Modular handbook of the educational program "Chemical technology of inorganic substances" (Ma)

Module name:	**M1 History and Philosophy of Science**
Semester(s) in which the module is taught	1 semester
The responsible person for the module	Candidate of Philosophical Sciences, Ibraeva N.A.
Language	Russian, Kazakh
Relationship to curriculum:	Basic discipline, university component
Teaching methods	Lecture, seminar
Study load (including contact hours, independent study hours)	Total workload – 120 hours: lectures – 30 hours; seminars – 15 hours; current MSIW – 50 hours; intermediate MSIW – 10 hours; MSIWT – 15 hours.
Credit scores	4 ECTS-credits
Required and recommended prerequisites (conditions) for admission to the module	Required bachelor modules: Philosophy, Modern history of Kazakhstan
Module Objectives / expected results of study	After master's students have completed the course, they should be able to: - recognize the forms and methods of pre-scientific, scientific and extra-scientific cognition, as well as modern methods of cognition; -to choose ways to solve problems arising in the course of research activities and requiring in-depth professional knowledge; - to discuss the collegial choice of the necessary research methods in practical classes, with critical analysis and understanding of the realities of modern theory and practice based on the methodology of natural science cognition; - streamline and comprehensively explore the features of the classification of sciences in the modern world; - submit a creative scientific report on the search for features of the study of knowledge about science.
Content	**Lectures:** History and philosophy of natural and technical sciences. New European Science in culture and civilization, the emergence of science, its historical dynamics, the structure of scientific knowledge, the philosophical problems of specific sciences. Communication technologies of the XXI century and their role in modern science. Philosophical problems of the development of modern global civilization. Modern current methodic, methodological and philosophical problems of the natural and social sciences and humanities, as well as special branches of scientific knowledge in accordance with the specialization of undergraduates. **Seminars:** The subject of history and philosophy of science. The ideological foundation of science. The functions of the philosophy of science. The emergence and formation of science. New European science. The main concepts and directions of non-classical and post-non-classical stage of development of science. Structural levels of scientific knowledge. Science as a profession. Philosophical foundations of science and scientific picture of the world. History and philosophy of natural and technical sciences. History and philosophy of social and human sciences. Philosophical problems of the development of modern global civilization.
Examination/Assessment Forms	Current control - reports on individual studies of pre-scientific, scientific and extra-scientific knowledge with a collective discussion, collective reports and discussions on practical studies of the realities of modern theory and practice based on the methodology of natural science knowledge; presentations of

	scientific reports on the search for features of studying knowledge about science, glossaries, abstracts, oral surveys. Final control-exam
Training and examination requirements	During the semester, the master's student must complete assignments according to the syllabus and score a minimum of 30, maximum 60 points, and score a minimum of 20, maximum 40 points on the exam.
Reading list of literature	1. Kokhanovsky V.P. Fundamentals of the Philosophy of Science. Moscow: Phoenix, 2010. 2. History and Philosophy of Science. Edited by Kryanev Yu.V., Motorina L.E. Moscow: Infra-M, 2011. 3. Lipkina A.I. Philosophy of Science. Moscow, 2009. 4. Myrzaly S.K. History and Philosophy of Science. Almaty, 2014. (in Kazakh) 5. Martynov M.I., Kravchenko L.G. Philosophy: Intensive Course. Minsk: TetraSystems, 2012. – 304 p.

Module name:	**M2 Foreign Language (Professional)**
Semester(s) in which the module is taught	1 semester
The responsible person for the module	PhD, Associate Professor, Zhorabekova A.N.
Language	English
Relationship to curriculum:	Basic discipline, a required component
Teaching methods	Seminars
Study load (including contact hours, independent study hours)	Total workload – 120 hours: Seminar – 45 hours; Current MSIW – 50 hours; Intermediate MSIW – 10 hours; MSIWT – 15 hours.
Credit scores	4 ECTS-credits
Required and recommended prerequisites (conditions) for admission to the module	Bachelor's degree modules: Foreign language 1, 2, Profession-oriented foreign language
Module Objectives / expected results of study	After completion of the module, master's students should be able to: - perceive and understand public speaking (lectures, presentations, television and Internet programs). - free to read, translate the original literature in the specialty with subsequent analysis, - to participate in professional discussions, scientific debates, round table discussions; - to present a presentation of a scientific research, an article on a specialty in a foreign language; - work with lexicographic sources in a foreign language.
Content	The study of the subject area of the specialty in a foreign language corresponding to the level B2, C1. Reading. Improving reading skills: mastering the main types of reading (introductory, learning, viewing, searching) of foreign original sources with varying degrees of content coverage. Formation of the ability to isolate the reference semantic blocks in the material, to determine the logical links between them, to critically interpret and analyze fragments of text depending on the specific characteristics and target setting. Writing. Development of skills for the preparation of written communications on scientific topics in the specialty: scientific report, abstracts on the topic of scientific research, poster report, reviewing of original sources in a foreign language, annotation of a scientific text, summary. The basic principles of business writing, the design of written documentation for international scientific cooperation. Listening. Listening to authentic professional-oriented materials with speech of foreign language speakers in audio and video recordings. Understanding the general content of authentic records. Listening to lectures, messages containing professional information. Speaking. Development of skills of oral communication in the specialty in monological form: presentation with a scientific report, communication, presentation of scientific research. Development of skills of professional oral communication in the form of dialogue / polylogue: scientific discussion, scientific debate, debate, round table discussions, the use of situational games (case study).
Examination/Assessment Forms	Current control: written work on the translation of technical texts, the presentation of technical texts on specialization, tests, role exchange, oral

	surveys. Final Control – Differentiated credit
Training and examination requirements	During the semester, the master's student must complete assignments according to the syllabus and score a minimum of 30, maximum 60 points, and score a minimum of 20, maximum 40 points on the exam.
Reading list of literature	1. Harrison R., S.Philot, L. Curnick. New Headway Academic skills. Reading, Writing, and Study Skills. Oxford University Press, 2013. 2. Technical English. - Oxford University Press, 2013. 3. Stepanova T.A. English for technical specialties. - Practical course. St. Petersburg, 2006. 4. English grammar in use. Raymond Murphy. –Cambridge-University-press, 2006. 5. May P. IELTS. Practice Tests. Oxford University Press, 2013.

Module name:	**M3 Psychology of Management**
Semester(s) in which the module is taught	1 semester
The responsible person for the module	Candidate of Psychological Sciences, Shomanbaeva A.O.
Language	Russian, Kazakh
Relationship to curriculum:	Basic discipline, university component
Teaching methods	Lecture, seminar
Study load (including contact hours, independent study hours)	Total workload – 90 hours: lectures – 15 hours; seminars – 15 hours; current MSIW – 45 hours; intermediate MSIW – 7.5 hours; MSIWT – 7.5 hours.
Credit scores	3 ECTS-credits
Required and recommended prerequisites (conditions) for admission to the module	Modules of bachelor's programme: Philosophy, Actual problems and modernization of public consciousness
Module Objectives / expected results of study	After completion of the module, Master's students should be able to: - to show sociability and socio-psychological competence in professional activities; - possess the skills of mental self-regulation; - to conduct a methodological analysis of the problem of personality psychology; - to set and solve psychological problems associated with developmental and correctional processes in accordance with the requirements of science and practice; - show positive thinking and initiative in solving actual pedagogical and research tasks; - to work in a team, to offer new motivational solutions to psychological problems related to professional activities.
Content	**Lectures:** Basic approaches and principles of modern psychological science, necessary in the professional activities of highly qualified specialists. Formation of the scientific-theoretical worldview on the fundamental psychological concepts, the development of ideas about psychological science, revealing the content of the discipline. Formation of skills and abilities of psychological researches of a personality, acquaintance with the main methods of experimental psychological research and the main directions of psycho-correction work; practical skills, ability to apply, interpret and draw conclusions based on the results obtained. **Practical works:** Psychology as a modern science. The main methods of psychological research. Introduction to the psychology of personality. The main theories of personality. Personality and culture, temperament. Character, abilities, emotions. Activity and its main characteristics. Sensation and perception. Attention and memory. Imagination, thinking, speech. The verge of communication: the exchange of information, interaction. Psychological features of people's perception and understanding of each other.
Examination/Assessment Forms	Current control: protection of written research reports, presentations. Final control-exam
Training and examination requirements	During the semester, the master's student must complete assignments according to the syllabus and score a minimum of 30, maximum 60 points,

	and score a minimum of 20, maximum 40 points on the exam.
Reading list of literature	1. Gippenreiter Y.B. Introduction to General Psychology. -M.: CheRO, 2013.-195p. 2. Krylov A.A. Psychology. -M: Prospect, 2014.-230 p. 3. Nemov R.S. Psychology.-M: Enlightenment, 2014, V.1. – 250 p. 4. Zhonisbekova Zh.A., Koyshybaeva N.I. A study guide for masters of all specialties in the discipline "Psychology", Shymkent: SKSU, 2016.-180p. 5.Lawton Jean-Marc. Aqa A-Level Psychology: Revision MadeEasy .- Hodder Education, 2017. - 256 p.

Module name:	**M4 Pedagogy and Psychology of Higher School**
Semester(s) in which the module is taught	1 semester
The responsible person for the module	Doctor of Pedagogical Sciences, Professor Kalybekova A.
Language	Russian, Kazakh
Relationship to curriculum:	Basic discipline, university component
Teaching methods	Lecture, seminar
Study load (including contact hours, independent study hours)	Total workload – 150 hours: lectures – 30 hours; seminars – 30 hours; current MSIW – 55 hours; intermediate MSIW – 12.5 hours; MSIWT – 22.5 hours.
Credit scores	5 ECTS-credits
Required and recommended prerequisites (conditions) for admission to the module	Bachelor's degree modules: Introduction to the specialty, Philosophy
Module Objectives / expected results of study	After master's students have completed the course, they should be able to: - to discuss the problems of conducting research in higher education and foresee new needs and requirements of education; - strive for the need for continuous professional development; - analyze pedagogical situations and give them a justification; - apply effective university education technologies; - criticize the existing methods of the pedagogical process; - organize lectures and practical classes on specialization among students with the adjustment of the program for a specific educational context.
Content	Lectures: Modern higher education paradigms. The system of higher professional education in Kazakhstan. Methodology of pedagogical science. Methodological apparatus of pedagogical research. Professional competence of a high school teacher. The organization of the learning process based on the credit system of education in higher education. Methods and forms of training in the preparation of future professionals. New educational technology in higher education. The activities of the advisor, tutor and office registrar at the university. Technology of compiling teaching materials. Higher school as a social institution of education and the formation of the personality of a specialist. The essence and the main directions of educational work at the university. **Seminars:** Methodological foundations of higher school pedagogy. A teacher and a student of a higher school is a creatively self-developing personality. Priority strategies and trends in the development of higher education, pedagogical regularities, principles and methods. Forms of organization of studies in high school. The essence and priority strategies of education of students, pedagogical innovation and pedagogical monitoring. The organization of the educational process of higher education. The concept of research, intellectual, innovative universities.
Examination/Assessment Forms	Current control: - written materials of independent tasks on the implementation of the educational concept, theory and research in a systematic way;

	- protection in writing of materials on the ability to manage and coordinate educational programs in practical classes with the results of their vision, - discussions with professional teachers, written surveys. Final control-exam
Training and examination requirements	During the semester, the master's student must complete assignments according to the syllabus and score a minimum of 30, maximum 60 points, and score a minimum of 20, maximum 40 points on the exam.
Reading list of literature	1. Akhmetova G.K., Isaeva Z.A. Pedagogy: a textbook for graduate universities. - Almaty: Kazakh University, 2012.-328 p. 2. Shalgynbaeva Q.K. Pedagogy. - Astana: publishing house of Gumilyov ENU, 2016. (in Kazakh) 3. Tileuova S.S. Higher school pedagogy. - Shymkent, 2013. (in Kazakh). 4. Mynbayeva A.K., Sadvakasova Z.M. Innovative teaching methods or how interesting to teach.-Almaty.2010. -174p.

Module name:	**M5.1 Designing Chemical Production**
Semester(s) in which the module is taught	1 semester
The responsible person for the module	Doctor of Technical Sciences, Professor Zhantasov K.T. Candidate of Technical Sciences, Professor Kadirbaeva A.A.
Language	Russian, Kazakh
Relationship to curriculum:	Basic discipline, elective component
Teaching methods	Lectures, practical classes
Study load (including contact hours, independent study hours)	Total workload – 120 hours: lectures – 15 hours; practical classes – 30 hours; current MSIW– 50 hours; intermediate MSIW– 10 hours; MSIWT – 15 hours.
Credit scores	4 ECTS-credits
Required and recommended prerequisites (conditions) for admission to the module	Bachelor's degree modules: Bases of Project Engineering and Equipment of Plants; Processes and Apparatuses of Chemical Technology, Fundamental of Chemical Technology
Module Objectives / expected results of study	Upon completion of this course, master's students should be able to: - analyze the results of calculating the mineralogical composition of natural raw materials based on their chemical composition; - describe the main technologies associated with the production of inorganic acids, salts, and fertilizers; - conduct process calculations to select optimal process parameters and determine performance indicators; - scientifically substantiate optimal production modes and process standards for the consumption of raw materials and energy resources; - perform calculations and process the results as part of the design of chemical engineering systems.
Content	**Lectures:** Process flow charts for the production of inorganic acids, salts, and mineral fertilizers, including the specifics of their extraction from lean phosphate raw materials. Calculation of the mineralogical composition of natural raw materials. Main process flows; calculation of decomposition processes for mineral and secondary raw materials. Methods for calculating material and heat flows, consumption of initial reagents and energy carriers, composition of finished products, and determining their quality. Material balances for the production of mineral acids, salts, and fertilizers: reactive, food-grade, and feed-grade phosphate salts of sodium, potassium, calcium, and ammonium; ammonium phosphate, diammonium phosphate, ammophos, potassium nitrate, and phosphate; and ammonium nitrate and sulfate. Consideration of raw material composition and the introduction of microelement additives in process calculations. Analysis of production efficiency indicators: determination of the raw material decomposition coefficient and product yield. Determination of the optimal production mode based on process calculations. **Practical classes:** Calculation of the mineralogical composition of natural

