**SYLLABUS**
**Spring semester 2023-2024 academic year**
**The educational program 6B05301 - Chemistry**

| ID and discipline name | IWS | Amount of hours | | | Credits | IWSL |
|---|---|---|---|---|---|---|
| | | Lec | Pract | Lab | | |
| 92061 Polymer chemistry | 3 | 1.5 | - | 3.5 | 5 | 7 |

| ACADEMIC INFORMATION ABOUT THE COURSE | | | | |
|---|---|---|---|---|
| Type of education | Cycle, component | Type of lectures | Type of practical lessons | Form of final control |
| Offline | CD, EC (БД, КпВ) | Presentation, analytical lecture | Laboratory works | Writing offline |
| **Lecturer** | L.E. Agibayeva<br>PhD, Senior Lecturer | | | |
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| **Phone number** | +77013268402 | | | |

## ACADEMIC PRESENTATION OF THE COURSE

| Aim of discipline | Expected learning outcomes (LO) | Achievement indicators for LO (AI) |
|---|---|---|
| **Aim of discipline** is to develop the ability to explain the preparation of polymers, the features of the structure, properties of HMCs and their dependence on synthesis methods; carry out the synthesis of polymers by polymerization and polycondensation methods; evaluate the thermodynamic parameters of solutions; evaluate the method for producing polymers. Concepts about polymers, solutions, structure and mechanical properties of polymers, methods of polymer synthesis will be considered. | As a result of studying the discipline, the student will be able to: | |
| | LO 1 Describe the concepts and terms, the classification and nomenclature of polymers, the main methods for their preparation, structural features and properties determined by the chain structure of macromolecules, as well as the supramolecular structure, physical and mechanical properties of polymers and their solutions | AI 1.1 Classify polymers using systematic, rational and trivial nomenclature<br>AI 1.2 Reveal the meaning of specific terms, definitions, concepts used to describe processes involving polymers<br>AI 1.3 List the distinctive properties of polymers due to their chain structure and high molecular weight<br>AI 1.4 Name the possible conformational states and configurational isomers of polymers<br>AI 1.5 Reveal features of different polymer production methods |
| | LO 2 Choose the optimal method for obtaining a polymer for a specific type of monomer | AI 2.1 Use specific terms to describe processes involving polymers<br>AI 2.2 Write the equations of polymer synthesis reflecting the elementary reactions of the macromolecules formation<br>AI 2.3 Analyze the advantages and disadvantages of a specific method for producing polymers |
| | LO 3 Determine the temperatures of relaxation and phase transitions using mechanical and thermophysical research methods | AI 3.1 Use specific terms to describe the phase transitions of polymers and their mechanical properties<br>AI 3.2 Analyze thermomechanical curves for different types of polymers<br>AI 3.3 Analyze the deformation and relaxation characteristics of polymers based on tension and compression curves |
| | LO 4 Apply research methods for polymer solutions to assess the thermodynamic quality of the solvent, molecular weight and other characteristics of macromolecules | AI 4.1 Determine molecular weight characteristics of a polymer based on viscometric data<br>AI 4.2 Assess the thermodynamic quality of a solvent based on viscometric data<br>AI 4.3 Determine isopoints of polyampholytes |
| | LO 5 Synthesize polymers by various methods with specific properties and characteristics | AI 5.1 Synthesize polymers by radical polymerization<br>AI 5.2 Synthesize polymers by ionic polymerization<br>AI 5.3 Synthesize polymers by linear polycondensation |

