**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 2212 | Physical chemistry, part I | 82 | 15 | 15 | | 60 | | 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 | | |
| e-mail | Supiyeva.Zhazira@kaznu.kz | | | | | |
| Telephone number | 8 701 391 91 56 | | | | | |

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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  thermodynamic  functions of systems  for predicting the  possibility,  direction, and  control of the  physical and  chemical process. | 1. Explain the content of the main regularities and rules of chemical thermodynamics, ideal solutions, homogeneous and heterogeneous equilibriums | 1.1. operates with definitions and terms of thermodynamics;  1.2. executes the classification of thermodynamic systems, processes and their characteristics;  1.3. formulates the main rules, regulations, and principles of chemical thermodynamics;  1.4. characterizes thermodynamic parameters and state functions of systems;  1.5. operates with basic formulas describing thermodynamic regularities. |
| 2. Calculate thermodynamic parameters of physical and chemical processes | 2.1. defines the necessary data for calculating the specified thermodynamic parameter;  2.2. selects an equation and its form for calculating the specified thermodynamic parameter;  2.3. chooses the most appropriate method (analytical, graphical, least squares) for calculating the specified thermodynamic parameter;  2.4. substantiates the choice of the method for calculating the specified thermodynamic parameter;  2.5. properly expresses the dimensions of the initial and calculated values; |
| 3. Describe the main thermodynamic regularities of physical and chemical processes | 3.1. evaluates the influence of various factors on the value of a particular thermodynamic parameter of the system;  3.2. describes the state diagrams of the system;  3.3. determines the nature of the influence of different factors on the equilibrium in the system. |
| 4. Predict the possibility, direction, and depth of a physical and chemical process on the basis of calculated thermodynamic parameters or system state diagrams | 4.1. evaluates the thermodynamic probability and direction of a chemical reaction/phase transformation under specific conditions;  4.2. determines the depth of transformation of the initial substances under the specified conditions;  4.3. sets the conditions of chemical / phase equilibrium in the system and the factors that affect it; |
| 5. Independently perform a physical and chemical experiment (according to the elaborated methodic) with subsequent analysis and interpretation of obtained results and finalizes with conclusions | 5.1. understands the basic safety rules for working in a chemical laboratory  5.2. performs a statistical assessment of the determined physical quantities;  5.3. defines a system/process parameter based on measurement data for physical values;  5.4. builds a diagram of the system state using experimental data and "expound" it;  5.5. analyzes and interprets experimental data based on the acquired knowledge of the main thermodynamic rules of physical and chemical processes. |
| **Prerequisites** | Physics, maths, general and inorganic chemistry | |
| **Post requisites** | Physical chemistry, part II, The basis of Physico – chemical Analysis, Modern concepts of the theory of solutions, general chemical technology | |
| **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**  Basic concepts and the Laws of Thermodynamics | | | |
| 1 | **Lec 1.** Physical chemistry, methods of its research, basic concepts. The first law of thermodynamics, its definitions, analytical formula. Hess's law, its consequences. | 1 |  |
| 1 | **Sem 1.** Internal energy, heat, work, their physical and thermodynamic values, their relationship (showing differences in properties A, Q, ΔU, ΔQ, ΔA), solving problems. | 1 | 5 |
| 1 | **Lab 1.** Introductory lesson. Introduction to the academic policy of the course. The procedure for conducting a laboratory classes. Basic safety in a chemical laboratory. Tasks of laboratory work No. 1 | 4 | 5 |
| 2 | **Lec 2.** Heat capacity, its dependence on various factors. Mayer's equation. Temperature dependence of the thermal effect of a chemical reaction, Kirchhoff's equation. | 1 |  |
| 2 | **Sem 2.** Temperature dependence of the heat capacity of chemicals. Methods for calculating the thermal effect of a chemical reaction. | 1 | 5 |
| 2 | **Lab 2.** The task of the theoretical part of the laboratory work No. 1 «The study of the temperature dependence of the vapor elasticity of an individual substance by the dynamic method». | 4 | 5 |
| 2 | **IWST 1.** Consultation on the implementation of the IWS 1 on the topic: «Calculate the thermal effects and the change in heat capacity at 298 K; sum up the temperature dependences of changes in heat capacity and thermal effects and calculate their numerical value with a step of ∆Т=100К in the range of 298-1000K». | 1 |  |