	raw materials. Material calculations for the decomposition of phosphate raw materials, the production of reactive, food-grade, and feed-grade phosphate salts of sodium, potassium, calcium, and ammonium, ammonium phosphate, diammonium phosphate, ammophosphate, nitrate, sulfate, and potassium phosphate, as well as ammonium nitrate and sulfate. Determination of the decomposition coefficient of natural raw materials. Thermal calculations for the production of complex mineral fertilizers, salts, and acids. Refined calculation of consumption coefficients for raw materials and heat transfer fluid based on material and heat balances. Calculation of the process yield of the product, taking into account the composition of the raw materials and the introduction of micronutrient additives. Calculation of the productivity of the main production equipment based on hourly process flows. Calculation of the amount of solid, liquid, and gaseous production waste. Determination of optimal production parameters based on process calculations.
Examination/Assessment Forms	Current control: - written materials of independent assignments on the implementation of the educational concept, theory and research in a systematic way; - written defense of materials on the ability to manage and coordinate educational programs during practical classes, reflecting the results of one's own vision; - discussions with professional educators, written surveys. Final assessment – exam
Training and examination requirements	During the semester, the master's student must complete assignments according to the syllabus and score a minimum of 30, maximum 60 points, and score a minimum of 20, maximum 40 points on the exam.
Reading list of literature	1. Kadirbaeva A., Zhantasov K., Moldabekov Sh. Okulyk. – Shymkent: M.әuezov atyndagy OқMU, 2015. 2. Fundamentals of design of chemical production: Textbook for universities / Ed. A. I. Mikhailichenko. – M.: ICC “Akademkniga” 2010. – 371 p. 3. Zhanmoldaeva Zh.K. Chemical technology negizderi, mysaldars and esepteri. Oku kuraly.- Shymkent: M.O.Auezov at.OҚMU, 2004.-79b. 4. Dzhanmuldaeva Zh.K., Seitmagzimova G.M. “Zhalpy chemical technology esepteuleri.” Electrondyk oku kuraly.- 2008. 5. Eskendirova M.M., Kadirbaeva A.A. Project Engineering the Chemical Productions/Textbook. – Shymkent, SKSU named after. M. Auezova. 2017 – 187 p. 6. Fundamentals of designing chemical production: textbook / S. I. Dvoretsky, D. S. Dvoretsky, G. S. Kormiltsin, A. A. Pakhomov. – Moscow: Spektr Publishing House, 2014. – 356 p. 7. Sinnott R.K. Chemical Engineering Design: Chemical Engineering. Volume 6/FourthEdition. — Elsevier, Butterworth-Heinemann, 2005. XVI, 1038 p. — ISBN: 0-7506-6538-6.

Module name:	**M 5.2 Statistical Methods for Processing Scientific Data**
Semester(s) in which the module is taught	1 semester
The responsible person for the module	Candidate of Technical Science, Associate Professor Zhaksanova A.
Language	Russian, Kazakh
Relationship to curriculum:	Basic discipline, elective component
Teaching methods	Lectures, practical classes
Study load (including contact hours, independent study hours)	Total workload – 120 hours: lectures – 15 hours; practical classes – 30 hours; current MSIW– 50 hours; intermediate MSIW– 10 hours; MSIWT – 15 hours.
Credit scores	4 ECTS-credits
Required and recommended prerequisites (conditions) for admission to the module	Bachelor's degree modules: Processes and Apparatuses of Chemical Technology, Fundamental of Chemical Technology.
Module Objectives / expected results of study	Upon completion of this course, master's students should be able to: - use computer programs to solve problems in their professional activities; - develop skills in using statistical methods in processing and analyzing scientific research data; - master the theoretical foundations of applying statistical methods; - acquire practical skills in working with applied statistical programs; - calculate statistical indicators using electronic statistical programs such as MS Office Excel, STATISTICA, and SPSS..
Content	**Lectures:** Processing experimental results using statistical methods. The concept of a random variable. Basic numerical characteristics of a random variable: mathematical expectation, variance. Stochastic relationship. The concept of a population, a sample. Sample statistical characteristics: arithmetic mean, sample variance, sample correlation coefficient. Passive experiment. Methods of correlation and regression analysis in processing chemical experiment data. Types of regression. Determining model parameters using the least squares method. Statistical analysis of chemical experiment results. Determining the homogeneity of variances using the Cochran test. Estimating the variance of reproducibility. Student's t-test for assessing the significance of regression coefficients. Fisher's test for checking the adequacy of the obtained regression equation to a real experiment. Fractional factorial experiment. Algorithm of the simplex method. Planning and optimization of the mechanical dewatering of peat using the simplex method. Statement of the optimization problem in chemical technology. Optimality criterion, objective function, and optimization resources. General strategy for solving optimization problems on a computer. Optimization methods and classification. Full factorial experiment (FFE). Concept of the planning matrix, variation interval, and base level. Variable coding. Properties of the planning matrix. Determining the FFE regression

	coefficients. Experimental and statistical methods of optimization. The Box-Wilson method. **Practical classes:** Processing experimental results using statistical methods. Concept of a random variable. Basic numerical characteristics of a random variable. Sample statistical characteristics: arithmetic mean, sample variance, sample correlation coefficient. Passive experiment. Methods of correlation and regression analysis in processing chemical experiment data. Types of regression. Statistical analysis of chemical experiment results. Analysis criteria. Formulation of the optimization problem in chemical engineering. Optimality criterion, objective function, and optimization resources. General strategy for solving optimization problems on a computer. Optimization parameters for chemical engineering systems. Performance indicators for chemical engineering processes.
Examination/Assessment Forms	Current control: - written materials of independent assignments on the implementation of the educational concept, theory and research in a systematic way; - written presentation of materials on the ability to manage and coordinate educational programs during practical sessions, demonstrating the results of one's vision; - discussions with professional educators, written surveys. Final assessment – exam
Training and examination requirements	During the semester, the master's student must complete assignments according to the syllabus and score a minimum of 30, maximum 60 points, and score a minimum of 20, maximum 40 points on the exam.
Reading list of literature	1. 1. Statistical Methods of Analysis: [textbook] / I.S. Shorokhova, N.V. Kislyak, O.S. Mariev; Ministry of Education and Science of the Russian Federation, Ural Federal University. - Yekaterinburg: Ural University Publishing House, 2015. - 300 p. 2. 2. Barsukov A.V., Pankina I.A. (compiled) Mathematical Processing of Results of Physicochemical Measurements. - St. Petersburg: SPbTEI, 2011. - 30 p. 3. 3. Agayants I.M. Basics of Statistics in the World of Chemistry: Processing Experimental Data. - St. Petersburg: NOT Publishing House, 2015.-614 p.

Module name:	**M 6.1 Research Methods of Inorganic Compounds**
Semester(s) in which the module is taught	1 semester
The responsible person for the module	Candidate of Technical Sciences, Associate Professor Koshkarbaeva Sh.T.
Language	Russian, Kazakh
Relationship to curriculum:	Basic discipline, elective component
Teaching methods	Lectures, laboratory classes
Study load (including contact hours, independent study hours)	Total workload – 120 hours: lectures – 15 hours; laboratory classes – 30 hours; current MSIW– 50 hours; intermediate MSIW– 10 hours; MSIWT – 15 hours.
Credit scores	4 ECTS-credits
Required and recommended prerequisites (conditions) for admission to the module	Bachelor's degree modules: Physics, Fundamentals of Scientific Research, Analytical Chemistry
Module Objectives / expected results of study	Upon completion of this course, master's students should be able to: - define the goals, objectives, and key stages of research projects; - to master the methods of theoretical, analytical and experimental research of inorganic substances; - substantiate their judgments and select research and development methods; - perform optimal experimental design, conduct research and process experimental data; - draw conclusions based on the research results and propose ways to improve technological processes.
Content	**Lectures:** Theoretical and Applied Research. Stages of Planning and Conducting Research on Inorganic Compounds. Methods for Selecting and Evaluating Research Topics. Processing and Analyzing Scientific Information, Formulating Research Objectives. Theoretical Research Methods. Creative Thinking, the Creative Process of Theoretical Research. Problems Solved Using Theoretical Research Methods. Analytical, Chemical, Physicochemical, and Instrumental Research Methods. Probabilistic-Statistical Research Methods. Systems Analysis Method. Experimental Plan and Program. Objectives, Tasks, and Stages of the Experiment. Measurement Methods and Instruments. Errors. Conducting and Presenting Experimental Results. Methods for Assessing Experimental Adequacy. Methods for Processing Measurement and Observation Results. **Laboratory Classes:** Setting the Goal and Objectives of Scientific Research, Conducting an Analytical Review of the Research Topic, Calculating Process Indicators, and Mathematically Describe Relationships Using Experimental Planning, Analysis, and Data Processing Software. Setting up an experiment, performing experimental work on the research topic, assessing measurement

	error in parallel experiments, analyzing raw materials, semi-finished products and products using chemical, analytical and physicochemical methods.
Examination/Assessment Forms	Current control: - submission of a literature review, successful completion of technological calculations for the experiment; written and oral quizzes. Final assessment - exam
Training and examination requirements	During the semester, the master's student must complete assignments according to the syllabus and score a minimum of 30, maximum 60 points, and score a minimum of 20, maximum 40 points on the exam.
Reading list of literature	1. Myrzakhozha D.A., Myrzakhodzhaev A.A. Physicochemical Methods of Analysis. – Almaty, 2009. – 113 p. 2. Lebukhov R.I. et al. Physicochemical Research Methods. – Lan Publishing House, 2012. – 430 p. 3. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 4: Experimental Techniques and Methodical Developments .- Apple Academic Press Inc., 2018. — 419 p. 4. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 2: Principles, Methodology, and Evaluation Methods .- AppleAcademicPressInc., 2018. — 393 p.

Module name:	**M 6.2 Physico-Chemical Analysis of Inorganic Substances**
Semester(s) in which the module is taught	1 semester
The responsible person for the module	Candidate of Technical Sciences, Associate Professor Koshkarbaeva Sh.T.
Language	Russian, Kazakh
Relationship to curriculum:	Basic discipline, elective component
Teaching methods	Lectures, laboratory classes
Study load (including contact hours, independent study hours)	Total workload – 120 hours: lectures – 15 hours; laboratory classes – 30 hours; current MSIW– 50 hours; intermediate MSIW– 10 hours; MSIWT – 15 hours.
Credit scores	4 ECTS-credits
Required and recommended prerequisites (conditions) for admission to the module	Bachelor's degree modules: Physics, Fundamentals of Scientific Research, Analytical Chemistry
Module Objectives / expected results of study	Upon completion of this course, master's students should be able to: - analyze the operating principles of basic physicochemical methods, such as electrochemical, spectral, chromatographic, thermal, and mass spectrometric. - select and justify the principles of electrochemical reactions, electrode potentials, operating principles of electrochemical cells, and various types of electrodes. - perform quantitative and qualitative analysis of inorganic substances using the methods studied. - effectively apply various sample preparation techniques for solid, liquid, and gaseous inorganic samples. - analyze the obtained data (spectra, chromatograms, thermograms, titration curves) and draw valid conclusions about the composition, structure, and properties of inorganic substances. - ability to solve complex analytical problems related to determining the composition and properties of inorganic substances. - ability to formulate analytical problems, select appropriate methods for their solution, and propose solutions to potential problems.
Content	**Lectures:** Classification of physicochemical analysis methods. Theoretical foundations of analytical methods. Measurement errors and their classification. Statistical processing of analytical results. Calibration curves and their plotting. Electrochemical methods of analysis. Potentiometric methods. Voltammetric methods. Conductometric methods. Coulometric methods. Spectral methods of analysis. Atomic absorption spectrometry. X-ray methods of analysis. Chromatographic methods of analysis. Fundamentals of chromatography. Gas chromatography (GC) for inorganic compounds. Liquid chromatography (HPLC) for inorganic compounds.

	Laboratory classes: Preparation of solutions and fundamentals of quantitative analysis. Statistical processing of measurement results, Potentiometric determination of pH and ion concentration. Potentiometric titration. Mastering the potentiometric titration technique for determining the equivalence point. Quantitative determination of a substance by UV/visible spectrophotometry. Determination of elements by atomic absorption spectrometry (AAS). Emission spectral analysis. Determination of inorganic ions by ion chromatography.
Examination/Assessment Forms	Current control: - submission of a literature review, successful completion of technological calculations for the experiment; written and oral quizzes. Final assessment - exam
Training and examination requirements	During the semester, the master's student must complete assignments according to the syllabus and score a minimum of 30, maximum 60 points, and score a minimum of 20, maximum 40 points on the exam.
Reading list of literature	1. Mukhidova Z. Sh. Analytical chemistry and physicochemical methods of analysis. Laboratory classes: Textbook / Z. Sh. Mukhidova - 2nd ed., - St. Petersburg: Lan, 2025. - 132 p. 2. Lebukhov V.I. Physicochemical research methods. Textbook / V.I. Lebukhov, A.I. Okara, L.P. Pavlyuchenkova. - St. Petersburg: Lan, 2025. - 480 p. 3. Lakiza, N. V. Fundamentals of chemical methods of analysis: textbook / N. V. Lakiza; Ministry of Science and Higher Education of the Russian Federation, Ural Federal University named after the first President of Russia B. N. Yeltsin. - Yekaterinburg: Publishing house of the Ural. University, 2021. - 184 p.

