CONTROL 1** |  | **100** |
| 8 | **Lec 8.** Heterogeneous catalysis. Adsorption on the catalyst surface. The main stages of a heterogeneous catalytic reaction. Kinetics of heterogeneous catalytic reactions, Langmuir's adsorption theory. | 1 |  |
| 8 | **Sem 8.** Delivery of IWS 2. Report on most popular catalytic reactions. | 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.** Consultation on the implementation of IWS No. 3 «Chemical Kinetics II – Catalysis». | 1 | 5 |
| **Module 2**  **Fundamentals of Electrochemistry** | | | |
| 9 | **Lec 9.** Basic characteristics of electrochemical reactions. Causes of electrostatic dissociation. Positive and negative sides of Arrhenius' theory of electrostatic dissociation. Solvation and hydration in electrolyte solutions. | 1 |  |
| 9 | **Sem 9.** Solving problems. Thermodynamics of electrochemical reactions. | 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 |
| 10 | **Lec 10** Thermodynamic theory of electrolyte solutions. Activity and activity coefficient. Ionic strength of solution, Lewis Randall rule.  Debye-Gückel theory of strong electrolytes. Basic concepts of the electrostatic theory of electrolyte solutions. Equations for activity coefficients in the first, second and third approximations, concentration limits of their application. | 1 |  |
| 10 | **Sem 10.** Solving problems.  Application of the thermodynamic theory of strong electrolyte solutions to calculate the activity. Calculation of activity coefficients in the first, second and third approximations of the theory of strong electrolytes Debye-Gückel and their analysis. | 1 | 5 |
| 10 | **Lab 10.** Examination and colloquium based on the materials of lectures 6-9. | 4 | 5 |
| 10 | **IWST 4.** Completion of IWS No. 3task «Chemical Kinetics II – Catalysis» | 1 |  |
| 11 | **Lec 11** Electrical conductivity of electrolyte solutions. Specific and molar electrical conductivity. Dependence of the electrical conductivity of weak and strong electrolytes on their concentration. Kohlrausch, Debye-Onsager laws. Electrophoretic and relaxation effects of inhibition. Effects of Wine, Falkenhagen. | 1 |  |
| 11 | **Sem 11.** Solving problems. Calculation of the electrical conductivity of electrolyte solutions: specific and molar electrical conductivity. Application of the laws of Kohlrausch, Debye-Onsager. | 1 | 5 |
| 11 | **Lab 11.** Defense of laboratory work No. 4 «Determination of the pH of hydrate formation and the product of the solubility (PoS) of metal hydroxide». Tasks of the laboratory work No. 5 «Electrical conductivity of electrolyte solutions». | 4 | 5 |
| 12 | **Lec 12** Mobility and transfer numbers, methods of their determination. Electrolysis. Electrolysis laws. Hittorff method. Moving border method. | 1 |  |
| 12 | **Sem 12.** Solving problems on the laws of electrolysis. Calculation of the transport numbers of ions. | 1 | 5 |
| 12 | **Lab 12.** Delivery of the theoretical part of the laboratory work No. 5 «Electrical conductivity of electrolyte solutions». | 4 | 5 |
| 12 | **IWST 5.** Consultation on the implementation of IWS No. 3 “Introduction to battery-management systems”  1.1.5: What are the best materials to use in an electrochemical cell?  1.1.6: Example electrochemical (incl. PbA and NiMH) cells  1.1.7 Summary of "Battery boot camp" module plus next steps | 1 | 5 |
| 13 | **Lec 13** The appearance of a potential jump at the interface. Electromotive force of a galvanic cell (EMF). Nernst equation. Equilibrium and standard electrode potentials. Types of electrodes. Electrodes of the first and second kind. Redox electrodes. Luther's rule. Amalgam and gas electrodes. | 1 |  |
| 13 | **Sem 13.** Solving problems. Application of cells drawing rules on electrodes. | 1 | 5 |
| 13 | **Lab 13.** Performance of the laboratory work No. 5 «Electrical conductivity of electrolyte solutions». | 4 | 5 |
| 13 | **IWS 3.** Completion of IWS No. 4task “Introduction to battery-management systems”  1.1.5: What are the best materials to use in an electrochemical cell?  1.1.6: Example electrochemical (incl. PbA and NiMH) cells  1.1.7 Summary of "Battery boot camp" module plus next steps | 1 |  |
| 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 by the EMF method. | 1 |  |
| 14 | **Sem 14.** Solving problems. Composition of chemical cells (galvanic cell). EMF of a galvanic cell. Nernst equation. Thermodynamics of an electrochemical cell, determination of standard thermodynamic functions and equilibrium constants of electrochemical reactions by 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 |
|  | **IWST 6.** Consultation on examination issues | 1 | 5 |
| 15 | **Lec 15** Concentration chains with and without charge transfer. Diffusion potential. | 1 |  |
| 15 | **Sem 15.** Solving problems. Composition of chemical cells (galvanic cell). Calculation of the EMF of a galvanic cell. Calculation of standard thermodynamic functions and equilibrium constants of electrochemical reactions by the EMF method. | 1 | 5 |
| 15 | **Lab 15.** Examination and colloquium based on the materials of lectures 11-14.  Defense of the laboratory work No. 6. «Measurement of the galvanic elements' EMF». | 4 | 10 |
| 15 | **IWST 7.** Consultation on examination issues | 1 |  |
|  | **LEVEL CONTROL 2** |  | **100** |

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