**SYLLABUS**

**Fall semester 2020-2021 academic years**

**on the educational program “Physical Chemistry, 2”**

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| **Discipline’s code** | **Discipline’s title** | **Independent work of students (IWS)** | **No. of hours per week** | | | | | **Number of credits** | **Independent work of student with teacher (IWST)** |
| **Lectures (L)** | **Practical training (PT)** | | **Laboratory (Lab)** | |
| **FH 3326** | Physical Chemistry, 2 | 68 | 15 | - | | 60 | | 5 | 7 |
| **Academic course information** | | | | | | | | | |
| **Form of education** | **Type of course** | **Types of lectures** | | | **Types of practical training** | | **Number of IWS** | | **Form of final control** |
| Combined (synchronously /  asynchronously | Mixed (theoretical /  applied) | Informative,  Video-lecture  Lecture-discussion | | | - | | 3 | | Test |
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| **Academic presentation of the course** |

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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** | - mathematics 1, 2; - physical chemistry 1;  - physics 1, 2; - general chemistry. | |
| **Post requisites** | - chemical physics;  - colloidal chemistry;  - kinetics of complex processes. | |
| **Information resources** | 1. Ospanova A.K., Seilkhanova G.A. Chemical Kinetics and Electrochemistry [Text ] // educational man. Al-Farabi Kazakh National University. - Almaty : Qazaq University, 2017. - 135 p. 2. Seilkhanova G.A., Ospanova A.K. Fundamentals of chemical kinetics and electrochemistry (theory and tests)//Учебное пособие. – Алматы: Unique Service, 2019. – 116 p. 3. 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 4. Atkins, P. Elements of Physical Chemistry: 6th Edition / Peter Atkins, Julio de Paula.- Oxford: Oxford University Press, 2013.- 591 p.   **Internet resources:**  1.www.chem.msu.su  Available online: Additional educational material for ISW, tasks of intermediate control and materials for preparation of laboratory work performance will be available on your page on the site univer.kaznu.kz in the section EMCD. | |
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| **Academic policy of the course in the context of university moral and ethical values** | **Academic Behavior Rules:**  Regular attendance at all types of classes, timely delivery of midterm assignments, repeated retaking of intermediate control assignments for various reasons is estimated with a coefficient of 0.75, the obligatory presence of a calculator, a reference book on physical and chemical values. For absences from more than 20% of classes without a valid reason students are given an "F" grade.  **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 akmaral.rahym@gmail.com. |
| **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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| weeks | Topic name | LO | ID | amount of hours | Maximum score | Form of Knowledge Assessment | The  Form of the lesson  / platform |