Module name:	**M7.1 Graphic Analysis of Processes in Multicomponent Systems**
Semester(s) in which the module is taught	1 semester
The responsible person for the module	Candidate of Technical Sciences, Professor Seitmagzimova G.M.
Language	Russian, English
Relationship to curriculum:	Basic discipline, elective component
Teaching methods	Lectures, practical classes
Study load (including contact hours, independent study hours)	Total workload – 150 hours: lectures – 30 hours; practical classes – 30 hours; current MSIW – 55 hours; intermediate MSIW – 12.5 hours; MSIWT – 22.5 hours.
Credit scores	5 ECTS-credits
Required and recommended prerequisites (conditions) for admission to the module	Bachelor's degree modules: Technology of mineral fertilizers, Physical chemistry, Theory and technology of mineral-salt processes
Module Objectives / expected results of study	Upon completion of this course, master's students should be able to: - analyze the phase composition of a multicomponent water-salt system using a graphical analysis of the solubility diagram; - calculate the process material balance and target product yield in inorganic salt technology; - apply the results of evaporation and crystallization process calculations to improve the technology of inorganic acids and salts; - use knowledge of solubility and phase transformations in multicomponent water-salt systems to select a rational method for processing mineral raw materials.
Content	**Lectures:** Kinetic principles of mineral salt dissolution and crystallization from solutions. Effect of solution supersaturation on crystallization rate and crystal size. Graphical analysis of multicomponent water-salt systems and its importance for process calculations for inorganic salt production. Use of phase diagrams to select rational methods for processing mineral raw materials. State diagrams of ternary and quaternary systems. Calculation of evaporation, dissolution, and crystallization processes in ternary systems using solubility diagrams in the form of equilateral and right triangles. Graphical analysis of dissolution and crystallization processes using Jeneke solubility diagrams in quaternary systems. Compilation of a material balance of processes based on graphical calculations using solubility diagrams. Crystallization fields of simple salts and co-crystallization. Practical exercises: Graphical representation of the composition of a multicomponent system. Calculation of the material balance of mineral salt processing using solubility diagrams for ternary systems in equilateral and right triangles. Calculation of product yield, reagent consumption, and mother liquor composition using solubility diagrams in ternary systems CaO-P2O5-

	H2O, NH3-H3PO4-H2O, Na2O-P2O5-H2O, NaCl-KCl-H2O, KCl-MgCl2-H2O, NaCl-Na2SO4-H2O. Determination of the salt composition of the system and optimal conditions for the cyclic process of obtaining salts in mutual quaternary systems KCl-NaNO3-H2O, KCl-MgSO4-H2O, NaCl-NH4HCO3-H2O, Ca3(PO4)2-HNO3-H2O. Analysis of crystallization fields of quinary systems.
Examination/Assessment Forms	Current control: - processing of experimental results; lab reports, colloquiums; written surveys. Final assessment - exam
Training and examination requirements	During the semester, the master's student must complete assignments according to the syllabus and score a minimum of 30, maximum 60 points, and score a minimum of 20, maximum 40 points on the exam.
Reading list of literature	1. Seitmagzimova, G. M. Graphic analysis of processes in multicomponent systems: Study guide for master students / G. M. Seitmagzimova, Zh. K. Dzhanmuldayeva. - Shymkent: SKSU, 2019. - 80 p. 2. Esteban Brignole, Selva Pereda. Phase Equilibrium Engineering. - eBook ISBN: 97804445h.94716, Elsevier, 2013. - 346 rubles. 3. Stanley M. Walas. Phase Equilibria in Chemical Engineering. - Boston, EUA: Butterworth, 2013. – 688 p. 4. Stephen A. Nelson. Ternary Phase Diagrams. - Tulane University, 2011. 5. Petrovpavlovsky I.A., Dmitrevsky B.A., Levin B.V., Pochitalkina I.A. Technology of mineral fertilizers. - St. Petersburg: Prospect of Science, 2018. - 312 p.

Module name:	**M7.2 Advanced Studies of Phase Equilibria in Multi-Component Systems**
Semester(s) in which the module is taught	1 semester
The responsible person for the module	Candidate of Technical Sciences, Professor Seitmagzimova G.M.
Language	Russian, English
Relationship to curriculum:	Basic discipline, elective component
Teaching methods	Lectures, practical classes
Study load (including contact hours, independent study hours)	Total workload – 150 hours: lectures – 30 hours; practical classes – 30 hours; current MSIW – 55 hours; intermediate MSIW – 12.5 hours; MSIWT – 22.5 hours.
Credit scores	5 ECTS-credits
Required and recommended prerequisites (conditions) for admission to the module	Bachelor's degree modules: Technology of mineral fertilizers, Physical chemistry, Theory and technology of mineral-salt processes
Module Objectives / expected results of study	Upon completion of this course, master's students should be able to: - analyze the physicochemical principles of dissolution and crystallization processes; - calculate crystallization processes and final product yields in mineral fertilizer and salt technology; - apply the calculated crystallization process results to improve the technology of inorganic acids and salts; - use knowledge of solubility and phase transformations to select the optimal production process.
Content	**Lectures:** Properties of aqueous solutions of inorganic compounds. Activity of electrolyte solution components. Ionic strength of a solution. The mechanism of dissolution of solids. Kinetic laws and methods for accelerating the dissolution process. Crystallization of salts from solutions. The theory of nucleation and crystal growth. Large-scale industrial crystallization. Methods for producing large crystals and purifying solutions from impurities; application of recrystallization. Phase diagrams of ternary and quaternary systems. Analysis of phase transformations in a multicomponent system on a volumetric diagram. Analysis of evaporation, dissolution, and crystallization processes in ternary systems. Calculation of dissolution and crystallization processes in quaternary systems with mutually paired salts. Calculation of crystallization processes in a square diagram during isothermal evaporation and during exchange decomposition of salts. Features of the analysis of quinary systems. **Practical classes:** Calculation of the activity coefficients of solution components of various concentrations. Estimation of the degree of supersaturation and stability of supersaturated solutions. Determining the

	yield of the solid phase and the mass of the solution during isothermal evaporation and cooling of the solution in ternary systems with double salts and crystal hydrates. Calculating the material balance of mineral salt processing using solubility diagrams for ternary systems. Calculating the exchange decomposition process of salts using the Jeneke diagram.
Examination/Assessment Forms	Current control: - successful completion of technological calculations; colloquiums, written assessments. Final assessment: oral exam
Training and examination requirements	During the semester, the master's student must complete assignments according to the syllabus and score a minimum of 30, maximum 60 points, and score a minimum of 20, maximum 40 points on the exam.
Reading list of literature	1. Seitmagzimova, G. M. Graphic analysis of processes in multicomponent systems: Study guide for master students / G. M. Seitmagzimova, Zh. K. Dzhanmuldayeva. - Shymkent : SKSU, 2019. - 80 p. 2. Esteban Brignole, Selva Pereda. Phase Equilibrium Engineering. - eBook ISBN: 97804445ч.94716, Elsevier, 2013. - 346p. 3. Introduction to Chemical Engineering Thermodynamics // // J.M. Smith, Hendrick Van Ness, Michael M. Abbott. - McGraw-Hill Education, 2005. – 817p. 4. Stanley M. Walas. Phase Equilibria in Chemical Engineering - Boston, EUA: Butterworth, 2013. – 688 p. 5. Besterekov U., Bolysbek A.A., Nazarbek U.B. Galurgiyalyk urdister technologies: Okulyk. - Shymkent, 2014. 6. Bazhin N.M. Thermodynamics for chemists. / N. M. Bazhin, V. A. Ivanchenko, V. N. Parmon. - M.: Chemistry: Koloss, 2004. - 416 p.

Module name:	**M8 Research Work of a Master Student 1**
Semester(s) in which the module is taught	1 semester
The responsible person for the module	Leading full-time faculty members of the educational program who hold an academic degree. Department of Technology of Inorganic and Petrochemical Productions
Language	Russian, Kazakh
Relationship to curriculum:	Additional types of studying
Teaching methods	
Study load (including contact hours, independent study hours)	
Credit scores	1 ECTS-credit
Required and recommended prerequisites (conditions) for admission to the module	Methods of studying inorganic compounds, Design of chemical plants
Module Objectives / expected results of study	Upon completion of this course, master's students should be able to: - formulate the goal and objectives of a dissertation research project, as well as the object and subject of the research; - conduct a dissertation research project using advanced information technologies; - conduct scientific research in the field of mineral acid, salt, and fertilizer technology; - utilize advanced international experience in the field of mineral acid, fertilizer, and salt technology, and build on modern scientific and industrial achievements; - compile a research report and defend the obtained scientific results.
Content	An analysis of modern scientific and technological advances in a specific field of production, with a study of practical recommendations and methods for solving research problems. A justification for the relevance of the chosen research topic will be provided. A literature review and patent search will be conducted for new production methods in the studied area of research, as well as new technologies for obtaining inorganic compounds related to the master's thesis topic, using electronic databases. Research objectives will be stated. Chemical analysis of the raw materials used, chemical waste, and identification of their mineralogical composition using physicochemical research methods will be conducted. Preparation and defense of the research report for the third semester.
Examination/Assessment	Current control: - completed analytical review on the topic of dissertation

Forms	research. Final assessment - report
Training and examination requirements	During the semester, the master's student must complete assignments according to an individual work plan and score a minimum of 30, maximum 60 points, and score a minimum of 20, maximum 40 points when defending the report.
Reading list of literature	1. Zhantasov K.T., Iskandirov M.Z., et al. Modern technologies for processing mineral raw materials. Textbook. – Shymkent: SKSU named after M.Auezov, 2015. 2. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 2: Principles, Methodology, and Evaluation Methods .- Apple Academic Press Inc., 2018. — 393 p. 3. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 3: Interdisciplinary Approaches to Theory and Modeling with Applications.- — Apple Academic Press Inc., 2018. — 407 p. 4. Cavani F. et al. Sustainable Industrial Chemistry. Principles, Tools and Industrial Examples.- Wiley. 2009. - 623 p. 5. Seitmagzimova G.M., Kadyrbaeva A.A. Methodological guidelines for writing and defending a master's dissertation for master's students in scientific and pedagogical fields. - Shymkent: SKU named after M. Auezov, 2024. - 42 p.

Module name:	**M9 Pedagogical Practice**
Semester(s) in which the module is taught	2 semester
The responsible person for the module	Leading full-time faculty members of the educational program, appointed by the department meeting Department: Technology of Inorganic and Petrochemical Productions
Language	Russian, Kazakh
Relationship to curriculum:	Additional types of studying
Teaching methods	
Study load (including contact hours, independent study hours)	120
Credit scores	4 ECTS-credits
Required and recommended prerequisites (conditions) for admission to the module	Master's degree modules: Psychology of Management, Pedagogy and Psychology of Higher Education, History and Philosophy of Science.
Module Objectives / expected results of study	Upon completion of this course, master's students should be able to: -professionalize basic teaching methods and understand the structure and goals of the educational system; - apply logical and critical thinking to solve problems in the field of inorganic technology; - demonstrate the ability to conduct classes and communicate effectively with both individual students and groups; - utilize innovative teaching methods and manage time effectively; - combine existing teaching methods and professionally respond to the diverse needs of students; - improve their self-education and evaluate student learning outcomes and achievements.
Content	Developing a professional research culture in the field of chemical engineering of inorganic substances as a prerequisite for pedagogical excellence and creativity, developing professional and pedagogical skills in chemical engineering, and a culture of scientific and pedagogical thinking. Developing educational and methodological documents for the core discipline. Preparing for classes and conducting practical and laboratory classes in specialized disciplines for the bachelor's degree program "Chemical Engineering of Inorganic Substances." Developing new active learning methods for students and applying them in practical classes. Attending lectures given by leading faculty members of the department, as well as participating in educational and other activities with students. Participating in seminars and conferences on the implementation of modern teaching

	methods.
Examination/Assessment Forms	Final assesment – Differential credit
Training and examination requirements	During the semester, the master's student must complete assignments according to the work plan and score a minimum of 30, maximum 60 points, and score a minimum of 20, maximum 40 points when defending the report.
Reading list of literature	1. Akhmetova G.K., Isaeva Z.A. Pedagogy: A Textbook for University Master's Degrees. - Almaty: Kazakh University, 2012.-328 p. 2. Tileuova S.S. Pedagogy of Higher Education. - Shymkent, 2013. (in Kazakh). 3. Mynbaeva A.K., Sadvakassova Z.M. Innovative Teaching Methods or How to Make Teaching Interesting. - Almaty, 2010. -174 p. 4. Isaeva Z.A. et al. Active Forms and Methods of Teaching at a University. - Almaty, 2015. 5. Dresher Yu.N. Andragogy: Modern Technologies in the Preparation and Conduct of the Educational Process, 2017.

Module name:	**M10.1 Study of Thermodynamics and Kinetics of Technological Processes**
Semester:	2 semester
The responsible person for the module:	candidate of technical sciences, professor Tleuova S.T.
language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods:	Lecture, seminars (practical work)
Study load:	Lectures-30 hours; seminars -30 hours; current MSIW-55 hours; intermediate MSIW-12.5 hours; MSIWT- 22,5hours, Total labor intensity-150 hours
Credit scores:	5 ECTS-credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Methods of research of inorganic compounds, Design of chemical productions
Module Objectives / expected results of study:	After completion of the module, master's students should be able to: -Analyze the theoretical foundations of chemical thermodynamics and kinetics, calculate rate constants, activation energy and reaction order to determine the area of the technological process.; -To select and justify the application of various kinetic models to single-stage and multicomponent reactions in a variety of temperature and pressure conditions; -Analyze the thermodynamic probability of chemical processes taking into account changes in technological parameters; -Calculate the isobaric-isothermal potential, the equilibrium constant and the equilibrium yield of the product to justify the optimal technological regime;
Content:	**Lectures:** Thermodynamic concepts; The first principle of thermodynamics. Enthalpy; Heat capacity. Temperature dependence of enthalpy of reactions; Hess' law. Reversible chemical reactions; Gibbs energy dependence on temperature and pressure. Influence of temperature and pressure on the equilibrium position of reversible reactions; Methods for obtaining thermodynamic functions and thermochemical kinetics. Approximate methods for calculating enthalpy and entropy by stoichiometric composition; Approximate method for calculating Gibbs energy. Graphical dependences of thermodynamic parameters; Calculation of equilibrium constants. The rate of chemical reactions and kinetic curves; Kinetic equation. Monomolecular reactions; Kinetics of second-order reactions. Influence of temperature on the rate of chemical reactions; Temperature coefficient and the Arrhenius

	equation. Activation energy in the theories of chemical kinetics; Methods for determining activation energy. Approximate methods of chemical kinetics; The method of quasi-stationary concentrations. Derivation of the kinetic equation in the quasi-stationary approximation; Methods for determining the parameters of the kinetic equation. Kinetics of diffusion-limited reactions; Kinetics at comparable rates of diffusion and chemical reaction. Heterogeneous catalysis; Adsorption as a stage of heterogeneous catalytic reactions. **Practical classes:** Calculations of the heat capacity and enthalpy of reactions. Calculation of the enthalpy and entropy changes in the decarbonization reaction of calcium and magnesium carbonate. Calculation of changes in enthalpy and entropy of phosphorus reduction. Calculation of Gibbs energy of decarbonization of calcium and magnesium carbonate. Calculation of the Gibbs energy of phosphorus reduction. Calculation of the Gibbs energy of calcium carbide formation. Preparation and protection of calculations of thermodynamic characteristics. Calculation of the Gibbs energy of sodium hexametaphosphate formation. Calculation of the Gibbs energy of zinc oxide chlorination with calcium chloride. Calculation of the Gibbs energy of chromium oxide chlorination. Calculation of kinetic data of heterogeneous phosphorus reduction. Processing of experimental data on obtaining an effective enzyme constant according to the Kolmogorov equation. Processing of experimental data on the production of diammonium phosphate according to the Yander equation. Processing of experimental data on the production of superphosphate according to the Rotingen–Drozdov scheme. Determination of the apparent activation energy of heterogeneous catalytic processes.
Study / examination results forms of control:	Current control: - successful execution of technological calculations; colloquiums, written control papers. Final control – oral exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
Literature:	1. Tsvetkov D.S. General chemistry: fundamentals of chemical thermodynamics and kinetics: Theory and exercises: textbook.-the method. manual / D. S. Tsvetkov, T. V. Aksenova; Yekaterinburg: Ural Publishing House. University, 2017. — 120 p. 2. Kalyaeva N. A., Vasilyuk O. V. Chemical thermodynamics: a textbook for SPO / N. A. Kalyaeva, O. V. Vasilyuk. — St. Petersburg: Lan, 2024. — 156 p. 3. Mechkovsky, L. A. Chemical thermodynamics: A course of lectures. At 2 o'clock in 1. / L.A. Mechkovsky, A.V. Blokhin. Minsk: BSU, 2010. 141 p. 4. Chemical kinetics: textbook. manual / V. A. Cherepanov, T. V. Aksenova ; Yekaterinburg : Ural Publishing House. University, 2016. 132 p. 5. Dyachenko A.N. Chemical kinetics of heterogeneous processes: a textbook / A.N. Dyachenko, V.V. Shagalov; Tomsk: Publishing House of Tomsk Polytechnic University, 2014. 102 p. 6. Editor(s): Luis Arnaut,Chemical Kinetics (Second Edition), Elsevier, 2021, Pages v-ix,ISBN 9780444640390, https://doi.org/10.1016/B978-0-444-64039-0.00028-5

