

**NJC «Kazakh national research technical University named after K. Satbayev»
Mining and Metallurgical Institute named O.A. Baikonurov
Department of «Metallurgical processes, heat engineering and technology of
special materials»
Department of «Metallurgy and mineral processing»**

CURRICULUM PROGRAM

**«8D07204 - Metallurgical Engineering»
PhD in Metallurgy**

based on the following specialties, the expired Classifier of specialties:
"6D070900-Metallurgy"
1st edition
in accordance with the state higher education system of 2018

Almaty 2021

Разработано:	Рассмотрено: заседание УС Института	Утверждено: УМС КазННТУ	Страница 1 из 24
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The program was drawn up and signed by the parties:

from KazNRTU named after K« Satbayev:

1. Head of the Department "MPHEaTSM" Chepushtanova T.A.
2. Head of the Department "MaMP" Barmenshinova M.B.
3. Director of Mining and Metallurgical Institute named after O.A. Baikonurov Rysbekov K. B.
4. Chairman of the TG of the departments "MaMP" and "MPHEaTSM", professor Baimbetov B.S



From the employer:

Head Of the Department of complex processing of technogenic raw materials of "Kazakhmys" LLP, doctor of technical Sciences

Ospanov E.A.

From a partner University:

- 1 Worcester Polytechnic Institute (USA)

Mishra B.

Approved at a meeting of the Academic Council of the Kazakh National Research Technical University named after K. Satpayev. Protocol No. 3 of 25.06.2021.

Approved at a meeting of the Scientific Council of the Institute of Metallurgy and Industrial Engineering. Protocol No. 10 of 10.06.2021.

Qualification:

- Level 8 of the National qualifications framework:
- 8D07 Engineering, manufacturing and construction industries
- 8D072 Manufacturing and processing industries

Professional competence: design and development, design and research activities, improvement and optimization of metallurgical production. Implementation of development and implementation of technological processes for processing mineral, natural and man-made raw materials. Assessment of innovation and technological risks in the implementation of new technologies. Competence in the implementation of marketing high technology. Skills of setting tasks and problems, their system solution with the use of innovative approaches, methods of building concepts and strategies of activity. System and strategic thinking, skills of making mutually beneficial decisions using logical methods, building and playing models of professional activity and interaction in the metallurgical industry.

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Short description of the program:

Specialty 6D070900 Metallurgy is accredited by the international agency IAAR (Kazakhstan). A distinctive feature of the doctoral program is that the educational program provides international training for specialists of the highest category, capable of independently conducting research and innovation and project activities, conducting science-intensive businesses that can be leaders in world-class scientometric indicators. Accreditation of the program - IAAR (Kazakhstan). The educational program provides knowledge in the field of development and implementation of metallurgical technologies, production of innovative metallurgical products, and enhanced consumer properties; graduates have high leadership and organizational qualities; capable of creating small high technology metallurgical businesses.

1 The objectives of the educational program of the specialty of doctoral studies “Metallurgy” are the training of highly qualified specialists with basic competencies in the field of solving organizational and production problems in the implementation of innovative projects in the field of metallurgy; staff formation for the innovative economy in metallurgy, covering modern energy-saving technologies, project activities, innovative solutions, entrepreneurship in the high-tech field. The educational program is aimed at the implementation by graduates of the implementation of their developments in production and commercialization, obtained scientific results.

1 Types of work. Specialists who have completed doctoral studies carry out production, technological and organizational work at industrial enterprises in leading positions corresponding to level 8 of the national qualification framework, and also conduct research work in the field of complex processing of mineral raw materials and obtaining innovative products with enhanced consumer properties.

Types of economic activity: metal ore mining; iron ore mining; underground mining of iron ore; opencast mining of iron ore; non-ferrous metal ore mining; mining of uranium and thorium ore; mining of uranium and thorium ore; mining of ores of other non-ferrous metals; mining and enrichment of aluminum-containing raw materials; mining and processing of copper ore; mining and processing of lead-zinc ore; mining and processing of nickel-cobalt ores; mining and concentration of titanium- magnesium raw materials (ores); mining and concentration of tin ore; mining and concentration of antimony-mercury ores; mining of precious metals and rare metal ores; mining of other non-ferrous metal ores.