| 3 | **Lec 3.** Application of the first law of thermodynamics to various processes involving ideal gases. | 1 |  |
| 3 | **Sem 3.** Calculation of thermal effects of chemical reactions and phase transitions at different temperatures. The increase in the enthalpy of an individual substance depends on temperature. Work to increase the ideal gas in different conditions. | 1 | 5 |
| 3 | **Lab 3.** Рerformance of laboratory work No. 1. «The study of the temperature dependence of the vapor elasticity of an individual substance by the dynamic method». Tasks of laboratory work No. 2 «Еquilibrium liquid vapor in binary solutions» | 4 | 5 |
| 3 | **IWS 1.** Completion of the IWS 1 on the topic: «Calculate the thermal effects and the change in heat capacity at 298 K; sum up the temperature dependences of changes in heat capacity and thermal effects and calculate their numerical value with a step of ∆Т=100К in the range of 298-1000K». | 1 | 5 |
| 4 | **Lec 4.** The second law of thermodynamics, its concepts. Carnot cycle and Carnot's principle. Efficiency of an ideal heat engine. Entropy. | 1 |  |
| 4 | **Sem 4.** Calculation of changes in the internal energy and enthalpy of a substance in various temperature ranges under conditions of constant pressure and volume. | 1 | 5 |
| 4 | **Lab 4.** Defense of laboratory work No. 1. Delivery of the theoretical part of the laboratory work No. 2 «Еquilibrium liquid vapor in binary solutions». | 4 | 5 |
|  | **IWST 2.** Colloquium. Write essay on the topic «What is physical chemistry: variables, relationships and laws. Introduction to thermodynamics: internal energy, enthalpy, etc.». | 1 | 5 |
| 5 | **Lec 5.** Entropy is a criterion for the direction of the process (constructive condition). Equations for calculating the change in entropy in various processes. Planck's postulate. | 1 |  |
| 5 | **Sem 5.** Calculation of the change in the entropy of a chemical reaction at various temperatures based on the standard absolute entropy of substances and the temperature dependence of the heat capacity. | 1 | 5 |
| 5 | **Lab 5.** Examination and colloquium based on the materials of lectures 1-5. | 4 | 25 |
| **Module 2**  Chemical Equilibrium | | | |
| 6 | **Lec 6.** Thermodynamic potentials. Characteristic functions and their natural variables. Comparative characteristics of thermodynamic functions (ΔU, ΔH, ΔS, ΔF, ΔG) as a criterion for the direction of the process. | 1 |  |
| 6 | **Sem 6.** Calculation of the change in entropy of various processes in the presence of ideal gases and standard absolute entropy of matter. | 1 | 5 |
| 6 | **Lab 6.** Рerformance of laboratory work No. 2 «Еquilibrium liquid vapor in binary solutions» | 4 | 5 |
| 7 | **Lec 7.** Chemical potential, its relationship with thermodynamic functions and composition of the system. Chemical potential of a component in ideal and real solutions. Activity, activity coefficient. | 1 |  |
| 7 | **Sem 7.** Calculation of changes in Gibbs and Helmholtz energies at different temperatures for thermodynamic processes and chemical reactions. | 1 | 5 |
| 7 | **Lab 7.** Defense of laboratory work No. 2 «Еquilibrium liquid vapor in binary solutions» | 4 | 5 |
| 7 | **IWST 3.** Consultation on the implementation of the IWS 2 on the topic: «Calculate the change in entropy of this reaction (consider the equation) with a step of 298 K and ∆Т=100К in the range of 298-1000K» | 1 |  |
|  | **LEVEL CONTROL 1** |  | **100** |
| 8 | **Lec 8.** Homogeneous equilibrium, its features and conditions. Isothermal equations of chemical reactions and directions of processes for various homogeneous systems. The law of mass interaction and the equilibrium constant of a chemical reaction. | 1 |  |
| 8 | **Sem 8.** Equations of equilibrium constants and their relationship, depending on various forms of the chemical reaction equation and various methods of expressing the composition of the reaction mixture, solving problems. | 1 | 5 |
| 8 | **Lab 8.** Delivery of the theoretical part of the laboratory work No. 3 «Study of mutual solubility in a two -component system». | 4 | 5 |
| 8 | **IWS 2.** Completion of the IWS 2 on the topic: «Calculate the change in entropy of this reaction (consider the equation) with a step of 298 K and ∆Т=100К in the range of 298-1000K» | 1 | 5 |
| 9 | **Lec 9.** Temperature dependence of the equilibrium constant. Isobaric and isochoric Van't Hoff equations. | 1 |  |
| 9 | **Sem 9.** Le Chatelier-Brown principle of mobile equilibrium Analytical and graphical calculation of the equilibrium constant, heat effect and entropy of a chemical reaction. | 1 | 5 |
| 9 | **Lab 9.** Рerformance of laboratory work No. 3 «Study of mutual solubility in a two-component system». | 4 | 5 |