Module name:	**M10.2 Fertilizer Application Technologies**
Semester:	2 semester
The responsible person for the module:	PhD, associate professor Altybaev Zh.M.
Language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods:	Lecture, seminars (practical work)
Study load:	Lectures-30 hours; seminars -30 hours; current MSIW-55 hours; intermediate MSIW-12.5 hours; MSIWT- 22,5hours, Total labor intensity-150 hours
Credit scores:	5 ECTS-credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Methods of research of inorganic compounds, Design of chemical productions
Module Objectives / expected results of study:	After completion of the module, master's students should be able to: – to identify the need of soils for chemical reclamation and to calculate the norms of land reclamation; – master methods for calculating fertilizer rates for agricultural crops and fertilizer needs in crop rotation; – make a fertilizer application plan for the year; – to provide a scientific justification for the selected dates, methods, doses and forms of fertilizers applied, based on the agrochemical properties of soils, biological characteristics of crop nutrition; – calculate the balance of nutrients and humus, as well as the intensity of the balance.
Content:	**Lectures:** Harvesting of nutrients from the soil. The law of minimum, maximum, optimum and return. The structure of fertilizer application technology. Calculation of fertilizer doses and methods of their determination. Determination of application dates depending on the cultivated crops and forms of fertilizers. Methods of applying fertilizers, their role in crop formation. Basic and near-sowing fertilizers, top dressing. The fertilizer system in various crop rotations. Chemical soil reclamation. **Practical classes:** Calculation of the rates of application of mineral fertilizers based on the removal of nutrients by the crop and utilization coefficients. Calculation of the application rates of organic fertilizers (manure, compost, siderates), taking into account their chemical composition. Calculation of the ratio of macro- and microelements in complex fertilizers for various crops.

	Calculation of the need for lime or gypsum to regulate the pH of the soil. Calculations of the effectiveness of fertilizers and economic feasibility. Calculations for precision farming and application optimization.
Study / examination results forms of control:	Current control: - successful execution of technological calculations; colloquiums, written control papers. Final control – oral exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
Literature:	1. Torikov V.E. Fertilizer system in adaptive agriculture. Textbook / V.E. Torikov, N.M.Belous, O.V.Melnikova. - St. Petersburg: Lan, 2023. -196 p. 2. Fertilizer application system: textbook. manual /V.V. Lapa [et al.]; edited by V.V. Lapa – Grodno: GGAU, 2011. – 416 p. 3. Glukhikh M.A. Agrochemistry: a textbook / M.A.Glukhikh, Saint Petersburg: Lan, 2024. 104 p. 4. Samsonova N.E. Fundamentals of mineral nutrition of plants and technologies of application of fertilizers: A textbook. Smolensk: Smolenskaya State Agricultural Academy, 2021, 256 p. 5. Textbook of Fertilizers. Dipak Ranjan Biswas. Division of Soil Science and Agricultural Chemistry ICAR-Indian Agricultural Research Institute PUSA, New, 2021. - 247 p.

Module name:	**M11.1 Modern Constrution Materials in Chemical Technology**
Semester:	2 semester
The responsible person for the module:	candidate of technical sciences, associate professor Koshkarbayeva Sh.T.
Language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods:	Lectures, laboratory, practical
Study load:	Lectures-30 hours; laboratory classes -30 hours; practical classes - 15 hours, current MSIW-60 hours; intermediate MSIW-15 hours; MSIWT- 30 hours, Total labor intensity-180 hours
Credit scores:	6ECTS-credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Design of chemical productions. Bachelor's degree modules: Fundamentals of Chemical Technology, Corrosion and protection of metals, Processes and devices of chemical technology.
Module Objectives / expected results of study:	After completion of the module, master's students should be able to: - analyze the basic principles of material selection for chemical production equipment; - apply the results of process calculations to improve the technology of chemical production; - substantiate their judgments and choose construction materials for chemical technology; - draw conclusions based on the results of the study and propose methods for protecting the structural materials of technological processes.
Content:	**Lectures:** Study of characteristics and methods of protection of modern structural materials from corrosion. Promising structural materials used in the production of mineral salts, their corrosion resistance, modern ideas about the patterns and mechanisms of destruction of structural materials in the technology of inorganic compounds, metallic and non-metallic protective coatings. New methods of protecting equipment from corrosion, the use of electrochemical cathodic and anodic protection, corrosion inhibitors in scientific research. The use of artificial intelligence to design new devices.

	Laboratory classes: Investigation of the effect of temperature on the rate of gas corrosion of metals and on acid corrosion. Protection of structural materials from corrosion by means of a tread. Obtaining metal coatings on structural materials for corrosion protection. Investigation of the effect of inhibitors on the destruction of structural materials in acid solutions. Corrosion protection of chemical production materials using coatings obtained by the chemical method. **Practical classes:** Calculations of the main indicators of chemical production equipment. Material calculations of processes and devices of chemical technology of phosphorus production. Calculation of thermodynamic possibilities of gas corrosion of metals. Calculations of protection of structural metals and alloys from corrosion. Calculation of thermodynamic possibilities of electrochemical corrosion of metals. Calculations of protective coatings of metals.
Study / examination results forms of control:	Current control: - successful execution of technological calculations for the experiment; written and oral surveys. Final control– oral exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
Literature:	1. Solntsev Yu. P. Technology of structural materials: a textbook for universities / Yu. P. Solntsev, B. S. Ermakov, V. Yu. Pirainen. — 6th ed. — Saint Petersburg: KHIMIZDAT, 2024. — 504 p. 2. Gaz'aliev A.M. Materialtan zhane constructionalyk materialdar technologiyasi: Okulyk / A.M. Gaz'aliev [zhane T.B.]; KarMTU. - Karaganda: KarMTU baspasy, 2012. - 719 b. 3. Soshina T.O. New materials and technologies: a textbook for universities / T.O.Soshina, V.N.Trofimov. - St. Petersburg: Lan, 2023. - 196 p. 4. Kravtsov V.V., Zentsov V.N., Shingarkina O.V. Development, production and application of corrosion-resistant materials. Textbook: Infra-Engineering, 2023. 148 p. 5. Shrikaant Kulkarni, Vipul Srivastava. Contemporary Advancements in Materials Technology. Apple academic press, 2025. -342 p.

Module name:	**M11.2 Physical Chemistry of Surfaces**
Semester:	2 semester
The responsible person for the module:	Candidate of technical sciences, associate professor Koshkarbayeva Sh.T.
Language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods:	Lectures, laboratory, practical
Study load:	Lectures-30 hours; laboratory classes -30 hours; practical classes - 15 hours, current MSIW-60 hours; intermediate MSIW-15 hours; MSIWT- 30 hours, Total labor intensity-180 hours
Credit scores:	6 ECTS-credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Bachelor's degree modules: Physical and Colloidal Chemistry, Theoretical foundations of inorganic substances technology.
Module Objectives / expected results of study:	After completion of the module, master's students should be able to: - to explain the physico-chemical essence of phenomena and processes on the interfacial surface; - to use the acquired knowledge in the technology of mineral acids, fertilizers and salts for the analysis and design of production facilities; - manage the physico-chemical parameters of phenomena at the interface of phases to optimize technological processes and rational use of raw materials; - apply a scientifically based approach to the assessment and use of surface phenomena and dispersed systems; -apply adsorption isotherms to describe experimental data.
Content:	**Lectures:** Capillarity. The basic equation of the theory of capillary phenomena. Practical application of the Young–Laplace equation. Thermodynamics of liquid interfaces. Surface tension of solutions. Mixed films. Films on liquid–liquid and non-aqueous surfaces. Films deposited on the surface of solids. Theoretical estimates of surface energy and free surface energy. The solid–liquid interface. The marginal angle. Adsorption from solutions. Friction and lubrication. Adhesion wetting, flotation and washing action. The solid-gas interface. Physico-chemical properties of substances in an ultrafine state. Patterns and phenomena manifested by nanodisperse

	colloidal systems and materials. The structure and properties of the surface layers of matter at the nanometer level. **Laboratory classes:** Adsorption of gases on solid surfaces. Determination of the specific surface area of the adsorbent by adsorption isotherms. The study of the adsorption of surfactants. Determination of the critical concentration of micelle formation using methods of surface tension, conductometry and fluorescence.The effect of surfactant concentration on the surface tension of solutions. Construction of surface tension isotherms. Measuring the edge angle on various surfaces. Measurement of electrokinetic potentials. **Practical classes:** Analysis of the processes and phenomena of cohesion, adhesion, and wetting. Study of methods for determining surface tension and adsorption at the solid–gas interface. Application of the Langmuir adsorption isotherm equation for calculating adsorption and desorption processes. Calculation of Gibbs adsorption using the surface tension isotherm. Determination of molecular constants of surfactants. Study of coagulation of lyophobic sols by electrolytes. Calculation of coagulation thresholds, study of coagulation kinetics.
Study / examination results forms of control:	Current control: - successful execution of technological calculations; colloquiums, written control papers. Final control– oral exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
Literature:	1. Eskendirov M.Z. Physical chemistry of surfaces /Textbook. Shymkent, SKSU named after M.Auezov, 2016. 2. Shchukin E.D., Zelenev A.S. Physical-Chemical Mechanics of Disperse Systems and Materials. – Taylor & Francis Group, LLC, 2016. – 374 p. – ISBN: 1466567090. 3. Morachevsky A. G. Physical Chemistry. Surface phenomena and dispersed systems: A textbook. — 2nd ed., erased. St. Petersburg: Lan Publishing House, 2015. 160 p.: 4. Elaine M. McCash. Surface Chemistry. Oxford University Press, 2001. - 177 p. 5.Jean-Charles Joud, Marie-Geneviève Barthés-Labrousse.Physical Chemistry and Acid-Base Properties of Surfaces.ISTELtdJohnWiley.London, 2015. - 153 p.

Module name:	**M12.1 Energy Efficient Technologies of Mineral Acids**
Semester:	2 semester
The responsible person for the module:	Candidate of technical sciences, professor Seitmagzimova G.M.,
Language:	Russian, English
Relationship to curriculum:	Basic discipline, elective component
Teaching methods:	Lectures, laboratory, practical classes
Study load:	Lectures-30 hours; laboratory classes -30 hours; practical classes - 15 hours, current MSIW-60 hours; intermediate MSIW-15 hours; MSIWT- 30 hours, Total labor intensity-180 hours
Credit scores:	6 ECTS-credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Master's degree modules: Research methods of inorganic compounds, Graphic analysis of processes in multicomponent systems, Design of chemical productions.
Module Objectives / expected results of study:	After completion of the module, master's students should be able to: - use the acquired knowledge to select rational technological schemes; - analyze the results of thermal calculations of power plants in order to determine their energy efficiency; - operate with the results of calculating the heat utilization of chemical reactions to select the optimal production mode; - to develop new and improve existing technologies for processing mineral raw materials into inorganic acids; - to make optimal decisions on the modernization of existing equipment, on the selection of new equipment.
content:	**Lectures:** Trends in the use of Kazakhstani sulfur-containing raw materials for the production of sulfuric acid. Energy chemical units for pyrite roasting. Utilization of the heat of the firing gases in the fluidized bed furnace and in the recovery boiler. An energy technology plant for the production of sulfuric acid from sulfur. Utilization of sulfur combustion heat in cyclone and injection furnaces. Heat recovery of sulfur dioxide oxidation reaction in contact devices. Creation of energy-technological schemes for ammonia synthesis. Exergetic

	analysis of ammonia synthesis. Modern energy-saving scheme for the production of weak nitric acid at a pressure of 0.72 MPa. Energy-efficient equipment for nitric acid workshops. Heat recovery of the ammonia oxidation reaction in the recovery boiler. Methods of heat recovery by burning yellow phosphorus and hydration of phosphorus oxide. Regulation of the temperature and concentration regime of sulfuric acid extraction of phosphorites. Maintaining an optimal extraction temperature by cooling the circulating suspension in a vacuum evaporation unit. Production of boric acid from borate and datolite ores. Energy technology complexes for the production of hydrochloric acid. **Practical classes:** Calculation of the parameters of an intensive furnace with a fluidized bed for pyrite firing. The material and thermal balances of the furnace compartment. Calculation of the energy vapor output in the process of sulfur combustion heat recovery. Determination of the volume of heating steam produced in the ammonia oxidation department for the production of weak nitric acid. Calculation of the air flow rate supplied to the phosphorus combustion furnace and the cooling water supplied to the heat exchangers and to the furnace lid. Thermal calculations of the Karatau phosphorite extraction department. **Laboratory classes:** Comparative analysis of the production of sulfur dioxide from various types of sulfur-containing raw materials. Comparative analysis of the decomposition parameters of Karatau phosphorites from various deposits in dihydrate and semi-hydrate modes. Investigation of the effectiveness of de-fluorination of extractive phosphoric acid. Production of boric acid by decomposition of borates and datolite ores, analysis of process parameters. Determination of the degree of absorption of hydrogen chloride and the concentration of the resulting hydrochloric acid.
Study / examination results forms of control:	Current control: - successful solution of technological calculations; colloquiums, written control papers; written and oral surveys. Final control – *exam*
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
Literature:	1. Seitmagzimova G.M., Dzhanmuldaeva Zh.K. Energy efficient technologies of mineral acids. – Study guide, Shymkent, 2019. – 80p. 2. Bishimbaev U.K. and others. Phosphorus and phosphoric acid technology: Textbook.-Almaty, "Kitap", 2006. – 192s. (in Kazakh) 3. Bishimbaev U.K. et al. Synthesis of ammonia and technology of nitric acid: Textbook.-Almaty, "Kitap", 2006. – 428s. 4. Seitmagzimova G.M. The technology of mineral acids. – Study guide, Shymkent, 2018. – 98p. 5.Engineering Fundamentals and Problem Solving. Fifth Edition. // Arvid R. EIde, Rolad D. Jenison / Higher Education: Iowa State University, 2008. – 466p.