1 Objects of professional activity. The objects of professional activity of graduates are enrichment plants, enterprises of ferrous and non-ferrous metallurgy, chemical, mining, chemical and machine-building industries, industrial research and design institutes, factory laboratories, higher educational institutions, consulting companies, scientific, innovation centers, banks.

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PASSPORT OF THE EDUCATIONAL PROGRAM

1 The scope and content of the program

The educational program for the preparation of a Doctor of Philosophy (PhD) has a scientific and pedagogical focus and involves fundamental educational, methodological and research training and in-depth study of disciplines in the relevant areas of science for the system of higher and postgraduate education and the scientific field.

The educational program for the preparation of a doctor in profile involves fundamental educational, methodological and research training and in-depth study of disciplines in the relevant areas of science for the sectors of the national economy, social sphere: education, medicine, law, art, economics, business administration and in the field of national security and military business.

Educational doctoral programs in vocational training are developed on the basis of studying the experience of foreign universities and research centers that implement accredited training programs for PhD doctors or doctors in profile.

The content of the educational program of specialized doctoral studies is established by the university on its own.

The main criterion for completing the educational process for the preparation of Doctors of Philosophy (PhD) (doctorate in profile) is the development by a doctoral student of at least 180 academic loans, including all types of educational and scientific activities.

The term of study in doctoral studies is determined by the amount of spent academic loans. When mastering the established amount of academic loans and achieving the expected learning outcomes for obtaining a Ph.D. or PhD degree, the doctoral education program is considered fully mastered.

Training in doctoral studies is carried out on the basis of educational programs of the magistracy in two areas:

- 1) scientific and pedagogical with a term of study of at least 2 years;
- 2) profile with a training period of at least 1 year.

The content of the EP.

The content of the educational doctoral program consists of: 1) theoretical training, including the study of cycles of basic and major disciplines; 2) the practical training of doctoral students: various types of practices, scientific or professional internships; 3) research work, including the implementation and defense of a doctoral dissertation PhD 4) final certification.

The educational program includes the following stages of training students: methods of scientific research, academic writing, scientific research of the processes of complex extraction of metals from industrial raw materials of the mining and metallurgical complex; innovative technologies for the production of new types of

products from waste and secondary raw materials of non-ferrous metallurgy; complexation in metallurgical systems and processes. Possibility of choosing disciplines from the catalog of elective disciplines of Satbayev University.

The objectives of the educational program:

The objectives of the educational program are:

- training professionals for analytical, consulting and research activities;
- independent conducting of research, research and development, any project activity in the field of metallurgy; compliance with international engineering qualifications;
- training of specialists for the implementation of pedagogical activities in universities on the metallurgical profile;
- retraining and advanced training of specialists and senior employees of non-ferrous metallurgy;
- mastery of knowledge on energy-intensive, innovative technologies of the metallurgical sector, nanotechnology, technologies that meet the requirements of the green economy in metallurgy, advanced methods of physicochemical analysis, software operation in the calculation of various metallurgical, thermodynamic, kinetic systems, production of special-purpose products; development of design solutions;
- assessment of innovative technological risks in the implementation of new technologies;
- competence in marketing high-tech technologies;
- operating time of personal scientific and metric indicators of the student;
- foreign internship.

2 Entry Requirements

Persons with a master's degree and at least 1 (one) year work experience or who have completed studies in a residency program are accepted for doctoral studies.

Enrollment in the number of doctoral students is carried out by the selection committees of universities and scientific organizations based on the results of the entrance exam for groups of educational programs for doctoral studies and a certificate confirming knowledge of a foreign language in accordance with the European competencies (standards) of foreign language proficiency.

When enrolling in universities, doctoral students independently choose an educational program from the corresponding group of educational programs.

Enrollment of persons for targeted training of Doctors of Philosophy (PhD) by state educational order is carried out on a competitive basis.

The procedure for admitting citizens to doctoral studies is established in accordance with the "Model Rules for Admission to Education in Educational Organizations Implementing Educational Programs of Postgraduate Education".