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| | | AI 5.4 Synthesize polymers by three-dimensional polycondensation<br>AI 5.5 Evaluate the relative activity of comonomers in radical copolymerization |
| **Prerequisites** | OH 1206 Organic chemistry Part 1<br>OH 2213 Organic chemistry Part 2 | |
| **Postrequisites** | NFPM 4310 New polymer materials<br>TOSFP 4311 The theoretic bases of synthesis of functional polymers | |
| **Literature and resources** | **Literature**:<br>1. Introduction to Polymer Science and Chemistry: A Problem-Solving Approach, Second Edition 2nd Edition / by Manas Chanda, CRC Press; 2nd edition (January 11, 2013)<br>2. Polymer Chemistry 2nd Edition / by Paul C. Hiemenz, Timothy P. Lodge, CRC Press; 2nd edition (February 15, 2007)<br>3. Семчиков Ю.Д. Высокомолекулярные соединения: Учебник для вузов. М.:Академия, 2003, 368 .<br>4. Киреев В.В. Высокомолекулярные соединения. Учебник. М.: -Юрайт.-2015. – 602 с.<br>5. Зезин А.Б. Высокомолекулярные соединения. Учебник и практикум. М.: -Юрайт.-2017. – 340 с.<br>6. В.Н.Кулезнев, В.А.Шершнев. Химия и физика полимеров. М.: Колос С, 2007.- 366с.<br>7. Тугов И.И., Кострыкина. Химия и физика полимеров. –М: Химия,1989. - 430с.<br>8. Ергожин Е.Е., Құрманәлиев М.Қ. Жоғары молекулалық қосылыстар химиясы. Алматы, 2008, 407 б.<br>9. Абдыкалыкова Р.А. Полимерлерді хим. түрлендіру ж/е модиф. //Оқу құр. -Қазақ унив.-2003.-44 б.<br>10. Абдыкалыкова Р.А., Рахметуллаева Р.К., Үркімбаева П.И. Оқу құралы. Алматы, «Қазақ университеті», 2011. -177 бет<br>11. Қаржаубаева Р.Ғ. Полимерлеу процестерінің химиясы //Оқу құр. -Қазақ унив.-2002, 80б.<br>**Internet resources:**<br>http://www.pslc.ws/russian/index.htm<br>http://www.xumuk.ru/<br>http://www.hemi.nsu.ru/ | |
| **Academic policy of the course** | The academic policy of the course is determined by the Academic Policy and the Policy of Academic Integrity of Al-Farabi Kazakh National University.<br>Documents are available on the main page of IS Univer.<br>**Integration of science and education.** The research work of students, undergraduates and doctoral students is deepening of the educational process. It is organized directly at the departments, laboratories, scientific and design departments of the university, in student scientific and technical associations. Independent work of students at all levels of education is aimed at developing research skills and competencies based on obtaining new knowledge using modern research and information technologies. A research university teacher integrates the results of scientific activities into the topics of lectures and seminars (practical) classes, laboratory classes and into the tasks of the IWST, IWS, which are reflected in the syllabus and are responsible for the relevance of the topics of training sessions and assignments.<br>**Attendance.** The deadline for each task is indicated in the calendar (schedule) for the implementation of the content of the course. Failure to meet deadlines results in loss of points.<br>**Academic honesty.** Practical/laboratory classes, IWS develop the student's independence, critical thinking, and creativity. Plagiarism, forgery, the use of cheat sheets, cheating at sll stages of completing tasks are unacceptable.<br>Compliance with academic honesty during the period of theoretical training and at exam, in addition to the main policies, is resulted by the "Rules for the final control", "Instructions for the final control of the fall/spring semester of the current academic year", "Regulations on checking student's text document for borrowings". Documents are available on the main page of IS Univer.<br>**Basic principles of inclusive education.** The educational environment of the university is conceived as a safe place where there is always support and equal attitude from the teacher to all students and students to each other, regardless of gender, race/ethnicity, religious beliefs, socio-economic status, physical health of the students, etc. All people need the support and friendship of peers and fellow students. For all students, progress is more about what they can do than what they can't. Diversity enhances all aspects of life.<br>All students, especially those with disabilities, can receive counseling assistance by e-mail Laura,Agibaeva@kaznu.edu.kz or using Zoom conference:<br>https://us04web.zoom.us/j/4143934796?pwd=VGRUTkdjMDVRYy8zY2YvY0RRZklRUT09<br>Conference ID: 414 393 4796 | |

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| | Access code: 3D6eZh<br><br>**ATTENTION!** The deadline for each task is indicated in the calendar (schedule) for the implementation of the content of the course. Failure to meet deadlines results in loss of points. |

## INFORMATION ABOUT TEACHING, LEARNING AND ASSESSMENT

**Score-rating letter system of assessment of accounting for educational achievements**

| Grade | Digital equivalent points | Points, % content | Assessment according to the traditional system |
|---|---|---|---|
| A | 4.0 | 95-100 | Great |
| A- | 3.67 | 90-94 | |
| B+ | 3.33 | 85-89 | Fine |
| B | 3.0 | 80-84 | |
| B- | 2.67 | 75-79 | |
| C+ | 2.33 | 70-74 | |
| C | 2.0 | 65-69 | Satisfactory |
| C- | 1.67 | 60-64 | |
| D+ | 1.33 | 55-59 | Insatisfactory |
| D | 1.0 | 50-54 | |
| FX | 0.5 | 25-49 | |
| F | 0 | 0-24 | |

**Assessment methods**

**Criteria-based assessment** is the process of correlating actual learning outcomes with expected learning outcomes based on clearly defined criteria. Based on formative and summative assessment.