Module name:	**M12.2 Advanced Soda Ash Technologies**
Semester:	2 semester
The responsible person for the module:	Doctor of technical sciences, professor Anarbaev A.A.
Language:	Russian, Kazakh
Relationship to curriculum:	Basic discipline, elective component
Teaching methods:	Lectures, laboratory, practical
Study load:	Lectures-30 hours; laboratory classes -30 hours; practical classes - 15 hours, current MSIW-60 hours; intermediate MSIW-15 hours; MSIWT- 30 hours, Total labor intensity-180 hours
Credit scores:	6 ECTS-credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Bachelor's Degree modules: Soda and Soda Products Technology; Master's degree modules: Physico-chemical analysis of inorganic substances, Advanced study of phase equilibria in multicomponent systems.
Module Objectives / expected results of study:	After completion of the module, master's students should be able to: - to substantiate the optimal temperature regime of the absorption and carbonation columns in the production of soda ash; - to determine the conditions of carbonation of ammoniated brine for the crystallization of coarse-grained sodium bicarbonate; - compare different types of raw materials and methods of their processing into soda ash; - suggest ways to recycle distiller liquid.
Content:	**Lectures:** Traditional and alternative raw materials for the production of soda ash. Preparation of table salt brine by hydro-cutting method. The main stages of soda ash production by the Solvent method. Justification of the need to purify raw brine from calcium and magnesium impurities. Technological scheme of limestone firing. Promising schemes for the operation of an absorption column and refrigerating equipment at the stage of ammonification. Justification of the temperature and concentration regime of carbonation of ammoniated brine; methods of cooling and supplying carbon dioxide along the height of the column to obtain coarse-grained sodium

	bicarbonate. Separation of the suspension by filtration, optimal mode of sodium bicarbonate calcination with carbon dioxide recirculation. Modern methods of filter fluid processing, technological scheme of ammonia regeneration. New ways of recycling and recycling distillery liquid. **Laboratory classes:** Study of the firing process of carbonate raw materials of various compositions. Comparative carbonation of ammoniated brine by various methods. Investigation of the filtering properties of sodium bicarbonate precipitate. Determination of the product yield after calcination of sodium bicarbonate. Research of methods of distiller liquid processing. **Practical classes:** Calculation of the optimal ratio of brine and ammonia at the stage of ammonification. Determination of the optimal crystallization temperature of sodium bicarbonate and the degree of sodium utilization according to the solubility diagram in the NH4HCO3-NaCl system. Calculation of the material and thermal balance of the stages of ammonification of purified brine, carbonation of ammoniated brine and regeneration of ammonia from the filter fluid.
Study / examination results forms of control:	Current control: - successful execution of technological calculations; defense of laboratory work, colloquiums, written control papers. Final control– exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
Literature:	1. Overview of the soda ash market in the CIS. – Informline, 11th edition, Moscow, 2014. 2. Temesgen Atnafu, Seid Yimer. Calcium Chloride Recovery in Soda Ash Production by Solvay's Process / GRIN Verlag, 2013. – 77p. 3. Manufacturing sodium carbonate by the Solvay process: overview of the process for post students. – 2016. 4. Gerasimova A.I., Gerasimov P.A., Kharitokhin D.V. Technological calculations in the production of soda ash. Kemerovo, KuzSTU, 2008. 66 p. 5. Fedyaeva O.A. Industrial ecology: Soda ash production: Lecture notes. Omsk, 2007. - 145c.

Module name:	**M13.1 Innovative Technologies of Available Phosphates and Nitrates**
Semester:	2 semester
The responsible person for the module:	Doctor of technical sciences, professor Zhekeyev M.K.
Language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods:	Lectures, laboratory, practical
Study load:	Lectures-30 hours; laboratory classes -30 hours; practical classes - 15 hours, current MSIW-60 hours; intermediate MSIW-15 hours; MSIWT- 30 hours, Total labor intensity-180 hours
Credit scores:	6 ECTS-credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Bachelor's degree modules: Technology of mineral fertilizers; Master's degree subjects: Research methods of inorganic compounds, Graphic analysis of processes in multicomponent systems, Advanced study of phase equilibria in multicomponent systems.
Module Objectives / expected results of study:	After completion of the module, master's students should be able to: - to summarize the main scientific and technical problems and prospects for the development of the production of digestible phosphates and nitrates; - to choose the optimal parameters of the technological regime of mineral fertilizers production; - to identify the main disadvantages of traditional methods of producing digestible phosphates and nitrates; - to reproduce in the laboratory innovative methods of production of digestible phosphates and nitrates; - analyze the results of technological calculations to determine production efficiency.
Content:	**Lectures:** Features of decomposition of substandard phosphate raw materials by phosphoric acid. Production of enriched superphosphate. Promising methods for the production of granular ammoniated superphosphate. Modern methods of dicalcium phosphate production, the choice of a rational

	technological scheme of production. Methods of obtaining calcium and potassium metaphosphate. Comparative characteristics of the production of ammophos according to various technological schemes.Innovative methods of obtaining ammophos and diammophos. Production of ammonium nitrate. The use of heat of neutralization in the ITN apparatus. New methods used to improve the physical properties of ammonium nitrate. Conversion method for obtaining potassium nitrate. New methods of sodium nitrate production. Promising methods of ammonium sulfate production. The advantages of producing ammonium sulfate from coke oven gas. **Laboratory classes:** Analysis of qualitative indicators of assimilated phosphates and nitrates. Production of enriched double superphosphate and analysis of process parameters. Production of ammoniated superphosphate and analysis of process parameters. Production of dicalcium phosphate and analysis of process parameters.Production and quality control of ammophos. Study of the process of obtaining potassium nitrate. Preparation and analysis of ammonium sulfate composition. **Practical classes:** Calculation of consumption coefficients. The methodology for calculating the material balance of irreversible CTP. Methods of drawing up the energy (thermal) balance and thermal calculations of CTP. Technological calculations in the production of enriched and ammoniated superphosphate. Technological calculations in the production of nitroammophoski, nitroammophosphate and carboammophoski. Technological calculations in the production of liquid nitrogen and complex fertilizers.
Study / examination results forms of control:	Current control: - submission of a literary review, successful execution of technological calculations for the experiment; written and oral surveys. Final control– *exam*
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
Literature:	1. Dmitrevskiy B.A. Properties, preparation and application of mineral fertilizers. – St. Petersburg: Prospekt Nauki, 2013. – 326 p. 2. Erdman S.V., Frolova I.V., Korobochkin V.V. Chemical technology of inorganic substances: A textbook. - Tomsk, 2011. – 194 p. 3. Bishimbaev U.K., Zhantasov K.T., Moldabekov Sh. and others. Technology of complex and complex-mixed mineral fertilizers and their development trends.: Textbook. Shymkent: SKSU named after M.Auyezov, 2015. (in Kazakh) 4. Dzhanmuldayeva Zh.K., Kadyrbaeva A.A. Innovative technologies of assimilable phosphates and nitrates / Textbook. Shymkent: SKSU named after M.Auyezov, 2016. 233 p. (in Kazakh) 5. Martin B. Hocking. Handbook of Chemical Technology and Pollution Control. Third Edition. – Elseiver Inc., Canada: University of Victoria, 2005.

Module name:	**M13.2 Chemical Technology of Reactive Acids and Salts**
Semester:	2 semester
The responsible person for the module:	Candidate of technical sciences, professor Kadirbaeva A.A.
Language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods:	Lectures, laboratory, practical
Study load:	Lectures-30 hours; laboratory classes -30 hours; practical classes - 15 hours, current MSIW-60 hours; intermediate MSIW-15 hours; MSIWT- 30 hours, Total labor intensity-180 hours
Credit scores:	6 ECTS-credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Master's degree subjects: Physico-chemical analysis of inorganic substances, Advanced study of phase equilibria in multicomponent systems.
Module Objectives / expected results of study:	After completion of the module, master's students should be able to: - to summarize the main scientific and technical problems and prospects for the development of the production of reactive acids and salts; - to choose the optimal technological regime and rational hardware design for the production of reactive acids and salts; - identify the main technological problems and identify ways to improve existing production; - possess methods of purification of raw materials from harmful impurities and disposal of waste from the production of reactive acids and salts.
Content:	**Lectures:** The influence of external pollutants on the processes of deep purification of substances. Methods for obtaining high-purity substances. Production of orthophosphoric acid brands "ch" and "chda". Industrial methods of purification of thermal phosphoric acid from impurities.

	Hardware design for the production of reactive phosphoric acid of the "hc" brand. Optimal parameters for obtaining meta- and pyrophosphoric acids, technological scheme of production. Production of reactive sodium salts of orthophosphoric acid: dihydrogen phosphate, sodium hydrophosphate and trisodium phosphate grades "ch" and "chda". Production of sodium sulfide and sodium sulfate. Modern technological schemes of production. Innovative methods for obtaining food grade sodium chloride and sodium bicarbonate. Methods of their deep purification from mechanical and chemical impurities. Production of tripolyphosphate and reactive sodium pyrophosphate. Production of reactive grade diammonium phosphate. Features of the production of reactive calcium phosphates. Modern technological schemes of production. **Laboratory classes:** Analysis of quality indicators of reactive acids and salts. Preparation and analysis of the composition of orthophosphoric acid. Production of reactive sodium chloride from local mineral raw materials; analysis of product quality indicators. Production of sodium sulfate; analysis of process parameters. Production of chemically pure monocalcium phosphate and analysis of process parameters. Preparation and analysis of the composition of reactive sodium pyrophosphate and tripolyphosphate. **Practical classes:** Calculation of the consumption of phosphate raw materials and sulfuric acid for the extraction of phosphoric acid. Optimization of the phosphogypsum filtration process. Calculations for reactive salts. The study of methods for purifying phosphoric acid from impurities. Consideration of thermal phosphoric acid technology. Calculation of the material and thermal balance of tripolyphosphate and sodium pyrophosphate production.
Study / examination results forms of control:	Current control: - submission of a literary review, successful execution of technological calculations for the experiment; written and oral surveys. Final control– *exam*
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
Literature:	1. Zhekeev M.K., Moldabekov S.M., Zhekeeva N.B. Physical-and-chemical bases and technology of manufacturing pure and especially pure phosphorus containing substances. - Almaty: Ғылым, 2010. 2. Kadirbaeva A., Zhantasov K., Moldabekov S. Technological calculations of the production of inorganic salts.: Textbook. Shymkent: SKSU named after M.Auyezov, 2015. 3. Chemical technology of inorganic acids, salts and alkalis: a textbook / Niftaliev S. I. - Voronezh: Voronezh State University of Engineering Technologies, 2021. - 80 p. 4. Yeskendirova M.M., Kadirbayeva A.A. Chemistry and technology of reactive acids and salts: Study guide. – Shymkent: M.Auezov SKSU, 2017. – 105 p. 5.Benvenuto M.A. Industrial Inorganic Chemistry. 2nd Edition: Walter de Gruyter, 2024. — 212 p. — ISBN 978-3111329445. 6. Gilmour R. Phosphoric Acid: Purification, Uses, Technology, and Economics Hardcover/ CRC Press, Taylor & Francis Group, 2014. XX, 334 p.