The formation of the contingent of doctoral students is carried out by placing a state educational order for the preparation of scientific and pedagogical personnel, as well as paying for tuition at the expense of citizens and other sources. For the citizens of the Republic of Kazakhstan, the state ensures the right to receive, on a competitive basis, in accordance with the state educational order of free postgraduate education, if they receive education at this level for the first time.

At the “entrance”, the doctoral candidate must have all the prerequisites necessary for mastering the corresponding professional doctoral study program. The list of required prerequisites is determined by the higher educational institution independently.

In the absence of the necessary prerequisites, the doctoral student is allowed to master them on a paid basis. In this case, doctoral studies begin after the doctoral student has fully mastered prerequisites.

3 Requirements for completing studies and obtaining a diploma

Persons who have mastered the educational program of doctoral studies and defended their doctoral dissertation, if the dissertation councils of the university with special status or the Committee for control in the field of education and science of the Ministry of Education and Science of the Republic of Kazakhstan are positive, according to the results of the examination, will be awarded the degree of Doctor of Philosophy (PhD) or doctor in profile and issued a state diploma with the application (transcript).

Persons who have received a PhD doctorate, in order to deepen scientific knowledge, solve scientific and applied problems on a specialized topic, carry out a postdoctoral program or conduct scientific research under the guidance of a leading scientist of the chosen university.

3.1 Requirements for the key competencies of doctoral graduates:

1) have an idea:

- about the main stages of development and paradigm shift in the evolution of science;
- on the subject, worldview and methodological specifics of the natural (social, humanitarian, economic) sciences;
- about scientific schools of the corresponding branch of knowledge, their theoretical and practical developments;
- on the scientific concepts of world and Kazakhstani science in the relevant field;
- on the mechanism for introducing scientific developments into practical activities;
- on the norms of interaction in the scientific community;
- About the pedagogical and scientific ethics of a scientist-researcher;

2) *know and understand:*

- current trends, directions and patterns of development of domestic science in the context of globalization and internationalization;
- methodology of scientific knowledge;
- achievements of world and Kazakhstani science in the relevant field;
- (recognize and accept) the social responsibility of science and education;
- perfect foreign language for the implementation of scientific communication and international cooperation;

3) *be able to:*

- organize, plan and implement a research process;
- analyze, evaluate and compare various theoretical concepts in the field of research and draw conclusions;
- analyze and process information from various sources;
- conduct independent scientific research, characterized by academic integrity, based on modern theories and methods of analysis;
- generate their own new scientific ideas, communicate their knowledge and ideas to the scientific community, expanding the boundaries of scientific knowledge;
- choose and effectively use modern research methodology;
- plan and predict their further professional development;

4) *have skills:*

- critical analysis, evaluation and comparison of various scientific theories and ideas;
- analytical and experimental scientific activity;
- planning and forecasting research results;
- oratory and public speaking at international scientific forums, conferences and seminars;
- scientific writing and scientific communication;
- planning, coordination and implementation of research processes;
- a systematic understanding of the field of study and demonstrate the quality and effectiveness of selected scientific methods;
- participation in scientific events, fundamental scientific domestic and international projects;
- leadership and team leadership;
- responsible and creative attitude to scientific and scientific-pedagogical activity;
- conducting a patent search and experience transferring scientific information using modern information and innovative technologies;
- protection of intellectual property rights to scientific discoveries and

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developments;

- free communication in a foreign language;

5) *be competent:*

- in the field of scientific and scientific-pedagogical activity in the conditions of rapid updating and growth of information flows;
- in carrying out theoretical and experimental scientific research;
- in the formulation and solution of theoretical and applied problems in scientific research;
- in conducting a professional and comprehensive analysis of problems in the relevant field;
- in matters of interpersonal communication and human resource management;
- in matters of university training of specialists;
- in the examination of scientific projects and research;
- in ensuring continuous professional growth.

3.2 Requirements for research work of a doctoral student studying under the program of doctor of philosophy (PhD):

- 1) compliance with the main problems of the educational program of doctoral studies, on which the doctoral dissertation is defended;
- 2) relevant and contains scientific novelty and practical significance;
- 3) based on modern theoretical, methodological and technological achievements of science and practice;
- 4) based on modern methods of data processing and interpretation using computer technologies;
- 5) performed using modern methods of scientific research;
- 6) contains research (methodological, practical) sections on the main protected provisions.