**Formative assessment** is a type of assessment that is carried out in the course of daily learning activities. It is the current measure of progress. Provides an operational relationship between the student and the teacher. It allows to determine the capabilities of the student, identify difficulties, help achieve the best results, timely correct the educational process for the teacher. The performance of tasks, the activity of work in the classroom during lectures, practical exercises (discussions, quizzes, debates, round tables, laboratory works, etc.) are evaluated. Acquired knowledge and competencies are assessed.

**Summative assessment** is a type of assessment which is carried out upon completion of the study of the section in accordance with the program of the course. Conducted 3-4 times per semester when performing IWS. This is the assessment of mastering the expected learning outcomes in relation to the descriptors. Allows to determine and fix the level of mastering the course for a certain period learning outcomes are evaluated.

| **Formative and summative assessment** | **Points, %** |
|---|---|
| Activity at lectures | 5 |
| Work in practical classes | 20 |
| Independent work | 25 |
| Design and creative work | 10 |
| Final control (exam) | 40 |
| TOTAL | 100 |

## Calendar (schedule) for the implementation of the content of the learning course

| Week | Topic name | Amount of hours | Max mark |
|---|---|---|---|
| 1 | **Lecture 1.** The role of polymers in living nature and their importance as industrial materials. Basic concepts and definitions of the chemistry of high molecular weight compounds. | 1 | |
| 1 | **Lab lesson 1.** Labwork №1. Study of the kinetics of radical polymerization of methyl methacrylate (MMA) or styrene in bulk in the presence of azobisisobutyronitrile (AIBN) by dilatometric method | 4 | 5 |
| 2 | **Lecture 2.** Classification of polymers. Molecular weight of polymers and its types. | 1 | |
| 2 | **Lab lesson 2.** Labwork №1. (continue) Study of the kinetics of radical polymerization of methyl methacrylate (MMA) or styrene in bulk in the presence of azobisisobutyronitrile (AIBN) by dilatometric method | 4 | 5 |
| 3 | **Lecture 3.** Synthesis of polymers. Radical polymerization. | 1 | |
| 3 | **Lab lesson 3.** Labwork №2. Determination of molecular weight of polymers by viscometric method | 4 | 10 |
| 3 | **IWSL 1.** Consultation on the implementation of IWS1. Radical copolymerization. Copolymerization types.<br>«Determination of the radical copolymerization constants in the system of the methyl methacrylate - vinyl butyl ether (methyl methacrylate - styrene)». Consultation | | |
| 4 | **Lecture 4.** Ionic polymerization. Cationic polymerization and anionic polymerization, kinetics. | 1 | |
| 4 | **Lab lesson 4.** Labwork №3. Evaluation of polydispersity of polymers by viscometric method | 4 | 10 |
| 5 | **Lecture 5.** Ion Coordination Polymerization. | 1 | |
| 5 | **Lab lesson 5.** Labwork №4. Synthesis of polystyrene by cationic polymerization. | 4 | 10 |
| 5 | **IWSL 2.** Defense of IWS 1. Radical copolymerization. Copolymerization types. «Determination of the radical copolymerization constants in the system of the methyl methacrylate - vinyl butyl ether (methyl methacrylate - styrene)» | | 30 |
| 6 | **Lecture 6.** Stepwise processes of formation of macromolecules. Polycondensation. Kinetics and mechanism of polycondensation. | 1 | |