Module name:	**M14 Research Work of a Master Student 2**
Semester:	2 semester
The responsible person for the module:	Leading full-time teachers of the educational program who have an academic degree. Department of Technology of Inorganic and Petrochemical Productions
Language:	Russian, Kazakh
Relationship to curriculum:	Additional types of training relationship to previous period
Teaching methods:	
Study load:	
Credit scores:	3 ECTS-credits
Mandatory and recommended pre-requisites (conditions) for admission to the module	Methods of research of inorganic compounds, Designing Chemical Productions
Module Objectives / expected results of study:	After completion of the module, master's students should be able to: - to use the acquired theoretical knowledge on the technology of mineral acids, fertilizers and salts for experimental work; - to conduct scientific research in the field of chemical technology of inorganic compounds and draw conclusions based on the results of the work; - to substantiate and develop technological regimes for the production of inorganic acids, salts and fertilizers; - to propose new methods for the production of inorganic compounds in accordance with the research topic; - perform technological calculations on the topic of the dissertation research.
Content:	Research of actual production problems on the topic of the master's thesis. The choice of experimental research methodology and methods of analysis of raw materials, man-made chemical waste, intermediates and products. Conducting experimental research work according to the academic period plan using the instrument base of the cathedral laboratory and analytical

	instruments of the regional engineering testing laboratory (RETL). The use of advanced information technologies for processing the results of experimental research. Performing technological calculations of the process, apparatus, or research object under study. Processing and interpretation of the obtained results, forming conclusions on the completed part of the research and development. Preparation and protection of the research report for the 2nd semester. Participation in scientific seminars of the department with a report on the results of scientific work.
Study / examination results forms of control:	Current control: the results of scientific research, performed technological calculations. Final control– Differentiated credit
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
Literature:	1. Zhantasov K.T., Iskandirov M.Z. and others.Modern technologies for processing mineral raw materials. Textbook. Shymkent: SKSU named after M.Auyezov, 2015. 2. HaghiA.K. etal. (Eds.) Applied Chemistry and Chemical Engineering, Volume 2: Principles, Methodology, and Evaluation Methods .- Apple Academic Press Inc., 2018. — 393 p. 3. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 3: Interdisciplinary Approaches to Theory and Modeling with Applications.- — Apple Academic Press Inc., 2018. — 407 p. 4. Seitmagzimova G.M., Kadyrbaeva A.A. Methodological guidelines for writing and defending a master's thesis for undergraduates in the scientific and pedagogical field. Shymkent: M.Auezov Law School, 2024. 42 p. 5. GOST 7.32 – 2001. Research report. The structure and rules of registration.
Module name:	**M15 Research Practice**
Semester:	3 semester
The responsible person for the module:	Department of Technology of Inorganic and Petrochemical Industries
Language:	Russian, Kazakh
Relationship to curriculum:	Additional types of training
Teaching methods:	
Study load:	
Credit scores:	6 ECTS-credits
Mandatory and recommended pre-requisites (conditions) for admission to the module	All Master's degree disciplines
Module Objectives / expected results of study:	After completion of the module, master's students should be able to: - to set goals and objectives for experimental fundamental and technological research; - independently develop plans for conducting experimental scientific research; - independently conduct scientific research using modern physico-chemical analysis methods; - to process the results obtained and use them to solve scientific and technological problems.
Content:	An analytical review of known production methods in the field of study and new technologies for the production of inorganic compounds in accordance with the purpose and objectives of the dissertation research. Mastering the methods of analysis of raw materials, intermediates and products using analytical instruments in a research laboratory. Carrying out theoretical and experimental research on the topic of the dissertation in accordance with an

	individual plan; analysis of raw materials and initial reagents used for scientific research; performing laboratory experiments on the topic of the master's thesis. Processing and interpretation of the obtained research results, forming conclusions on the research section.
Study / examination results forms of control:	Final control– Differentiated credit
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
Literature:	1. Myrzakhoda D.A., Myrzakhodzhaev A.A. Physico-chemical methods of analysis. Almaty, 2009. 113s. 2. Lebukhov R.I. et al. Physico-chemical research methods. - Ed. Lan, 2012. - 430. 3.Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 2: Principles, Methodology, and Evaluation Methods .- Apple Academic Press Inc., 2018. — 393 p. 4. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 3: Interdisciplinary Approaches to Theory and Modeling with Applications.-AppleAcademicPressInc., 2018. — 407 p. 5. GOST 7.32 – 2001. Research report. The structure and rules of registration.

Module name:	**M16.1 Adsorption Processes in Inorganic Technology**
semester:	3semester
Person responsible for the module	PhD, Associate Professor Sh.T. Koshkarbayeva
language:	Russian, Kazakh
Relationship to curriculum:	Major (core) discipline, elective component
Teaching methods	Lectures, practical
Workload (including contact hours, self-study hours)	The total workload is 150 hours: lectures-30 hours; practical - 30 hours, current MSIW-55 hours; intermediate MSIW -12.5 hours; MSIWT - 22.5 hours.
Number of credits	5 credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Master's degree modules: Physical chemistry of surfaces, Methods of research of inorganic compounds;
Module objectives / Expected learning outcomes	After undergraduates have completed the study of this course, they should be able to: - use knowledge of the theoretical foundations of adsorption processes in solving applied problems; - perform mathematical processing of the kinetics of adsorption processes; - evaluate and select selective adsorbents for certain purified mixtures; - select and calculate adsorption plants for the production of inorganic acids, salts and fertilizers; - calculate the adsorption processes of one or more adsorbed components.
Content	**Lectures**: Characteristics of adsorption. The concept of absorption, desorption, chemisorption and capillary condensation. Features and patterns of surface phenomena at different phase boundaries. Statistics and kinetics

	of adsorption and desorption. The main thermodynamic characteristics of adsorption. Theoretical foundations of adsorption processes. The monomolecular theory of Langmuir adsorption. The effect of the structure and size of a surfactant molecule on adsorption at the liquid–gas interface. The concept of surfactants and surfactants. General characteristics of adsorption at the solid–liquid interface. Industrial adsorbents. Adsorption of weakly sorbing gases. The design of adsorbers in periodic installations. Continuous gas separation method of gas mixtures in an adsorbent with a moving adsorbent layer. **Practical classes**: Calculation of adsorption of substances based on the theory of Langmuir and Freundlich. Calculation of the adsorption capacity of substances based on the Gibbs equation. Adsorption equilibrium and porous structure of adsorbents. Methods for the determination of adsorption isotherms. Thermodynamic approach to the consideration of adsorption at the liquid-gas interface. Graphically constructing the adsorption isotherm at the liquid–gas interface and determining the characteristics of the surface layer.
Exam forms/grades	Ongoing monitoring: - successful solution of technological calculations; colloquiums, written control papers; written and oral surveys. Final control – exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
The list of literature to read	1. Berdi K.S. Surface and colloidal chemistry: principles and applications. – CRC Press/ Taylor &Francis Group, 2010.-244 p. 2. Babenko S.A. Surface phenomena in heterogeneous systems with a solid phase. Tomsk: Publishing House of Tomsk Polytechnic University, 2012. 210 p. 3. Frolov, Yu.G. Course of colloidal chemistry. Surface phenomena and dispersed systems / Yu.G. Frolov, Moscow: Khimiya, 2009, 464 p. 4. Kirovskaya, I.A. Dispersed systems and surface phenomena: A textbook. Omsk: Publishing House of OmSTU, 2011. 216 p. 5. Deepak Huseyn, Faizalbooks. The process of periodic adsorption of metals and anions to purify polluted water. CRC Press. 2024. -330 p.

Module name:	**M16.2 Technology of Inorganic Polymers**
semester:	3 semester
Person responsible for the module	PhD, Professor Tleuova S.T.
Language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods	Lectures, practical classes
Workload (including contact hours, self-study hours)	Total workload – 150 hours: lectures-30 hours; practical - 30 hours, current MSIW -55 hours; intermediate MSIW -12.5 hours; MSIWT - 22.5hours.
Number of credits	5credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Master's degree modules: Methods of research of inorganic compounds, Physical chemistry of surfaces
Module objectives / Expected learning outcomes	After undergraduates have completed the study of this course, they should be able to: - describe technologies for producing inorganic polymer carbon, aluminum, and boron-containing materials from non-standard raw materials; - it is reasonable to choose new methods for obtaining inorganic polymer materials; - to evaluate the economic efficiency of using secondary raw materials for the production of inorganic polymer compounds; - synthesize new inorganic polymer materials - boron carbide and nitride using carbon-containing waste; - to conduct scientific research in the field of technology of inorganic polymer materials and analyze their results.
Content	**Lectures**: The fundamental commonality between all polymer compounds:

	organic, organoelement, inorganic. Structure and properties of polymers. Microstructure and physico-mechanical characteristics of inorganic polymer materials. Crystalline and amorphous polymers. Preparation of inorganic polymers by polycondensation and polymerization reactions. The ability of elements to form homochain and heterochain polymers. Polymer compounds of aluminum and silicon. Hydroaluminates of alkaline and alkaline earth elements. Anhydrous aluminates. High-temperature synthesis of aluminosilicates. High-temperature processes and the general scheme of chemical transformations in the production of inorganic carbon-, aluminum-, boron-containing polymer materials. Physico-chemical patterns of high-temperature synthesis processes of inorganic polymer materials. **Practical classes**: Calculation of the charge composition for the production of electrocorundum and monocorundum from local aluminum-containing raw materials. Production of aluminosilicate agglomerates. Production of alumina from local bentonite clays. Calculation of the consumption of the charge composition for the production of silicon carbide using quartz-containing secondary materials; calculation of the charge composition for the production of calcium carbide; Determination of the litre of calcium carbide.
Exam forms/grades	Ongoing monitoring: - successful solution of technological calculations; colloquiums, written control papers; written and oral surveys. Final control – exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
The list of literature to read	1. Birdi K.S. Surface and Colloid Chemistry: Principle and Applications. CRC Press/ Taylor &Francis Group, 2010.244 p. 2. Babenko S.A. Surface phenomena in heterogeneous systems with a solid phase. Tomsk: Publishing House of Tomsk Polytechnic University, 2012. 210 p. 3. Frolov, Yu.G. Course of colloidal chemistry. Surface phenomena and dispersed systems / Yu.G. Frolov, Moscow: Khimiya, 2009, 464 p. 4. Kirovskaya, I.A. Dispersed systems and surface phenomena: A textbook. Omsk: Publishing House of OmSTU, 2011. 216 p.

Module name:	**M17.1 Innovative Feed Salt Technologies**
semester:	3 семестр
Person responsible for the module	Doctor of Technical Sciences, Professor Anarbaev A.A.
language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods	Lectures, practical
Workload (including contact hours, self-study hours)	Total workload – 150 hours: lectures-30 hours; practical - 30 hours, current MSIW -55 hours; intermediate MSIW -12.5 hours; MSIWT - 22.5hours
Number of credits	5credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Modern technologies for processing mineral raw materials, Innovative technologies of available phosphates and nitrates, Energy-efficient technologies of mineral acids
Module objectives / Expected learning outcomes	After undergraduates have completed the study of this course, they should be able to: - formation of knowledge and skills in the field of modern technologies of feed salts; - critically analyze scientific and technical information in the field of chemical engineering; - the use of foreign language learning and information resources, summarizing research results in scientific articles, reports and dissertations, taking into account the principles of scientific ethics.
Content	**Lectures:** An introduction. The current state and development of the production of feed salts. To deepen knowledge about new economical methods of production of feed mineral products, the requirements of standards for the composition. Characteristics and composition of raw materials. Selection of optimal technological modes for the production of condensed and thermal fluorinated phosphates, feed monocalcium phosphate, precipitate, diammonium phosphate, disodium phosphate. Management of the

	process of obtaining feed phosphates from various types of raw materials. Analysis of the calculation results for the production of feed salts based on solubility diagrams. Mathematical modeling of the process of obtaining feed salts. **Practical classes**: Calculation of the mineralogical composition of raw materials. Calculation of consumables for obtaining feed phosphates. Calculation of the material balance of feed monocalcium phosphate. Calculation of material flows of diammonium phosphate and disodium phosphate. Calculation of thermodynamic characteristics of phosphate salt formation. Calculation of the composition of food and feed salts. Calculation of consumable reagents for purification of natural salts from impurities. Calculation of material flows of sodium phosphate salts.
Exam forms/grades	Ongoing monitoring: - successful solution of technological calculations; colloquiums, written control papers; written and oral surveys. Final control – exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
The list of literature to read	1. Bishimbayev U.K., MoldabekovSh.M., Zhantasov K.T., Anarbayev A.A. Beyorganikalyk zattardyn khimiyalyk technologiyasi. B.:Bilim, Almaty, 2007.VI-volume,-429 b. 2. Bishimbayev U.K., MoldabekovSh.M., Zhantasov K.T., Anarbayev A.A., BesterkovU.B. Beyorganikalyk zattardyn khimiyalyk technologiyasi. Mineraldy tynaytkyshtardyn khimiyalyk technologiyasi. B.:Bilim, Almaty, 2007.III-volume,-543 b. 3. Degtyarev V. The effectiveness of monocalcium phosphate in animal feeding. //Dairy and beef cattle breeding. 2003. No. 2. from 7-10. 4. Karmyshev, F. Chemical Processing of Phosphorites. Moscow: Khimiya, 19810. Animal Feed Phosphates Technology, by Chuck Snyder and Marten Walters, KEMWorks Technology, Inc. 2002. 5. A.A.Sokolovsky, E.V. Yashke. Technology of mineral fertilizers and acids. -M.: Chemistry, 2001, -281p.

Module name:	**M17.2 Mathematical Planning and Processing Experimental Results**
semester:	3 semester
Person responsible for the module	Candidate of Technical Sciences, senior instructor A.N. Zhaksanova
language:	Kazakh, Russian
Relationship to curriculum:	Profile discipline, elective component
Teaching methods	Lecture, practical
Workload (including contact hours, self-study hours)	The total workload is 150 hours: lectures-30 hours; practical - 30 hours, current MSIW-55 hours; intermediate MSIW-12.5 hours; MSIWT - 22.5 hours.
Number of credits	5credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Research work of master's students 1,2, Research practice, Graphic analysis of processes in multicomponent systems
Module objectives / Expected learning outcomes	After undergraduates have completed the study of this course, they should be able to: - research as an object of information processing using new information technologies - research of instrumentation for data analysis and processing - master the theoretical foundations of data mining - master the practical skills of setting tasks in specific subject areas and their implementation in the environment of existing software products
Content	**Lectures**: Mathematical modeling as a modern method of (basic) analysis and synthesis of chemical and technological processes. Algorithmization of mathematical models.Geometric method for solving linear programming problems. Mathematical model of the transport problem.Models of thermal

	processes. Typical modeling schemes.Elements of the theory of complex reactions. **Practical**: Mathematical modeling. Data entry and analysis in MATLAB. Mathematical modeling. Plotting using PLOT. Mesh and Surf functions in MATLAB. The conditional MATLAB operator. The loop operator for MATLAB. Solving systems of nonlinear algebraic equations in MATLAB. Mathematical analysis of the model. Working with mathematical functions in Matlab. The least squares method. The solution is using MATLAB. Computer calculation of the Runge-Kutta method.
Exam forms/grades	Current control - solutions of tasks according to the variant, reports on individual assignments with research on modern methods, presentations, glossaries, abstracts, oral surveys. Final control – exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
The list of literature to read	1. UshevaN.V.Modeling of chemical and technological processes. The electronic version of the lecture course. TPU, 2010. 2. Kravtsov A.V., Usheva N.V., Kuzmenko E.A., Fedorov A.F. Mathematical modeling of chemical and technological processes. Tomsk., 2009. – 135 p. 3. Kravtsov A.V., Moises O.E., Kuzmenko E.A. Bazhenov, D.A.Koval P.I., Computer Science and Computational Mathematics. /Textbook for students of chemical specialties of technical universities (grif UMO), Tomsk: TPU Publishing House, 2003. – 246 p. 4. Bogolyubova M. N. System analysis and mathematical modeling : a textbook / M. N. Bogolyubova ; Tomsk Polytechnic University. Tomsk : TPU Publishing House, 2012. 104 p. 5. Lilian Maria Ferraresolona: A step-by-step approach to modeling chemical engineering processes. 2017 – 173 pages . 6. JiriMatousek, Bernd Gertner: Understanding and using linear programming. 2007 – 226 pages . 7. Sheldon Lee: Mathematical modeling using MATLAB. Southeastern University of Alaska. 2021 – 213 pages .