3.3 Requirements for the organization of practices:

The practice is conducted in order to form practical skills of scientific, scientific-pedagogical and professional activities.

The educational program of the doctoral program includes:

- 1) pedagogical and research practice - for students on the program of the doctor of philosophy;
- 2) industrial practice - for students in the program of specialized doctoral studies. During the period of pedagogical practice, doctoral students, if necessary, are involved in conducting classes in the bachelor's and master's programs.

Practice doctoral research is to study the latest theoretical, methodological and technological advances domestic and foreign science and consolidate practical skills of application of modern methods of scientific research, processing and interpretation of

experimental data in this thesis.

Production practice of a doctoral student is carried out in order to consolidate the theoretical knowledge obtained in the course of training, and improve the professional level.

The content of research and production practices is determined by the theme of the doctoral dissertation.

4 Working curriculum of the educational program

4.1. Working curriculum doctoral PhD "Metallurgical Engineering" Academic degree: Doctor of Philosophy (PhD)

year of study	Code	Name of course	Cycle	Academic cred its	Total hours	Lecture/ lab/ prac/DSIW	IWMIS (including IWMST), in hours	Prerequisites	Code	Name of course	Cycle	Academic cred its	Lecture/ lab/ prac/DSIW	Prerequisites	
															1 semester
1	MET 322	Research methods	BD IC	5	150	2/0/1/2	105		AAP3 45	Doctoral student research work, including internships and doctoral dissertations	DS R W	24			
	LNG 305	Academic writing	BD IC	5	150	0/0/3/2	105		AAP3 50	Pedagogical practice	BD	10			
	MET 309	Scientific research of the processes of complex extraction of metals from the industrial mining and metallurgical complex	BD OC	5	150	2/0/1/2	105								
	MET 308	Innovative technologies for the production of new types of products from waste and recycled raw materials of non-ferrous metallurgy	PS OC	5	150	2/0/1/2	105								
	MET 323	Complexation in metallurgical systems and processes	PS OC	5	150	2/0/1/2	105								
		In total			25		15				In total		34		
2	3 semester							4 semester							

	AAP 345	Doctoral student research work, including internships and doctoral dissertations	DS R W	24						AAP3 46	Doctoral student research work, including internships and doctoral dissertations	DS R W	25				
	AAP 349	Research scientific training	PS	10													
		In total		34							In total		25				
	5 semester								6 semester								
3	AAP 346	Doctoral student research work, including internships and doctoral dissertations	НИРД	25						AAP3 46	Doctoral student research work, including internships and doctoral dissertations	НИРД	25				
										ECA3 03	Writing and defending doctoral dissertation	ИА	12				
		In total		25							In total		37				
											In all		180				



MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN
KAZAKH NATIONAL RESEARCH TECHNICAL UNIVERSITY named after K.I. SATPAYEV



WORKING CURRICULUM

Education Program "8007204 - Metallurgical engineering"
Group of Educational Programs "D117 - Metallurgical engineering"
enrollment for 2021 - 2022 academic year

Academic Degree: Doctor of Philosophy (PhD)
Term of study: 3 years

Year of study	Code	Name of course	Component	Academic credits	Total hours	Lectures/Laboratory/practicum	DSRW (including DSW, FA, In)	Prerequisites	Code	Name of course	Component	Academic credits	Lectures/Laboratory/practicum	Prerequisites	
1	3 semester														
	MET322	Research methods	BD IC	5	150	20/1/2	108		AAP345	Doctoral student research work, including internships and doctoral dissertations	DSRW	24			
	LNG305	Academic writing	BD IC	5	150	100/3/2	102		AAP350	Pedagogical practice	BD	10			
	MET309	Scientific research of the processes of complex extraction of metals from the industrial mining and metallurgical complexes	BD OC	5	150	20/1/2	103								
	MET308	Innovative technologies for the production of new types of products from waste and recycled raw materials of non-ferrous metallurgy	PS OC	5	150	20/1/2	105								
	MET323	Complexation in metallurgical systems and processes	PS OC	5	150	20/1/2	108								
	In total				25	15			In total				34		
2	4 semester														
	AAP345	Doctoral student research work, including internships and doctoral dissertations	DSRW	24					AAP346	Doctoral student research work, including internships and doctoral dissertations	DSRW	24			
	AAP355	Research scientific training	PS	10					In total				25		
	In total				34				In total				25		
3	5 semester														
	AAP346	Doctoral student research work, including internships and doctoral dissertations	DSRW	25					6 semester						
									AAP346	Doctoral student research work, including internships and doctoral dissertations	DSRW	25			
								ECA303	Writing and defending doctoral dissertations	FA	12				
	In total				25				In total				37		
	In all				180				In all				180		

