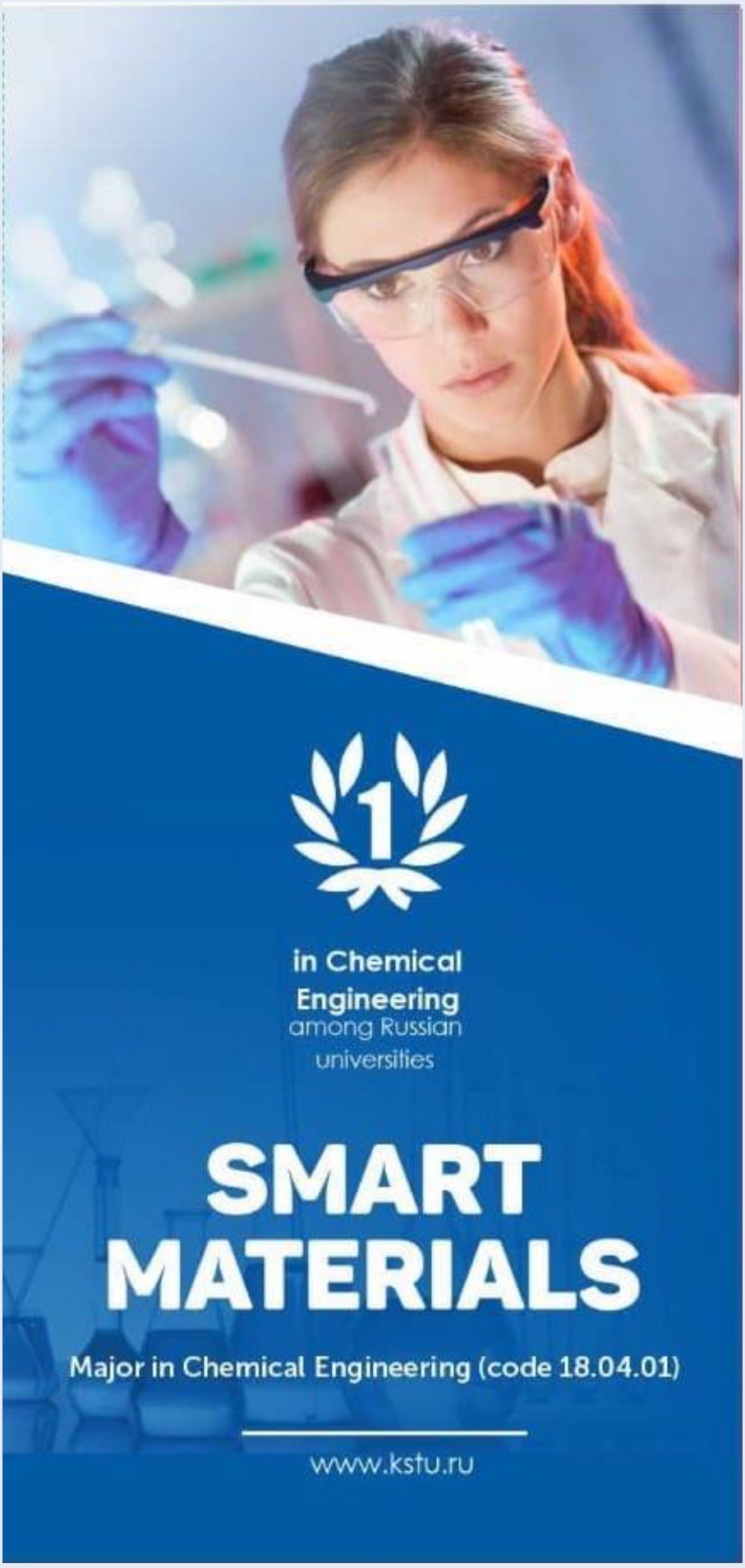
# Handbook

## MSc Program




**Kazan National Research Technological University**

# R E C T O R ' S  W E L C O M E

Dear students!

Kazan National Research Technological University is one of the oldest universities located in the capital of the Republic of Tatarstan and one of the leading Russian centers of higher engineering education.

KNRTU faculty members are excellent professors, whose books and research developments are known around the world.

The university opens its doors for those who are eager to examine achievements of leading research teams, gain skills to become first-class professionals and find their places in life.

KNRTU education meets the most demanding world standards. Its fundamental and applied courses form a strong foundation for personal and professional growth. Our graduates are intelligent, self-sufficient and creative. They have everything to become leaders and succeed in their professions.

A regular university degree is no longer enough to face global issues. A professional should be open to life-long learning, vocational training and obtaining additional competences in order to address the needs of society and industry. Our students have the opportunity to be enrolled in the programs offered by the Institute of Additional Professional Education and to obtain additional qualifications along with earning their degree.

KNRTU is one of the few Russian universities which facilitate job placement of graduates. The number of job offers annually exceeds the number of graduating students by over 30 percent. This proves the fact that KNRTU graduates are going to stay in demand for the years to come and have great chances to find interesting and well-paid jobs.