Module name:	**M18.1 Resource Saving Technologies of Technogenic Waste Processing**
semester:	3 semester
Person responsible for the module	Candidate of Technical Sciences, Professor Tleuova S.T.
language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods	Lectures, laboratory classes
Workload (including contact hours, self-study hours)	The total workload is 150 hours: lectures-30 hours; laboratory - 30 hours, current MSIW - 55 hours; intermediate MSIW-12.5 hours; MSIWT - 22.5 hours.
Number of credits	5credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Modern technologies for processing mineral raw materials, Innovative technologies of available phosphates and nitrates, Energy-efficient technologies of mineral acids
Module objectives / Expected learning outcomes	After undergraduates have completed this course, they should be able to: - use advanced methods of man-made waste disposal in order to ensure comprehensive and waste-free recycling and disposal of secondary raw materials; - carry out work on the feasibility study of the introduction of innovative waste disposal technologies and the identification of risks in their use; - perform laboratory studies of man-made waste recycling and analyze process indicators; - to substantiate the optimal technological modes of processing man-made waste.
Content	**Lectures:** The main directions of creating a resource-saving, waste-free and low-waste technology of mineral fertilizers. Thermal neutralization of toxic

	industrial waste. A comprehensive resource-saving technology for processing waste from the production of phosphorus, extraction phosphoric acid and phosphoric fertilizers. Environmental problems of processing and disposal of cottrel dust and phosphorous sludge. The use of phosphogypsum and waste from the production of mineral fertilizers in the production of building materials. Comprehensive use of nepheline sludge. Improving the technology of mineral fertilizers using metal-containing waste with trace elements. Wastewater treatment methods. Gaseous waste from the production of mineral fertilizers and methods of their regeneration and recovery. **Laboratory classes:** Analysis of the composition of waste from various industries used to produce complex mineral fertilizers. Production of double superphosphate from low-grade phosphorites with the introduction of phosphorus sludge, phosphorus-produced cottrel dust. Synthesis of precipitate from substandard raw materials containing trace elements. Obtaining a polycomponent organomineral fertilizer using coal mining waste containing trace elements and potassium. Determination of the degree of wastewater purification from mechanical and chemical impurities.
Exam forms/grades	Ongoing monitoring: - successful settlement of calculations; colloquiums, written control papers; written and oral surveys. Finalcontrol – exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
The list of literature to read	1. Tleuova S.T., AltybaevZh.M., Tleuov A.S., Zhuldysbaeva S.E. Processing and utilization of man-made waste in the production of mineral fertilizers. The training manual. Shymkent, SKSU namedafterM.Auyezov, 2015. 2. Tleuova S.T., Zhuldyzbayeva S.E., Tleuov A.S. Waste–free technology:Educational special.-Almaty: Nurayprintservice, 2015.-195 p. 3. Water Research and Technology. Selected publications from the Water Harmony Project. / Zhekeyev M.K., Water Harmony Project, 2015. 4. Yeskendirova M.M. The environmental problems of technology of inorganic substances. - Shymkent, M. Auezov SKSU, 2008. - 90p. 5. Tleuova S.T., AltybaevZh.M., Tleuov A.S.,Nazarbek U.B. Resource–saving technologies for processing man-made waste/ Textbook - Shymkent, SKSU named after M.Auezov, 2016.

Module name:	**M18.2 Environmental Risk Management**
semester:	3rd semester
Person responsible for the module	Candidate of Technical Sciences, Professor S.T. Tleuova.
language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods	Lectures, laboratory classes
Workload (including contact hours, self-study hours)	The total workload is 150 hours: lectures-30 hours; laboratory - 30 hours, current MSIW-55 hours; intermediate MSIW-12.5 hours; MSIWT - 22.5 hours.
Number of credits	5credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Master's degree modules: Energy-efficient technologies of mineral acids, Adsorption Processes in Inorganic Technology, Innovative Technologies of Available phosphates and nitrates
Module objectives / Expected learning outcomes	После того, как магистранты завершили изучение данного курса, они должны быть способны: - применять методы анализа и оценки техногенного риска при работе на промышленных предприятиях; - прогнозировать, определять зоны повышенного техногенного риска и зоны повышенного загрязнения; - проводить оценку негативного воздействия производства на состояние окружающей среды; - оценивать экологические последствия деятельности химических производств; - использовать теоретические знания при моделировании и управлении экологическими рисками.
Content	**Lectures:** Components and factors of environmental risk. The amount of

	damage caused by environmental pollution from industrial chemical waste. Assessment of the degree of influence of factors on the magnitude of environmental risk. International experience in the field of environmental risk analysis and assessment. Environmental national laws. Methodology of technogenic risk analysis: hazard identification, risk assessment, risk characterization. The main stages of risk management: risk analysis; selection of methods of risk management; decision-making; direct impact on risk; control and correction of the results of the management process. Building a risk management service in an enterprise. Risk forecasting. Strategic risk management as a risk management system based on long-term forecasting and strategic planning of the enterprise. Tactical risk management is a set of techniques and methods used in a specific economic situation. **Laboratory classes:** Identification of environmental risk zones. Study of methods of solid waste processing and disposal. Methods for assessing the level of environmental risk. The methodology for calculating fees for environmental pollution by gas emissions, for industrial water discharge, and for solid waste disposal. The main stages of the risk management process: risk analysis; selection of risk management methods. Analysis of environmental risks of contamination of the work area.
Exam forms/grades	Ongoing monitoring: - successful solution of environmental calculations; colloquiums, written control papers. Final control – exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
The list of literature to read	1. Timofeeva S.S. Assessment of technogenic risks: a textbook. - Moscow: FORUM: INFRA – M., 2015. - 208 p. 2. Barbotko A. I. Reliability of technical systems and technogenic risk: a textbook for university students. - StaryOskol : TNT, 2015. 256 p. 3. Raskatov V.A., Fokin A.D., Titova V.I., Raskatov A.V. Organization of environmental protection activities at the enterprise. Moscow: Publishing house RGAU–MSHA, 2010. - 187s. 4. Bashkin V.N. Environmental risks: calculation, management, insurance. Moscow: HigherSchool, 2007.- 351 p . 5. Cavani F. and others . Sustainable industrial chemicals. Principles, tools, and industrial examples."Wiley." 2009.- 623 p.

Module name:	**M19.1 Development Prospects of Complex Mineral Fertilizer Production**
semester:	3 semester
Person responsible for the module	Doctor of Technical Sciences, Professor K.T. Zhantasov
language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods	Lectures, laboratory classes
Workload (including contact hours, self-study hours)	The total workload is 150 hours: lectures-30 hours; laboratory - 30 hours, current MSIW-55 hours; intermediate MSIW-12.5 hours; MSIWT - 22.5 hours.
Number of credits	5credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Energy-efficient technologies of mineral acids, Innovative technologies of assimilable phosphates and nitrates, Graphic analysis of processes in multicomponent systems.
Module objectives / Expected learning outcomes	After undergraduates have completed this course, they should be able to: -use the basic principles of scientific schools aimed at developing methods for optimizing chemical production; - demonstrate knowledge of the basic principles of equipment placement in enterprises; - analyze and evaluate optimality criteria and methods of modernization of chemical enterprises; - to develop new and improve traditional technological solutions for processing mineral and man-made raw materials into target products; - make decisions on improving the operation of existing equipment, on the selection and design of new equipment.
Content	**Lectures**: The state and prospects of production of flour mixtures in

	Kazakhstan. New methods for obtaining complex-mixed fertilizers from poor phosphate raw materials for agricultural crops for various purposes. Technology of balanced NPK fertilizers and unbalanced compound fertilizers for various types of soils using phosphoric acid technology. Development of new compositions of mixed fertilizers for various types of soils. Obtaining nitroammophoska using nitric acid technology according to various schemes for the removal of calcium salts. Production of complex carbamide-phosphorous fertilizers. Technological features of innovative production of complex mineral fertilizers containing trace elements. The use of local vermiculites for the synthesis of long-acting polycomponent mineral fertilizers. Boron-containing micro fertilizers, manganese fertilizers, molybdenum fertilizers. Zinc and iron-containing mineral fertilizers. **Laboratory classes**: Obtaining nitroammophoska by nitric acid decomposition of natural phosphates. Analysis of indicators for obtaining a complexly mixed PK fertilizer containing trace elements. Production of prolonged complex-mixed fertilizers containing humates and moisture-retaining substances such as vermiculite. Obtaining a polycomponent organomineral fertilizer containing an increased amount of iron. Production of complex fertilizers containing boron, manganese, molybdenum and zinc.
Exam forms/grades	Ongoing monitoring: - successful solution of technological calculations; colloquiums, written control papers; written and oral surveys. Final control – exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
The list of literature to read	1. Dmitrevskiy B.A. Properties, preparation and application of mineral fertilizers. – St. Petersburg: ProspektNauki, 2013. – 326 p. 2. Bishimbaev U.K., Zhantasov K.T., Moldabekov Sh., and others.Technology of complex and complex-mixed mineral fertilizers and their development trends.: Textbook. Shymkent: SKSU named after M.Auyezov, 2015. (in Kazakh) 3. Zhantasov K.T., Iskandirov M.Z. and others.Modern technologies of processing of mineral raw materials.: Textbook. Shymkent: SKSU named after M.Auyezov, 2015. 4. Kadirbaeva A., Zhantasov K., Moldabekov S. Technological calculations of the production of inorganic salts.: Textbook. Shymkent: SKSU namedafterM.Auyezov, 2015. 5. Khaan A.B. Technology of technological processes: an introduction.- Berlin; Munich; Boston: WalterdeGruyterGmbH, 2015. — 471 p.

Module name:	**M19.2 Modern Technologies of Processing Mineral Raw Materials**
semester:	3 semester
Person responsible for the module	Candidate of Technical Sciences, Professor Tleuova S.T.
language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods	Lectures, laboratory classes
Workload (including contact hours, self-study hours)	The total workload is 150 hours: lectures-30 hours; laboratory - 30 hours, current MSIW-55 hours; intermediate MSIW-12.5 hours; MSIWT - 22.5 hours.
Number of credits	5 credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Innovative technologies of assimilable phosphates and nitrates, Energy-efficient technologies of mineral acids, Designing Chemical production
Module objectives / Expected learning outcomes	After undergraduates have completed the study of this course, they should be able to: - analyze modern methods of processing mineral and secondary raw materials - to solve the problems of improving the technologies of inorganic compounds using alternative mineral raw materials; - to use knowledge of the laws of modern methods of processing substandard chemical mineral raw materials in professional activities; - to propose new methods of extraction, leaching and enrichment of natural raw materials; - to scientifically substantiate technological schemes for processing new mineral resources based on the requirements of chemical safety and environmental protection.
Content	**Lectures:** Characteristics of mineral raw materials of the chemical industry.

	Modern technologies of electrochemical, electrothermal and extraction processing of mineral raw materials using man-made waste. The main stages of preparation and enrichment of natural substandard and secondary raw materials. Thermal and mechanical preparation of raw materials. Selection of the enrichment method depending on the chemical and mineralogical composition of the raw materials. The main problems and priorities of flotation and gravity enrichment of minerals. Types of flotation processes, the mechanism of action of flotation reagents, methods of pulp aeration in flotation machines. Purpose and mechanism of magnetic and electrostatic separation of ores. Characteristics of extraction and ion exchange processes, requirements for industrial extractants. The kinetics of extraction, the choice of the optimal technological mode of the process. Methods of process organization and hardware design of extraction. Equilibrium of ion exchange, indicators of ion exchange processes. Kinetic patterns of cation and anion exchange, selection of ion exchange resins for selective ion extraction. Patterns of leaching and dissolution processes, hardware design of processes. **Laboratory classes:** Research on the production of fluxed agglomerate using man-made waste. Investigations of the physico-chemical features of ammophos using agglomeration process dust. Production of complex mineral fertilizers with trace elements using metallurgical waste.
Exam forms/grades	Ongoing monitoring: - colloquiums, written control papers; written and oral surveys. Final control – exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
The list of literature to read	1. Zhantasov K.T., Iskandirov M.Z., Aybalayeva K.D., Alteev T.A., Novik D.M., Zhantasova D.M. Modern technologies of processing of mineral raw materials. Textbook. Shymkent: SKSU named after M.Auyezov, 2015 2. Vorobyov N.I. Mineral processing/ N.I.Vorobyov, O.M.Novik. – Minsk.: BSTU. 2008. - 174 p. 3. Tleuova S.T., Zhuldyzbayeva S.E., Tleuov A.S., Sikhymbaeva Zh. Waste-free technology. Educational special. – Almaty: Nurayprintservice, 2015h.. – 195 p. 4. Benvenuto M.A. Industrial Chemistry: For Advanced Students.- Berlin; Munich; Boston: Walter de Gruyter GmbH, 2015h.. - 139 p. 5. Zhantasov K., Iskandirov M.Z., Sakhi M.S., Alteev T.A. Industrial chemical and mechanical processes: Textbook.Shymkent: SKSU named after M. Auezov, 2016. (in Kazakh)