Decision of the Academic Board of KazNRTU named after K.I. Satpayev. Protocol No. 3 of 25.06.21

Decision of the Academic Board of the MaMI named after O. A. Baikunurov. Protocol No. 1 of 20.06.21

Vice-Rector for Academic Affairs

Director of the Mining and Metallurgical Institute named after O. A. Baikunurov

Head of the Department "Metallurgy and mineral processing"

Head of the Department "Metallurgical processes, heat engineering and technology of special materials"

Partner university:
Worcester Polytechnic Institute (USA)

[Signatures]
B.A. Zhanitkova
K.B. Rysbekov
M.B. Barmenshinova
T.A. Chepustunova
B. Mishra

Number of credits for the whole period of study	
Cycles of disciplines	Credits
Three cycle of general education	91
A cycle of basic disciplines (BD IC, BD OC)	29
A cycle of practical analysis (PS IC, PS OC)	20
All over the theoretical classes	48
DSRW	123
Registration and defense of the master's thesis (RadMT)	12
In total	180

5 Descriptors of the level and volume of knowledge, skills, competencies

The third-level descriptors within the framework of the Comprehensive Qualifications Framework of the European Higher Education Area (RK-EHEA) reflect the learning outcomes characterizing the student's abilities:

1) demonstrate a systematic understanding of the field of study, mastery of the skills and research methods used in the field of metallurgy.

A graduate of the doctoral program in metallurgy has knowledge of building cooperative systems of activity and interaction, a methodology for modeling and managing macro-social and macro-economic systems in the mining and metallurgical industry. He has knowledge of safety and labor protection rules.

2) demonstrate the ability to think, design, implement and adapt an essential research process with a scientific approach; Demonstrates systemic and strategic thinking, skills for making mutually beneficial decisions using logical methods, building and playing models of professional activity and interaction.

3) to contribute by own original research to expanding the boundaries of the scientific field, which deserves publication at the national or international level;

4) critically analyze, evaluate and synthesize new and complex ideas. Independence: management activity involving the creation of a strategy for the functioning and development of large institutional structures of a state-wide industry. Responsibility: for the planning, development and results of business processes that could lead to significant changes or development. Difficulty: an activity that involves solving development problems, developing new approaches, using a variety of methods. Resource management to achieve strategic goals.

5) communicate their knowledge and achievements to colleagues, the scientific community and the general public;

6) to promote the advancement in the academic and professional context of the technological, social or cultural development of a knowledge-based society.

6 ECTS Diploma Supplement

The application is developed according to the standards of the European Commission, Council of Europe and UNESCO / CEPES. This document is for academic recognition only and is not an official confirmation of an educational certificate. Without a diploma of higher education is not valid.

The purpose of filling out the European application is to provide sufficient data on the holder of the diploma, the qualification obtained, the level of this qualification, the content of the training program, the results, the functional purpose of the qualification, as well as information on the national education system. The application model for which the estimates will be translated uses the European transfer or credit transfer system (ECTS).

The European diploma Supplement provides an opportunity to continue education in foreign universities, as well as to confirm the national higher education for foreign employers. When traveling abroad for professional recognition will require additional legalization of the diploma of education. The European diploma Supplement is completed in English on individual request and is issued free of charge.

Доктор философии PhD в области металлургии, 8 уровень национальной рамки квалификаций с правом занимать следующие должности: 6, 7 должностной уровень, 8 уровень: президент предприятия, генеральный директор на предприятиях горно-металлургической промышленности согласно *Отраслевой рамки квалификаций «Горно-металлургическая промышленность»* от «16» августа 2016 года № 1 Объединения юридических лиц «Республиканская ассоциация горнодобывающих и горно-металлургических предприятий».