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| 6 | **Lab lesson 6.** Labwork №5. Synthesis of glyphthalic resin. | 4 | 5 |
| 7 | **Lecture 7.** Features of the polymer state of matter. Configuration and conformation of polymers. | 1 | |
| 7 | **Lab lesson 7.** Labwork №5. (continue) Synthesis of glyphthalic resin. | 4 | 5 |
| 7 | **IWSL 3. Colloquium** | | 20 |
| 7 | **LEVEL CONTROL 1** | | 100 |
| 8 | **Lecture 8.** Polymer chain flexibility. Loosely linked chain. | 1 | |
| 8 | **Lab lesson 8.** Labwork №6. Obtaining phenol-formaldehyde resins and studying some of their properties | 4 | 5 |
| 9 | **Lecture 9.** The structure of crystalline and amorphous polymers. Supramolecular structures of crystalline and amorphous polymers. Three physical states of amorphous polymers. | 1 | |
| 9 | **Lab lesson 9.** Labwork №6. (continue) Obtaining phenol-formaldehyde resins and studying some of their properties | 4 | 5 |
| 9 | **IWSL 4.** Consultation on the implementation of IWS 2 «Plotting thermomechanical curves» | 1 | |
| 10 | **Lecture 10.** Relaxation phenomena in polymers. Deformation properties of polymers in highly elastic state. Viscous state of polymers | 1 | |
| 10 | **Lab lesson 10.** Labwork №7. Determination of the glass point for polystyrene | 4 | 10 |
| 11 | **Lecture 11.** Mechanical properties of polymers in glassy and crystalline states. The phenomenon of forced elasticity | 1 | |
| 11 | **Lab lesson 11.** Labwork №8. Study of swelling kinetics of polymer hydrogels in different media | 4 | 5 |
| 11 | **IWSL 4.** Defense of IWS 2 «Plotting thermomechanical curves» | 1 | 20 |
| 12 | **Lecture 12.** The nature of polymer solutions, features of their physical and chemical properties. Dissolution thermodynamics | 1 | |
| 12 | **Lab lesson 12.** Labwork №8. (continue) Study of swelling kinetics of polymer hydrogels in different media | 4 | 5 |
| 12 | **IWSL 5.** Consultation on the implementation of IWS 3 «Polymer solutions» | 1 | |
| 13 | **Lecture 13.** Phase diagrams of polymer solutions. Raoult's law. State equation for a polymer. Thermodynamic quality of solvent | 1 | |
| 13 | **Lab lesson 13.** Labwork №9. Determination of the isoelectric point of polyampholyte (gelatin). | 4 | 5 |
| 14 | **Lecture 14.** Ionizing macromolecules (polyelectrolytes). Features of the behavior of polyelectrolytes. | 1 | |
| 14 | **Lab lesson 14.** Labwork №9 (continue) Determination of the isoelectric point of polyampholyte (gelatin). | 4 | 5 |
| 14 | **IWSL 6.** Defense of IWS 3 «Polymer solutions» | 1 | 20 |
| 15 | **Lecture 15.** Chemical reactions of polymers, features. | 1 | |
| 15 | **Lab lesson 15.** Labwork №10. Determination of the isoionic point of polyampholyte (gelatin). | 4 | 10 |
| 15 | **IWSL 7. Colloquium** | 1 | 10 |
| 15 | **LEVEL CONTROL 2** | | 100 |
| | **Final control** | | 100 |

**Criteria for evaluation of individual work of student.**

**IWS 1. «Determination of the radical copolymerization constants in the system of the methyl methacrylate - vinyl butyl ether (methyl methacrylate - styrene)»**

| Criteria for evaluation | Unsatisfactory (0-50%) | Satisfactory (50-75%) | Good (75-85%) | Excellent (90-100%) |
|---|---|---|---|---|
| **Task 1** | The work was done correctly at least for 50%: materials and equipment are not indicated completely; lack of an answer to some questions. | Completed at least 50% of all tasks, the approach to the solution is correct, but there are mistakes; only two of subtasks listed have been fulfilled. | At least 75% of the task was completed, and the solving route was correct: the materials and equipment were listed correctly, the synthesis procedure was described in detail; one method for determining the composition of | All tasks in the work were completed; the synthesis procedure is described in detail; several methods for determining the composition of copolymers are described; the solving |

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| | | | copolymers is described. | route and the results are correct. |
| | The work is standard, formulaic, demonstrates a formal attitude of student | The student showed interest, but did not demonstrate independence and creative approach in work | Work is independent, demonstrates an attempt to present personal view at the topic, elements of creativity are applied | The work is distinguished by a non-standard, creative approach to topic, problem solving, and design. |
| | Analytics is missing | There are some scattered analytical judgments | The analytics is high-quality in some places, in some superficial | Analytics is deep and complex |
| **Task 2** | The work is done correctly less than for 50%: there are attempts to solve one problem or write a reaction scheme. | Completed at least 50% of all tasks: there are correct answers to two questions | At least 75% of the task was completed and the solving route was correct: there were mistakes in writing the reaction scheme, a graph was built, but constants were not found. | All tasks in the work have been completed and the percentage of correctness of the solving route and calculations is at least 85%: there are minor mistakes in writing the reaction scheme. |
| | Incorrect interpretation of conclusions, or lack of conclusions | Incomplete interpretation of conclusions containing mistakes. | Incomplete interpretation of conclusions, which does not reflect the essence of the work. | Reasonably grounded conclusions, correct and complete interpretation of conclusions, the student expresses and proves his point of view. |