Module name:	**M20.1 Actual Problems of Electrochemical Technology**
semester:	3 semester
Person responsible for the module	Candidate of Technical Sciences, associate professor Koshkarbayeva Sh.T.
language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods	Lectures, laboratory classes
Workload (including contact hours, self-study hours)	The total workload is 180 hours: lectures-30 hours; laboratory - 30 hours, practical - 15 hours, current MSIW-60 hours; intermediate MSIW-30 hours; MSIWT -15 hours.
Number of credits	6 credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Modern construction materials in chemical technology, Adsorption processes in inorganic technology, Physical chemistry of surfaces.
Module objectives / Expected learning outcomes	After undergraduates have completed the study of this course, they should be able to: - analyze modern methods of processing mineral and secondary raw materials - to solve the problems of improving the technologies of inorganic compounds using alternative mineral raw materials; - to use knowledge of the laws of modern methods of processing substandard chemical mineral raw materials in professional activities; - to propose new methods of extraction, leaching and enrichment of natural raw materials; - to scientifically substantiate technological schemes for processing new mineral resources based on the requirements of chemical safety and environmental protection.
Content	**Lectures:** Features of energy saving in electrochemical technologies. Voltage

	balance and power consumption. Production of chlorine, alkalis and other inorganic products. Electroplating. Anodic treatment of metals. The mechanism of electrocrystallization of metals. The influence of various factors on the structure and properties of metal coatings. Features of applying different types of coatings on different substrates. Patterns of anodic dissolution of various metals. Oxidation, polishing. Hydroelectrometallurgy. The structure of molten salts, electrical conductivity, and electrode equilibria in melts. The effect of electrolyte properties on the electrolysis process. Specific phenomena in the electrolysis of melts. Production of aluminum, magnesium, sodium and other metals. Circuits and designs of electrochemical devices. **Laboratory classes**: Investigation of the effect of electrolyte composition on the structure and properties of metal coatings.Production of metal coatings on the surface of dielectric materials.Investigation of the production of composite coatings on the surface of various materials.Electrochemical production of metal powders.Extraction of cadmium from waste from hydrometallurgical zinc production.Production of aluminum by electrolysis of melts. Production of magnesium by electrolysis of melts.Production of alkaline and alkaline earth metals. **Practical classes**: Calculation of thermodynamic parameters of electrochemical systems of various types. Electroplating. Hydroelectrometallurgy. Learning the process electrolysis of alloys, anodic treatment of metals.Selection of the design of the elements of electrochemical technology devices, technological scheme. Comparative analysis of the efficiency indicators of caustic soda production by electrochemical methods – diaphragm and mercury cathode
Exam forms/grades	Ongoing monitoring: - colloquiums, written control papers; written and oral surveys. Final control – exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
The list of literature to read	1. Kuleshov N.V., Grigoriev S.A., Fateev V.N., Electrochemical technologies in hydrogen energy. - MEI, 2007. 2. Kuleshov N.V., Fateev V.N., Osina M.A., Nanomaterials and nanotechnologies in electrochemical systems. - MEI, 2010. 3. Ch.Lefrou, R. Fabry, Pierre, J-CPoignet. Electrochemistry. The Basics, With Examples.– 2012. - 352 pp. 4. Petrucci, Ralph H., Harwood, William S., Herring, F. G. General Chemistry: Principles and Modern Applications. - Pearson Education, Inc., 2007. 5. SataevM.S., Koshkarbaevash.T., TukibaevaA.S. Corrosion protection of Metals. -Shymkent: Yukguim.M.Auyezova, 2009. -144 p.

Module name:	**M20.2 Functional Electroplating**
semester:	3 semester
Person responsible for the module	Candidate of Technical Sciences, associate professor Koshkarbayeva Sh.T.
language:	Russian, Kazakh
Relationship to curriculum:	Profile discipline, elective component
Teaching methods	Lectures, laboratory classes
Workload (including contact hours, self-study hours)	The total workload is 180 hours: lectures-30 hours; laboratory - 30 hours, practical - 15 hours, current MSIW-60 hours; intermediate MSIW-30 hours; MSIWT -15 hours.
Number of credits	6 credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Modern construction materials in chemical technology, Adsorption processes in inorganic technology, Physical chemistry of surfaces.
Module objectives / Expected learning outcomes	After undergraduates have completed the study of this course, they should be able to: - analyze modern methods of processing mineral and secondary raw materials - to solve the problems of improving the technologies of inorganic compounds using alternative mineral raw materials; - to use knowledge of the laws of modern methods of processing substandard chemical mineral raw materials in professional activities; - to propose new methods of extraction, leaching and enrichment of natural raw materials; - to scientifically substantiate technological schemes for processing new mineral resources based on the requirements of chemical safety and environmental protection.
Content	**Lectures:** An introduction to functional electroplating. Fundamentals of

	electroplating and its role in modern technologies. A brief history of the development of electroplating. Basic principles of electrolysis and electrochemical deposition of metals. The difference between functional and decorative coatings: requirements for properties (wear resistance, corrosion resistance, electrical conductivity, magnetic properties, etc.). Overview of the main metals and alloys used in functional electroplating. Theoretical foundations of electrochemical deposition. The structure of the double electric layer. Kinetics of electrode processes: stages of electrode position, overvoltage (hydrogen, metal), deposition rate. The effect of ion concentration, temperature, and mixing on the deposition process. Diffusion and kinetic constraints. Technologies for obtaining functional coatings. Functional coatings and their properties. Current trends and quality control. **Laboratory classes:** Preparation of metal surfaces for electroplating. Study of the effect of current density on the quality of electrodeposited coating. Production of corrosion-resistant coatings of zinc or zinc alloys. Electrodeposition of hard chrome coatings. Obtaining nickel coatings (shiny or matte) and their properties. Study of the process of electrodeposition of tin or tin-bismuth coatings. Production of composite electrochemical coatings. Chemical nickel plating. Anodizing aluminum and obtaining oxide coatings.Control of the thickness and adhesion of electroplating. Analysis of electrolytes of galvanic baths. **Practical classes:** Calculation of the material and electrical balance of the electrodeposition process. Optimization of electrolyte parameters and deposition mode. Choosing a surface preparation scheme for different materials. The choice of technology for applying functional coatings. Calculations and methods for controlling the thickness, porosity and adhesion of coatings. Analysis of galvanic coating defects and methods of their elimination. Calculations for wastewater treatment and waste disposal of electroplating plants. Technical and economic calculations in electroplating.
Exam forms/grades	Ongoing monitoring: - colloquiums, written control papers; written and oral surveys. Final control – exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
The list of literature to read	1. Hamburg Yu.D. "Theory and practice of electrodeposition of metals"/ Yu.D. Hamburg, J. Zangari ; translated from English – M.: BINOM. Laboratory of Knowledge, 2015. – 438 p. 2. Smirnovk N. N. Electroplating. Textbook / K. N. Smirnov, A. A. Abrashov, N. S. Grigoryan, D. V. Mazurova.. Moscow: D. I. Mendeleev Russian Technical Technical University, 2022. 199 p. 3. Popov, A. P. Unconventional methods of processing materials / A. P. Popov, Yu. Yu. Komarov, T. A. Popova. Moscow : Centrosoyuz Publishing House, 2020. 119c. 4. Design of electroplating and paint industries. Guidelines for the preparation of final qualifying work: a textbook / A. N. Serov, N. A. Apanovich, V. H. Alyoshina [et al.]; - Moscow: Mendeleev Russian Technical Technical University, 2020. - 102s. 5. Khaibullov K.A.Technologies of automated mechanical engineering: textbook / K. A. Khaibullov, V. I. Levchuk. Moscow : Akademiya Publ., 2023. 222 p. 6. Electroplating in the modern era, improvements and problems: a review by Emmanuel Chukwuebukagugua, Chiki Oliver Uja, Christian O. Asado and others.Hybrid technologies. Volume 7, December 2024.

Module name:	**M21 Research Work of a Master Student 3**
semester:	3 semester
Person responsible for the module	Leading full-time teachers of the educational program who have an academic degree. Department of Technology of Inorganic and Petrochemical Productions
Language:	Russian, Kazakh
Relationship to curriculum:	Additional types of training
Teaching methods	
Workload (including contact hours, self-study hours)	
Number of credits	3 credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Research methods of inorganic compounds, Design of chemical productions, Research practice
Module objectives / Expected learning outcomes	After undergraduates have completed the study of this course, they should be able to: - analyze modern methods of processing mineral and secondary raw materials - to solve the problems of improving the technologies of inorganic compounds using alternative mineral raw materials; - to use knowledge of the laws of modern methods of processing substandard chemical mineral raw materials in professional activities; - to propose new methods of extraction, leaching and enrichment of natural raw materials; - to scientifically substantiate technological schemes for processing new mineral resources based on the requirements of chemical safety and environmental protection.
Content	Practical study of the latest theoretical, methodological and technological

	achievements of domestic and foreign science: modern methodology of scientific research; analysis of the state of development of chemical technology and science in the world and Kazakhstan; the role of science and innovation in the improvement and modernization of technology; basic laws of market economy, objectives, principles and mechanisms of innovative development of the Kazakh economy; current trends in the development of the production of inorganic substances.Get acquainted with the scientific areas of work of the Department of High Technology, leading professors and associate professors, state-funded and contractual research, scientific projects carried out by the faculty of the Department under grants from the Ministry of Education and Science of the Republic of Kazakhstan. Participation in scientific seminars of the department, in the discussion of problematic issues of the development of technology of inorganic substances.
Exam forms/grades	Ongoing monitoring: - colloquiums, written control papers; written and oral surveys. Final control – exam
Training and examination requirements	During the semester, the master's student must complete the tasks according to the syllabus and score min 30, max 60 points, and score min 20, max 40 points on the exam.
The list of literature to read	1. Zhantasov K.T., Iskandirov M.Z. and others.Modern technologies for processing mineral raw materials. Textbook. Shymkent: SKSU named after M.Auyezov, 2015. 2. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 2: Principles, Methodology, and Evaluation Methods .- Apple Academic Press Inc., 2018. — 393 p. 3. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 3: Interdisciplinary Approaches to Theory and Modeling with Applications.- — Apple Academic Press Inc., 2018. — 407 p. 4. Seitmagzimova G.M., Kadyrbaeva A.A. Methodological guidelines for writing and defending a master's thesis for undergraduates in the scientific and pedagogical field. Shymkent: M.Auezov Law School, 2024. 42 p. 5. GOST 7.32 – 2001. Research report. The structure and rules of registration.

Module name:	**M22 Research Work of a Master Student 4**
semester:	4semester
Person responsible for the module	Leading full-time teachers of the educational program who have an academic degree. Department of Technology of Inorganic an Petrochemical Productions
Language:	Russian, Kazakh
Relationship to curriculum:	Additional types of training
Teaching methods	
Workload (including contact hours, self-study hours)	
Number of credits	17 credits
Mandatory and recommended prerequisites (conditions) for admission to the module	Master's degree disciplines, Research practice
Module objectives / Expected learning outcomes	After undergraduates have completed the study of this course, they should be able to: know: - independently conduct scientific research in the field of technology of mineral acids, salts and fertilizers; - to develop and implement low-energy and resource-saving technologies for the production of inorganic compounds using man-made waste and substandard natural raw materials; - as part of the design team, perform engineering calculations, develop technological schemes and initial data for the design of new production facilities; - discuss and critically evaluate the economic significance of fundamental

	developments.
Content	Conducting experimental research work according to the plan of the academic period using the instrument base of the Cathedral laboratory and analytical instruments of the IRLIP. The use of information technologies and computer programs in the final qualifying work. Selection and justification of the technological scheme of production, calculation of the main equipment in accordance with the topic of the master's thesis. Determination of the economic efficiency of the developed technology. Drawing conclusions on all sections of the work. Preparation of an article on a research topic for publication in a scientific journal, proceedings of scientific conferences, or a collection of undergraduates and doctoral students. Preparation of a report on research and development for the 3rd semester and its defense with a presentation of the results..
Exam forms/grades	Current control: published scientific article, research results. Final control – report
Training and examination requirements	During the semester, the master's student must complete the tasks according to the individual work plan and score min 30, max 60 points, and score min 20, max 40 points while defending the report.
The list of literature to read	1. Zhantasov K.T., Iskandirov M.Z. and others. Modern technologies for processing mineral raw materials. Textbook. Shymkent: SKSU named after M.Auyezov, 2015. 2. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 2: Principles, Methodology, and Evaluation Methods .- Apple Academic Press Inc., 2018. — 393 p. 3. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 3: Interdisciplinary Approaches to Theory and Modeling with Applications.- — Apple Academic Press Inc., 2018. — 407 p. 4. GOST 7.32 – 2001. Research report. The structure and rules of registration. 5. Seitmagzimova G.M., Kadyrbaeva A.A. Methodological guidelines for writing and defending a master's thesis for undergraduates in the scientific and pedagogical field. Shymkent: M.Auezov Law School, 2024. 42 p.

Module name:	**M23 Execution and Defense of Master's Thesis**
semester:	4semester
Person responsible for the module	Leading full-time teachers of the educational program. Department of Technology of Inorganic an Petrochemical Productions
Language:	Russian, Kazakh
Relationship to curriculum:	
Teaching methods	
Workload (including contact hours, self-study hours)	
Number of credits	8 ECTS
Mandatory and recommended pre-requisites (conditions) for admission to the module	Research work of a Master Student 1,2,3,4 , Research practice
Module objectives / Expected learning outcomes	The goal is to demonstrate the level of research qualification of the master's student, the ability to independently conduct scientific research, test the ability to solve specific scientific and practical problems presentation of skills for public discussion and defense of scientific ideas, suggestions and recommendations After master student have completed the study of this course, they should be able to: know: - independently conduct scientific research in the field of technology of mineral acids, salts and fertilizers; - to develop and implement low-energy and resource-saving technologies for the production of inorganic compounds using man-made waste and substandard natural raw materials; - as part of the design team, perform engineering calculations, develop

	technological schemes and initial data for the design of new production facilities; - discuss and critically evaluate the economic significance of fundamental developments.
Content	Evaluation of learning outcomes and key competencies achieved upon completion of the master's degree program. **Content:** Formation of skills of summarizing the results of independent research by a master student of one of the urgent problems of the specialty, interpretation and substantiation of scientific research results and presenting them in the form of a master's thesis and defense to a wider audience.
Exam forms/grades	Current control: Final qualification work of the graduate of the master's program, confirming the competencies acquired in the course of training in accordance with the chosen specialization of training.
Training and examination requirements	Final control – defense of the master's thesis at an open meeting of the Attestation Commission with the participation of the chairman of the commission and at least half of its members.
The list of literature to read	1. Zhantasov K.T., Iskandirov M.Z. and others. Modern technologies for processing mineral raw materials. Textbook. Shymkent: SKSU named after M.Auyezov, 2015. 2. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 2: Principles, Methodology, and Evaluation Methods .- Apple Academic Press Inc., 2018. — 393 p. 3. Haghi A.K. et al. (Eds.) Applied Chemistry and Chemical Engineering, Volume 3: Interdisciplinary Approaches to Theory and Modeling with Applications.- — Apple Academic Press Inc., 2018. — 407 p. 4. GOST 7.32 – 2001. Research report. The structure and rules of registration. 5. Seitmagzimova G.M., Kadyrbaeva A.A. Methodological guidelines for writing and defending a master's thesis for undergraduates in the scientific and pedagogical field. Shymkent: M.Auezov Law School, 2024. 42 p.

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