Doctor of Philosophy PhD in metallurgy, level 8 of the national qualifications framework with the right to occupy the following positions: 6, 7 job level, 8 level: President of the enterprise, General Director at the mining and metallurgical industry enterprises according to the *Mining and Metallurgical Industry Qualifications Framework* from " 16 "August 2016 No. 1 of the Association of Legal Entities" Republican Association of Mining and Mining and Metallurgical Enterprises ".

Writing and defending a doctoral dissertation

CODE – ECA 303

CREDIT – 12

The purpose of the doctoral dissertation is to assess the scientific-theoretical and research-analytical level of the doctoral student, the formed professional and managerial competencies, the readiness to independently perform professional tasks and the compliance of its preparation with the requirements of the professional standard and the educational program of doctoral studies.

SHORT DESCRIPTION

Doctoral dissertation is a scientific work of a doctoral student, which is an independent study, in which theoretical provisions are developed, the totality of which can be qualified as a new scientific achievement, or a scientific problem is solved, or scientifically grounded technical, economic or technological solutions are set forth, the implementation of which makes a significant contribution to development the country's economy.

Doctoral dissertation is the result of research / experimental research work of a doctoral student, carried out during the entire period of doctoral student's training.

The defense of a doctoral dissertation is the final stage in the preparation of a master's degree. A master's thesis must meet the following requirements:

- The topic of the thesis should be related to the priority areas of development of science and / or government programs or programs of fundamental or applied research.
- The content of the dissertation, the goals and objectives, the scientific results obtained must strictly correspond to the topic of the dissertation.
- The dissertation is carried out in compliance with the principles of independence, internal unity, scientific novelty, reliability and practical value.

RESEARCH METHODS

CODE – MET322

CREDIT – 5 (2/0/1/2)

PREREQUISITES – Master's degree courses

PURPOSE AND OBJECTIVES OF THE COURSE

The purpose of the course: is to acquire knowledge about the laws, principles, concepts, terminology, content, specific features of the organization and management of scientific research using modern methods of scientometrics.

Course objectives:

- acquaintance with the basic theoretical provisions, laws, principles, terms, concepts, processes, methods, technologies, tools, operations for the implementation of scientific activities;

- studying methods of planning and organizing scientific research;

acquaintance with the general methodology of scientific design, creativity, the general scheme of organizing scientific research, the practice of using methods of scientific knowledge in the field of the relevant industry (mining and metallurgical complex);

- studying methods of planning and organizing scientific research; acquaintance with the general methodology of scientific design, creativity, the general scheme of organizing scientific research, the practice of using methods of scientific knowledge in the field of the relevant industry (mining and metallurgical complex);

- studying the mechanism of scientific research, analysis, conducting experiments, organizing surveys, drawing up questionnaires, etc. ;

- mastering the skills of choosing a scientific research topic and selecting the necessary bibliographic publications and information materials on the research topic; practice of working with scientific databases (ORCID, SCOPUS, Google Scholar, Web of Science, Elsevier, ClarivateAnalytics, Science Direct, Wiley InterScience, Cambridge Journals Online, RSCI, ProQuest Dissertations & Theses, databases of metallurgical and Canadian societies TMS and Met Soc, patent Derwent Innovations Index databases, etc.), the study of scientometrics and scientometric indicators; practice of selecting a journal for publication (understanding the quartiles Q1, Q2, Q3, Q4 WoS, percentiles by CiteScore in the Scopus database),

- study of the basic methods of scientific research;

- study of procedures for setting and solving scientific problems of information processes and informatization of enterprises and organizations;

- acquaintance with the possibilities of conducting scientific research in the international community in the field of fundamental and applied metallurgy; study of standards and norms for the registration of scientific research results, preparation of scientific projects, reports, publications for seminars and conferences; consideration of procedures for searching in global networks for information on scientific developments, opportunities for scientific contacts, applications for scientific grants at various levels;

- acquaintance with the procedures for approbation of the results of scientific research, preparation of publications based on the results of scientific research;

- studying the methods of presenting scientific materials and forming a manuscript of scientific work, preparing a PhD thesis.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