| 10 | **Lec 10** Phase, components, constituent. Heterogeneous chemical systems, equilibrium conditions in them. Gibbs Phase Rule. Clapeyron-Clausius equation. Description of the state of the water diagram by the Clapeyron-Clausius equation and the Gibbs phase rule. Phase transitions of types 1 and 2, their features. | 1 |  |
| 10 | **Sem 10.** Influence of pressure on the melting point, evaporation and flash evaporation (sublimation) of a substance. Determination of triple point coordinates on the curves of flash evaporation (sublimation) and evaporation. | 1 | 5 |
| 10 | **Lab 10.** Examination and colloquium based on the materials of lectures 6-9. | 4 | 5 |
| 10 | **IWST 4.** Consultation on the implementation of the IWS 3 on the topic: «Write the equations expressing the constants Кр, Кс and Кх; generalize the relationship between Kp and Kc, Kp and Kx for this reaction; solve the isotherm equation for a given reaction» | 1 |  |
|  | **Module 3**  Phase Equilibria |  |  |
| 11 | **Lec 11** Melting diagram of a two-component system: one-eutectic systems, systems in which components interact chemically (forming compounds with congruent and incongruent melting points). Solid solutions, their formation by penetration and displacement. Melting diagram of solid solutions. Gibbs-Rosebohm Rules I and II. | 1 |  |
| 11 | **Sem 11.** The number of degrees of freedom in phase planes (parts) on the melting diagram, in phase planes (parts), on curves of phase transitions, in invariant (nonvariant) equilibria. Cooling curve, number of phase transitions and degrees of freedom of the cooling curve. Node, the rule of the lever. | 1 | 5 |
| 11 | **Lab 11.** Defense of laboratory work No. 3 «Study of mutual solubility in a two -component system». Tasks of the laboratory work No. 4 «Study of mutual solubility in a three -component system». | 4 | 5 |
| 12 | **Lec 12** Solubility of two and three liquids in each other. Methods for displaying the composition of a three-component system. Tarasenkov's rule. Crisis melting points. Extraction. | 1 |  |
| 12 | **Sem 12.** Comparative analysis of diagrams of two- and three-component systems consisting of poorly soluble liquids. | 1 | 5 |
| 12 | **Lab 12.** Delivery of the theoretical part of the laboratory work No. 4 «Study of mutual solubility in a three -component system». | 4 | 5 |
| 12 | **IWST 5.** Completion of the IWS 3 on the topic: «Write the equations expressing the constants Кр, Кс and Кх; generalize the relationship between Kp and Kc, Kp and Kx for this reaction; solve the isotherm equation for a given reaction» | 1 | 5 |
| 13 | **Lec 13** Thermodynamic properties of ideal liquid solutions. Real solutions. Raoult's law. Thermodynamic substantiation of the linear dependence of the total and partial vapor pressure on the composition of the system for ideal systems. | 1 |  |
| 13 | **Sem 13.** The equation of interaction of liquid and vapor phases in ideal systems, its consequences. Deviations from Raoult's Law and Reasons for Deviations. | 1 | 5 |
| 13 | **Lab 13.** Performance of the laboratory work No. 4. «Study of mutual solubility in a three -component system». | 4 | 5 |
| 13 | **IWS 3.** Consultation on the implementation of the IWS 4 on the topic: «Write an equation that expresses the relationship between the standard isobaric potential and the equilibrium constant. Thermodynamically substantiate the influence of concentration, temperature and pressure of reagents and products on the above equilibrium system» | 1 |  |
| 14 | **Lec 14** Boiling point (vapor pressure) - composition (t, P - x) diagrams. Gibbs-Konovalov laws I and II. | 1 |  |
| 14 | **Sem 14.** Analysis of boiling diagrams. Boiling point (vapor pressure) is the ratio between the components of the liquid and vapor phases (y-x) in the composition diagrams. | 1 | 5 |
| 14 | **Lab 14.** Defense of the laboratory work No. 4. «Study of mutual solubility in a three -component system». | 4 | 5 |
|  | **IWST 6.** Completion of the IWS 4 on the topic: «Write an equation that expresses the relationship between the standard isobaric potential and the equilibrium constant. Thermodynamically substantiate the influence of concentration, temperature and pressure of reagents and products on the above equilibrium system» | 1 | 5 |
| 15 | **Lec 15** Ebuliometry. Cryometry. Determination of the molecular weight and molecular state of the solute from cryometric or ebuliometric data. Isotonic Van't Hoff coefficient. | 1 |  |
| 15 | **Sem 15.** Features of the application of the Schroeder-Le Chatelier equation in cryometry and thermal analysis Osmosis. | 1 | 5 |
| 15 | **Lab 15.** Examination and colloquium based on the materials of lectures 11-14. | 4 | 10 |
| 15 | **IWST 7.** Consultation on examination issues | 1 |  |
|  | **LEVEL CONTROL 2** |  | **100** |

Vice Dean for TM and EW L.K. Kudreeva

Head of Department Ye.A.Aubakirov

Lecturer Zh.A.Supiyeva