**IWS 2 «Thermomechanical curves of polymers»**

| **Assessment criteria** | **Unsatisfactory (0-50%)** | **Satisfactorily (50-75%)** | **Good (75-90%)** | **Excellent (90-100%)** |
|---|---|---|---|---|
| **Task 1**<br><br>**max 4 p.** | **0.00-1.99**<br>Structural formulas of 2-3 substances correspond to the indicated polymers, there are attempts to determine the flexibility of polymers. The work does not reveal the main content of the assignment and there are no conclusions and generalizations; or the work is completely borrowed. | **2.00-2.99**<br>There are attempts to write and explain the list of polymers in ascending order of flexibility and structural formulas of 3-4 polymers, which are typed in a graphic editor; or 1 mistake in writing structural formulas, but the job was scanned. The answer is not complete, unsystematic, there is no logical sequence. Plagiarism elements are present. | **3.00-3.59**<br>Structural formulas fully correspond to the indicated polymers, but are not executed in a graphical editor, i.e. task scanned from a notebook; or typed in a graphical editor, but there is one mistake in writing the structural formula. There may be 1-2 mistakes in determining flexibility and justifying the answer. The task was done neatly, the material is well stated. There is no plagiarism of work. | **3.60-4.00**<br>The structural formulas fully correspond to the indicated polymers and are executed in a graphic editor. Polymers are correctly numbered according to the assignment i.e. the flexibility of polymers is correctly defined. An exhaustive justification of the answer is given, i.e. reasoned and logically stated. There are no errors in the assignment and the assignment is completely neat. There is no plagiarism at all. |
| **Task 2**<br><br>**max 3 p.** | **0.00-1.49**<br>Less than 50% of all possible correct structural formulas of the required polymer dyads are presented using a graphical | **1.50-2.24**<br>Less than 75% of all possible correct structural formulas of the required polymer dyads are presented using a graphical | **2.25-2.54**<br>At least 75% of all possible correct structural formulas of the dyads of the required polymer are presented using a | **2.55-3.00**<br>All possible correct structural formulas are presented that correspond to the dyad of the required polymer. Formulas are |