- *professional*: knowledge: about critical thinking; on general scientific methods and their application in scientific research; some special methods and their application in scientific research; on methods of collecting and processing scientific data; on the role of technical sciences and engineering research in modern science; have an understanding of the methods of system and correlation analysis, modeling and optimization methods;

- *managerial*: to draw up plans for the analysis of literature data, the implementation of experimental work; formulate the goals, concepts and objectives of the proposed research; apply methods of ranking, abstraction and formalization in the analysis of literary and experimental scientific data; work with measuring instruments and obtained experimental data; perform SWOT analysis of scientific data and technological solutions; assess risks and ways to prevent them when planning scientific research; submitting applications for projects of any type; work with scientific bases and scientometric indicators.

- *communicative*: the ability to work in a team; show of initiative; consistency of judgments; the ability to effectively cooperate with other people, build subject-subject relationships in the process of professional activity, develop a collective solution to specific technical and theoretical problems.

ACADEMIC WRITING

CODE – LNG305

CREDIT – 5 (0/0/3/2)

PREREQUISITES – English for professional purposes

PURPOSE AND OBJECTIVES OF THE COURSE

Purpose and objectives of the course: Development of academic writing skills for writing research papers.

BRIEF DESCRIPTION OF THE COURSE

The course aims to develop academic writing skills and writing strategy for doctoral students in engineering and natural sciences.

The course focuses on

fundamentals and general principles of academic writing for;

-Writing effective sentences and paragraphs;

-use of times in scientific literature, as well

styles and punctuation;

- writing an abstract, introduction, conclusion, discussion, conclusion, literature and resources used;

- citations in the text;

- prevention of plagiarism, and preparation of a presentation at the conference.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

Upon completion of the course, doctoral students have the following knowledge and skills:

- recognize the features of effective academic writing;

- improve the accuracy and legibility of your own letter;

- correct your scientific work

- use the skills of reading scientific papers and the material read to write a research paper;

- analyze scientific articles published in international publications in their specialty, as well as write scientific articles according to the requirements of the content of each part of a scientific article.

Scientific researches of processes of complex extraction of metals from industrial mining and metallurgical complex

CODE – MET309

CREDIT – 5 (2/0/1/2)

PREREQUISITE – "Special chapters of the theory of metallurgical processes", "Technology of metallurgical production"

PURPOSE AND OBJECTIVES OF THE COURSE

Purpose: to form modern ideas and master the physical and chemical foundations of the basic laws of interaction of components in molten media, aqueous solutions, gas phases occurring in the metallurgical processing of unconventional raw materials: poor, difficult to enrich, complex polymetallic ores; man-made waste metallurgy, chemical industry and energy; secondary raw materials.

Course objectives: to learn to evaluate the quality of metallurgical substandard raw materials, analysis of the relationship between the quality of raw materials and production of metals, to manage all the processes of metallurgical processing of unconventional raw materials, to evaluate the performance of energy and materials conservation, predict and control the behavior of impurity elements and emissions into the environment.

BRIEF DESCRIPTION OF THE COURSE

New solutions, methods of processing substandard raw materials with additional extraction of metals from them in terms of technology and new requirements for environmental safety and environmental protection. New approaches of the theoretical basis necessary for the development of innovative technologies for the production of non-ferrous metals from non-traditional raw materials and waste. New directions of scientific researches applied for development of innovative technologies of complex extraction of non-ferrous metals from substandard types of raw materials. Theoretical and practical filling of technologies of complex extraction of non-ferrous metals and valuable components from substandard raw materials successfully passed the stage of pilot and industrial tests.

Innovative technologies of coke-free metallurgy using gas, coal and hydrogen technologies.

KNOWLEDGE, ABILITIES, SKILLS AT THE END OF THE COURSE

The ability to determine the metallurgical characteristics of non-traditional raw materials, to perform calculations of metallurgical processes, the composition of the charge, the finished metal and slag, waste gases, material and thermal balances of

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metallurgical processes using substandard raw materials, including man-made and secondary raw materials.