KNRTU students gain their knowledge from the best professors and educators, join research groups led by outstanding scientists, use advanced scientific equipment, and at the same time enjoy various social, cultural and sports events.

I do hope that our renowned University will become your home!

I wish you every success in your learning, cultural and social life! May the studies at KNRTU become one of the most important milestones in your biography that will make you proud for having obtained your higher education degree here.

Good luck!

Acting Rector, Dr.Sc. in Engineering YURY M. KAZAKOV

# OUR HISTORY

**1890** Kazan Industrial College

**1919** Kazan Polytechnic Institute

**1930** Kazan Institute of Chemical Technology

**1992** Kazan State Technological University

**2010** Kazan National Research Technological University

## KNRTU today

**> 250** Professors and Doctors of Science

More than **24,000** students

**~900** PhDs

## KNRTU in Rankings

**801+** Engineering and Technology 2021

**801+** QS World University Rankings 2022

**526** Subject Ranking: Technical Sciences

# S M A R T  M A T E R I A L S

# M A S T E R ' S  D E G R E E  P R O G R A M

## Greetings of the Program's Supervisor

Dear friends!

It is my pleasure to invite you to join our Master's degree program in Smart Materials.

I am Yuriy Galyametdinov, and I will guide you through the recent advances of smart materials science, teach you to understand key aspects of their design, and bring you to the top of your research expectations.

**What are smart materials?**

The world develops so rapidly that we hardly realize how many smart things and technologies surround us.
Smart materials are capable of generating a selective response to external stimuli by changing their size, shape, optical properties. Due to this particularity, smart materials are widely used in modern devices, drug delivery systems in biomedicine and optical methods for environmental monitoring.

Our research and academic team is comprised out of the leading experts in supramolecular chemistry, nanosystems, and liquid crystals

The combination of proficiency and expertise of our team forms a quintessence for developing outstanding competences for careers in engineering such as advanced materials, nanotechnology, and polymer engineering as well as engineering-related careers in research and development both nationally and internationally.

For those who are brave enough to challenge their skills and capabilities we open the doors to the fascinating world of smart materials.

Dr. YURIY GALYAMETDINOV
Chair, Department of Physical and Colloid Chemistry
Dr.Sc. in Chemistry
Professor, Honored Scientist of the Republic of Tatarstan

## About the Program

**Smart materials** are the materials capable of generating a selective response to various external and internal stimuli. Such materials represent the core of next generation technologies and also follow a sustainable development agenda. Smart materials science is a truly **interdisciplinary area** that combines chemistry, physics, nanotechnology, chemical engineering, soft matter science, and so on.

**The Master's program "Smart Materials"** offered by Kazan National Research Technological University is delivered entirely in English. The program provides a balanced set of courses, which nurture both hard and soft skills in theoretical knowledge, experimental research, and project teamwork.

**Unique properties** of smart materials usually root in their molecular and nanoscale structural features. Understanding physicochemical processes at these levels allows to predict macroscale properties of materials and develop new materials with smart properties. Therefore, a structure-property relationship in various smart materials is the core of this program.

**The program focuses on** various properties of optically active smart materials that face an increasing demand in molecular electronics and medicine. Physicochemical aspects of soft matter, nanosystems, supramolecular materials, and nanoscale and microscale phenomena are discussed in detail by the course instructors. Fundamental knowledge contributes to predicting smart properties of optical materials and highlighting their application potential.

**The program offers** intensive training of soft skills in teamwork, academic writing, critical thinking, and project management.

The “Smart Materials” program was developed by a team of professors at the Department of Physical and Colloid Chemistry. The partner departments are Organic Chemistry, Heat Engineering, Chemical Technology of Petroleum and Gas Processing, Social Work, Innovation in Chemical Technology, and Foreign Languages for Professional Communication departments.

The program development team is represented by professors who possess a professional experience in developing academic programs and supervising Master’s students within the framework of relevant theoretical and applied research projects.

**By the end of the program students will be able to:**

- Classify smart materials in terms of their practical applications;
- Distinguish appropriate smart materials for specific applications such as biomedicine, molecular electronics, petrochemistry, heat engineering, and nanotechnology;
- Demonstrate a structure-property relationship of selected soft matter smart materials;
- Apply theoretical, simulation, and experimental tools to characterizing smart materials;
- Use academic writing and teamwork skills for implementing applied projects in smart materials;
- Develop processes for fabricating optically active smart materials.