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| **Module 1**  **Chemical Kinetics** | | | | | | | |
| 1 | **Lecture 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. | LО 1 | ID 1.1. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 1 | **Laboratory lesson 1**  Organizational issues of the educational process in the discipline, providing a syllabus, explanations. Statistical processing of experimental results. Least square method.  Solving problems. Calculation of the rate of a chemical reaction: average and instantaneous rates. | LО 3 | ID 3.1. | 4 | **5** | Analysis | Webinar  Skype |
| 2 | **Lecture 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. | LО 1 | ID 1.2.  ID 1.3. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 2 | **Laboratory lesson 2**  Delivery of theoretical material on laboratory work No. 1. Analysis of the video lab work.  **Work 1.** Spectrophotometric determination of the rate of decomposition of the complex ion of manganese oxalate | LО 1 | ID 1.1.  ID 1.2.  ID 1.3. | 4 | **10** | Analysis | Webinar  in Skype |
| 2 | **IWST 1**  Consultations for the delivery of control work 1, calculations for laboratory work No. 1, IWS 1. |  |  | 1 |  |  | Webinar  in Skype |
| 3 | **Lecture 3**  Integral and differential methods for determining the reaction order and the rate constant of formal-simple reactions in closed systems. | LО 1 | ID 1.2.  ID 1.3. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 3 | **Laboratory lesson 3**  Delivery of the experimental part (calculations, graphs, analysis, conclusions) for laboratory work No. 1.  Solving problems. Calculation of the kinetic characteristics of formally simple homogeneous one-way reactions of different orders.  **Control work 1** | LO 5  LО 3 | ID 5.1  ID 5.2  ID 3.1.  ID 3.2. | 4 | **10**  **20** | Analysis | Webinar  in Skype  Test on Moodle |
| 4 | **Lecture 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. | LО 1 | ID 1.4. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 4 | **Laboratory lesson 4**  Solving problems. Determination of the order and rate constant for elementary and formally simple reactions in closed systems.  Delivery of theoretical material for laboratory work No. 2. Analysis of the video lab work.  Work 2. Study of the rate of saponification of an ester in the presence of hydroxyl ions (or hydrogen ions). | LО 3 | ID 3.1. | 4 | **10** | Analysis | Webinar  in Skype |
| 4 | **IWST 2**  Consultations for the delivery of control work 2, calculations for laboratory work No. 2. |  |  | 1 |  |  | Webinar  in Skype |
| 4 | **IWS 1** | LО 3 | ID 3.1. |  | **15** | Problem solving |  |
| 5 | **Lecture 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. | LO 1 | ID 1.1.  ID 1.2.  ID 1.3. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 5 | **Laboratory lesson 5.**  Solving problems.  Application of Van't Hoff's rule, Arrhenius's law. Calculation of the activation energy.  Delivery of the experimental part (calculations, graphs, analysis, conclusions) for laboratory work No. 2  **Control work 2** | LO 3  LO 5 | ID 3.1.  ID 5.1.  ID 5.2. | 4 | **10**  **20** | Analysis | Webinar  in Skype  Test on Moodle |
| 5 | **MT 1** |  |  |  | **100** |  |  |
| 6 | **Lecture 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. | LО 1 | ID 1.1.  ID 1.2. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 6 | **Laboratory lesson 6**  Solving problems. Calculation of rate constants for reversible and parallel first-order reactions.  Delivery of theoretical material on laboratory work No. 3. Analysis of the video lab work.  Work 3. Study of the kinetics of the thiourea oxidation reaction with potassium hexacyanoferrate (III) in alkaline solution. | LО 3 | ID 3.2. | 4 | **10** | Analysis | Webinar  in Skype |
| 6 | **IWST 3**  Consultations for the delivery of control work 3, calculations for laboratory work No. 3, IWS 2. | LO 3  LO 5 | ID 3.1.  ID 5.1. | 1 |  |  | Webinar  in Skype |
| 7 | **Lecture 7**  Homogeneous catalysis. Basic properties of the catalyst. Catalytic activity and selectivity. Kinetics of homogeneous catalytic reactions. | LО 1 | ID 1.4. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 7 | **Laboratory lesson 7**  Delivery of the experimental part (calculations, graphs, analysis, conclusions) for laboratory work No. 3.  **Control work 3** | LО 5 | ID 5.1.  ID 5.2. |  | **10**  **20** |  | Webinar  in Skype  Test on Moodle |
| 8 | **Lecture 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. | LО 1 | ID 1.1.  ID 1.4. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 8 | **Laboratory lesson 8**  Solving problems. Calculation of the kinetic characteristics of consequent reactions.  Delivery of theoretical material on laboratory work No. 4. Analysis of the video lab work.  Work 4. Determination of pH of hydrate formation and solubility product of metal hydroxides | LО 3 | ID 3.1.  ID 3.2. | 4 | **10** | Analysis | Webinar  in Skype |
| 8 | **IWST 4**  Consultations on calculations for laboratory work No. 4, ISW 2. | LO 3  LO 5 | ID 3.1.  ID 5.1. | 1 |  |  | Webinar  in Skype |
| **Module 2**  **Fundamentals of Electrochemistry** | | | | | | | |