Innovative technologies for production of new types of products from waste and secondary raw materials of non-ferrous metallurgy

CODE – MET308

CREDIT – 5 (2/0/1/2)

PREREQUISITE – "Special chapters of the theory of metallurgical processes", "Technology of metallurgical production"

PURPOSE AND OBJECTIVES OF THE COURSE

Purpose: to Study the theory and technology of modern new processes of processing technogenic waste and secondary raw materials of non-ferrous metallurgy to obtain new types of products. *Course objectives:* to learn to analyse the relationships between the quality of raw materials and production of metal, to control the processing of secondary metallurgical materials, operate equipment in the processing of technogenic raw materials, to evaluate the performance of energy and materials conservation, predict and control the behavior of impurity elements and emissions into the environment.

BRIEF DESCRIPTION OF THE COURSE

Characteristics of substandard raw materials: poor, difficult-to-enrich, complex polymetallic ores; technogenic waste of metallurgy, chemical industry and energy; secondary raw materials. New technologies for complex extraction of non-ferrous metals and valuable components from substandard raw materials. Physical and chemical bases of innovative technologies for processing slag waste, substandard semi-products and recycled materials, including the extraction of base metals and expanding the range of new types of commercial products. Improving the efficiency of enterprises by improving and modernizing production through the development and implementation of resource -, energy-saving, environmentally friendly technologies, as well as the utilization of man-made waste with the extraction of valuable components.

KNOWLEDGE, ABILITIES, SKILLS AT THE END OF THE COURSE

Formation of knowledge about the theoretical foundations and approaches to scientific research necessary for solving problems of processing various types and types of secondary raw materials. Skills to analyse the relationships between the quality of raw materials and production of metal, to control the processing of waste and secondary raw materials, operate the equipment in the processing of technogenic raw materials, to evaluate the performance of energy and materials conservation, predict and control the behavior of impurity elements and emissions into the environment. Acquisition of skills and ability to choose and justify the most effective ways of processing waste and secondary raw materials. Ability to conduct SWOT analysis

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The complex formation in metallurgical systems and processes

CODE – MET323

CREDIT – 5 (2/0/1/2)

PREREQUISITE – "Chemistry", "Physics", "Mathematics", "Theory of metallurgical processes".

PURPOSE AND OBJECTIVES OF THE COURSE

The purpose of the course: to Obtain knowledge of doctoral students in the chemistry of coordination compounds, the nature of the chemical bond in coordination compounds and their structure.

Course objective:

- consolidate previously obtained fundamental knowledge of inorganic, organic and physical chemistry;
- to comprehend the importance and necessity of possession of modern physical and physico-chemical research methods for studying the structure and properties of coordination compounds, establishing the mechanism of processes in metallurgical systems.
- master a creative approach to the discipline and learn to understand the basic concepts and patterns of the chemistry of coordination compounds;

BRIEF DESCRIPTION OF THE COURSE

Basic concepts of coordination compounds (CS) chemistry. The structure of the COP. Central atom, ligands in coordination compounds. Nomenclature and types of CS. Isomerism of coordination compounds. The nature of the chemical bond in CS. Ionic bond. Theory of valence bonds. Method of molecular orbitals. Mutual influence of atoms and ligands in CS. Theory of the crystal field. Equilibrium in solutions of CS. General and step stability constants CS. The role of solvent in CS chemistry. Solid-phase transformations in CS. Complexes with a metal-metal bond, n-complexes. Intracomplex connections. The use of CS in metallurgy, science and technology. Technological schemes of extraction, concentration and separation of non-ferrous and rare metals using CS.

KNOWLEDGE, ABILITIES, SKILLS AT THE END OF THE COURSE

- *professional:* doctoral student should be able in accordance with the IUPAC nomenclature to set the name of complex compounds (based on the name of the COP to make his formula); on the basis of the calculation of the equilibrium constants for the reactions of formation of complex compound to establish its stability; to produce a comparative analysis and selection of various physical and physicochemical research methods to study the structure and properties of coordination compounds to interpret the results of the analysis; identify complex compounds and materials based on them to solve specific technological problems of metallurgy;

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- *management*: if necessary, make decisions on the choice of the type of complex compound and methods of its physical and chemical analysis to establish its composition and structure in the development of a specific technological problem of metallurgy;
- *communicative*: ability to work in a team; display of initiative; logical judgments; ability to effectively cooperate with other people, to build subject-subject relationships in the process of professional activity.

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