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| | editor and polymer dyad names. The work does not reveal the main content of the assignment and there are no conclusions and generalizations; or the work is completely borrowed. | editor and polymer dyad names. The answer is not complete, unsystematic, there is no logical sequence. Plagiarism elements are present. | graphical editor. If you spell out all the formulas in the scanned version, the score decreases. There may be 1-2 errors in the presentation of the names of polymer dyads. The task was done neatly. | executed in a graphical editor clearly and correctly. The correct names are given to the presented dyads (configuration isomers). There are no errors in the assignment and the assignment is completely neat. |
| **Task 3**<br><br>**max 7 p.** | **0.00-3.49**<br>Less than 50% of correctly constructed thermomechanical curves are presented using a graphical editor and explanations for the construction of thermomechanical curves. There is poorly formed and incomplete knowledge; or the work is completely borrowed. | **3.50-5.24**<br>Less than 75% of correctly constructed thermomechanical curves are presented using a graphical editor and explanations for the construction of thermomechanical curves. The material is presented in an unsystematic, fragmentary manner; the insufficient formation of knowledge and skills on thermomechanical curves is shown. Plagiarism elements are present. | **5.25-6.29**<br>At least 75% of correctly constructed thermomechanical curves are presented using a graphical editor; or the answer is completely correct, but made in a workbook and scanned. A reasonable and comprehensive explanation of the construction of thermomechanical curves in accordance with the task is given. A comparative analysis of elastomers and plastics is presented, polymers in the task are correctly assigned to elastomers and plastics. There may be minor errors in the assignment and the assignment is completely neat. There is no plagiarism at all. | **6.30-7.00**<br>Thermomechanical curves are built using a graphical editor (Excel or others) and correspond to the true form of the curves. A well-grounded, well-reasoned and comprehensive explanation is given for the construction of thermomechanical curves in accordance with the task. A detailed comparative analysis of elastomers and plastics is presented, the polymers in the task are correctly assigned to elastomers and plastics. There are no errors in the assignment and the assignment is completely neat. There is no plagiarism at all. |
| **Task 4**<br><br>**max 6 p.** | **0.00-2.99**<br>Less than 50% of thermomechanical curves are constructed using a graphical editor (Excel or others) and are corresponding to the true form of curves of the requested series of polymer homologies; correct labeling of transition points, physical states and correct names are presented. There is poorly formed and incomplete knowledge; or the work is completely borrowed. | **3.00-4.49**<br>Less than 75% of thermomechanical curves are constructed using a graphical editor (Excel or others) and are corresponding to the true form of the curves of the requested series of polymer homologies; correct labeling of transition points, physical states and correct names are presented. The material is presented in an unsystematic, fragmentary manner; the insufficient formation of knowledge and skills on thermomechanical | **4.50-5.09**<br>At least 75% of thermomechanical curves are presented, built using a graphical editor (Excel or others) and corresponding to the true form of the curves of the requested series of polymer homologies; correct labeling of transition points, physical states and correct names are presented. There may be minor errors in the assignment and the assignment is completely neat. There is no plagiarism at all. | **5.10-6.00**<br>Thermomechanical curves were built using a graphical editor (Excel or others) and correspond to the true form of the curves of the requested series of polymer homologies. The points of transitions, physical states are correctly marked and given the correct names. A well-grounded, well-reasoned and comprehensive explanation is given for the construction of thermomechanical curves in accordance with the task. There |

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| | | curves is shown. Plagiarism elements are present. | | are no errors in the assignment and the assignment is completely neat. There is no plagiarism at all. |

**IWS -3. «Polymer solutions»**

| Evaluation criteria | Unsatisfactory (0-50%) | Satisfactory (50-75%) | Good (75-90%) | Excellent (90-100%) |
|---|---|---|---|---|
| **Task 1** | The work was done correctly for less than 50%: the axes are not indicated, there is no explanation for the graph, there are 2 errors in the location of the curves on the graph. The work is standard, formulaic, demonstrates the formal attitude of the student. Analytics is missing. | At least 50% of all tasks was completed, the approach to the task solution is correct, but there is one error in the location of the curves on the graph. The student showed interest, but did not demonstrate independence and creativity in work There are some scattered analytical judgments. | At least 75% of the task was completed and the solution was correct: the phase diagrams are shown correctly, there are explanations for the answer with some inaccuracies. Independent work, demonstrates an attempt to present a personal view of the topic, elements of creativity are applied. The analytics is partly high-quality, partly superficial. | All tasks in the work were completed; the phase diagrams are shown correctly, the course of the task solution and the results are correct. The answer is reasoned and described in detail. The work is distinguished by a non-standard, creative approach to the topic, problem solving, design. Deep and complex analytics. |
| **Task 2** | The work was done correctly for less than 50%: the axes are not indicated, there is no explanation for the graph, there are errors in the location of the curves on the graph. Incorrect deviations from ideality are indicated. Incorrect interpretation of conclusions, or lack of conclusions. | At least 50% of all tasks was completed, the approach to the task solution is correct, but there is one error in the location of the curves on the graph. Incomplete interpretation of the assignment findings with errors. | At least 75% of the task was completed and the task solution was correct: the phase diagrams are shown correctly, there are explanations for the answer with some inaccuracies. Incomplete interpretation of the findings, not reflecting the essence of the work. | All tasks in the work were completed; the phase diagrams are shown correctly, the course of the task solution and the results are correct. Reasonably grounded conclusions, correct and complete interpretation of the conclusions, the student expresses and proves his point of view. |
| **Task 3** | There are errors in the determination of the second virial coefficient at different temperatures. The phase diagram is inaccurate, the axes are not labeled. | There are 1-2 errors in determining the second virial coefficient at different temperatures. | The task was completed correctly, but there are errors in the explanation of the answer. | The task was completed correctly, and reasoned conclusions were presented. |

Dean of the faculty — A.K. Galeyeva

Head of department — G.S. Irmukhametova

Lecturer — L.E. Agibayeva