| 9 | **Lecture 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. | LО 1 | ID 1.5. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 9 | **Laboratory lesson 9**  Solving problems. Application of the Bodenstein principle of quasi-stationary concentrations.  Delivery of the experimental part (calculations, graphs, analysis, conclusions) for laboratory work No. 4.  **Control work 4** | LО 3  LO 5 | ID 3.2.  ID 5.1.  ID 5.2. | 4 | **10**  **20** | Analysis | Webinar  in Skype  Test on Moodle |
| 10 | **Lecture 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. | LО 2 | ID 2.1. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 10 | **Laboratory lesson 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.  Delivery of the experimental part (calculations, graphs, analysis, conclusions) for laboratory work No. 4. | LО 2  LO 5 | ID 2.1.  5.1.  ID 5.2. | 4 |  | Analysis | Webinar  in Skype |
| 10 | **IWSP 5**  Consultations on theoretical material for laboratory work No. 5. | LО 1 | ID 1.6. | 1 |  |  | Webinar  in Skype |
| 10 | **IWS 2** | LО 2 | ID 2.1.  ID 2.2.  ID 2.3. |  | **20** | Problem solving |  |
| 10 | **МТ (Midterm Exam)** | LO 1  LO 2 | ID 1.5.  ID 2.1.  ID 2.2.  ID 2.2. |  | **100** |  |  |
| 11 | **Lecture 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 | LО 1 | ID 1.6. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 11 | **Laboratory lesson 11**  Solving problems. Calculation of the electrical conductivity of electrolyte solutions: specific and molar electrical conductivity. Application of the laws of Kohlrausch, Debye-Onsager.  Delivery of theoretical material on laboratory work No. 5. Analysis of the video lab work.  Work 5. Study of the electrical conductivity of electrolyte solutions. | LО 2 | ID 2.2.  ID 2.3. | 4 | **10** | Analysis | Webinar  in Skype |
| 12 | **Lecture 12.**  Mobility and transfer numbers, methods of their determination. Electrolysis. Electrolysis laws. Hittorff method. Moving border method. | LО 1 | ID 1.7. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 12 | **Laboratory lesson 12**  Solving problems on the laws of electrolysis. Calculation of the transport numbers of ions.  Delivery of the experimental part (calculations, graphs, analysis, conclusions) for laboratory work No. 5. | LО 4  LO 5 | ID 4.1.  ID 5.1  ID 5.2 | 4 | **10** | Analysis | Webinar  in MS Teams |
| 12 | **IWSP 6**  Consultations for the delivery of control work 5, calculations for laboratory work No. 5, ISW 3 | LО 4 | ID 4.1. | 1 |  |  | Webinar  in Skype |
| 13 | **Lecture 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. | LО 1 | ID 1.7. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 13 | **Laboratory lesson 13.**  Delivery of theoretical material on laboratory work No. 6. Analysis of the video lab work.  Work 6. Galvanic cell. Measurement of EMF of galvanic cells.  **Control work 5** | LО 1 | ID 1.7. | 4 | **10**  **20** | Analysis | Webinar  in Skype  Test on Moodle |
| 14 | **Lecture 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. | LО 1  LO 4 | ID 1.7.  ID 4.2. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 14 | **Laboratory lesson 14**  Solving problems. Composition of chemical chains (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.  Delivery of the experimental part (calculations, graphs, analysis, conclusions) for laboratory work No. 6. | LО 4  LO 5 | ID 4.1.  ID 4.2.  ID 5.1.  ID 5.2. | 4 | **10** | Analysis | Webinar  in Skype |
| 14 | **IWSP 7**  Consultations for passing the control work 6. | LO 1  LO 4 | ID 1.7.  ID 4.2. | 1 |  |  | Webinar  in Skype |
| 14 | **IWS 3** | LO 1  LO 4 | ID 1.7.  ID 4.1.  ID 4.2. |  | **20** | Problem solving |  |
| 15 | **Lecture 15**  Concentration chains with and without charge transfer. Diffusion potential. | LО 1  LO 4 | ID 1.7.  LO 4.2. | 1 |  |  | Video lecture on YouTube,  On-line video lecture-discussion in Skype |
| 15 | **Laboratory lesson 15**  Solving problems. Composition of chemical chains (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.  Delivery of the experimental part (calculations, graphs, analysis, conclusions) for laboratory work No. 6.  **Control work 6** | LО 4  LO 5 | ID 4.1.  ID 4.2.  ID 5.1.  ID 5.2. | 4 | **20** | Analysis | Webinar  in Skype  Test on Moodle |
| 15 | **MT 2** | LО 1  LO 4 | ID 1.7.  ID 4.1.  ID 4.2. |  | **100** |  |  |

[Abbreviations: QS - questions for self-examination; TK - typical tasks; IT - individual tasks; CW - control work; MT - midterm.

Comments:

- Form of L and PT: webinar in MS Teams / Zoom (presentation of video materials for 10-15 minutes, then its discussion / consolidation in the form of a discussion / problem solving / ...)

- Form of carrying out the CW: webinar (at the end of the course, the students pass screenshots of the work to the monitor, he/she sends them to the teacher) / test in the Moodle DLS.

- All course materials (L, QS, TK, IT, etc.) see here (see Literature and Resources, p. 6).

- Tasks for the next week open after each deadline.

- CW assignments are given by the teacher at the beginning of the webinar.]

**Dean Tassibekov Kh.S**

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**Head of the Department Aubakirov Ye.A.**

**Lecturer Supiyeva Zh.**