# Academic Plan

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|---|---|---|---|
| **TOTAL: 120 ECTS**<br>**(Workshops not included)** | | | |
| **63**<br>ECTS<br>Disciplines | | **57**<br>ECTS<br>Research Internship | |
| Including Elective Disciplines (**16** ECTS) | | Including Master's Thesis (**9** ECTS) | |
| **FIRST YEAR** | **FIRST SEMESTER** | | **24 ECTS** |
| | Project Management for Research | | 3 |
| | Physiological Basis for Teamwork and Self-Development | | 4 |
| | Research Methods in Chemical Technology | | 4 |
| | Process Intensification in Chemical Engineering | | 3 |
| | Organic and Supramolecular Chemistry | | 5 |
| | Smart Materials: Experimental and Theoretical Approaches | Microfluidic Methods for Smart Materials | 5 |
| | Workshop: Research Practice | | 1 |
| | **SECOND SEMESTER** | | **36 ECTS** |
| | Academic Writing and Critical Thinking | | 4 |
| | Actual Problems of Physical Chemistry | | 6 |
| | Fundamentals of Chemical Engineering for Hydrocarbon Processing | | 5 |
| | Computer Simulation of Nanocomposite | Simulation Methods of Smart Materials | 6 |
| | Research Internship | | 15 |
| | Workshop: Russian language | | 1 |
| **SECOND YEAR** | **THIRD SEMESTER** | | **24 ECTS** |
| | Supramolecular Materials in Organic Electronics | | 5 |
| | Physicochemical Studies in the Structure of Matter Including Nanosystems | | 4 |
| | Soft Matter: Fundamental and Applied Aspects | | 4 |
| | Liquid Crystal Polymers (LCP) and Metallomesogens | Physicochemical Fundamentals of Nanotechnology | 5 |
| | Research Internship | | 6 |
| | **FOURTH SEMESTER** | | **36 ECTS** |
| | Pre-graduation Internship | | 27 |
| | Final Qualification Thesis (Master's Thesis) | | 9 |

## Meet Our Faculty

The program was developed in accordance with the most acute trends in engineering and research. We gathered a team of professionals who will share their expertise and knowledge in different aspects related to the development and research of smart materials. The program includes the number of compulsory and elective disciplines which were tuned to address the most interesting and challenging issues.

***Professor YURIY G. GALYAMETDINOV, Dr.Sc. in Chemistry***

Chair, Department of Physical and Colloid Chemistry, KNRTU
Professor, Honored Scientist of the Republic of Tatarstan

Contact details:
tel.: +7 (843) 231-43-89
e-mail: yugal2002@mail.ru

Professor Galyametdinov created a new scientific field - development of methods for obtaining metal-containing liquid crystalline compounds, study of molecular structure, structural organization, study of a new compounds class' physicochemical properties and specific features of their manifestation. The most important achievements of Professor Galyametdinov in this field are:

• creation of the first paramagnetic (nematic, smectic) and heterometallic liquid crystalline complexes;
• formulation of the criteria for liquid crystallinity of transition-group elements' complexes;
• obtaining extensive data on the structure, structural organization and physical properties of more than 300 liquid crystal of metal complexes.

Professor Galyametdinov has developed two courses for the Program:
- *Physicochemical Fundamentals of Nanotechnology*
- *Liquid Crystal Polymers (LCP) and Metallomesogens*

***Associate Professor ARTEM N. BEZRUKOV, Ph.D. in Chemistry***

Artem Bezrukov is an alumnus of the Fulbright Program. He developed two modules for Master's programs as parts of Potanin Foundation grants, launched the Coursera course entitled "Smart Materials: Microscale and Macroscale Approaches", and became a participant of two Erasmus+ Capacity Building and Jean Monet projects.

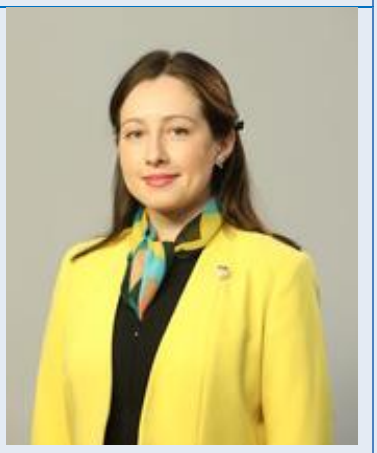
Dr. Bezrukov has developed two courses for the Program:
- *Microfluidic methods for Smart Materials*
- *Smart Materials: Experimental and Theoretical Approaches*

***Professor AZAT V. BILALOV Dr.Sc. in Chemistry***

Professor Bilalov is an expert of the Russian Foundation for Basic Research in nanostructures and clusters, supramolecular chemistry, and colloid systems. He contributes to PhD and postdoctoral projects, initiated within various European research programs: post-doctoral fellow for the Division of Physical Chemistry at Lund University, Sweden; visiting scientist at the Department of Physical Chemistry, University of Paderborn, Germany.

Professor Bilalov has developed two courses for the Program:
- *Actual Problems of Physical Chemistry*
- *Research methods at Chemical Technology*

***Associate Professor ELENA A. EMELYANYCHEVA, Ph.D. in Chemistry***



Elena A. Emelyanycheva is a researcher in the area of bituminous binders and materials based on them. Her research interests include:

- bituminous binders and materials based on them, petroleum refining and petrochemical technologies, thermodynamics and chemical kinetics of hydrocarbon processing.

The Program includes a course developed by Elena A. Emelyanycheva:
- *Fundamentals of chemical engineering for hydrocarbon processing*

***Associate Professor GULNAZ N. FAKHRETDINOVA***
***Ph.D. in Philology***

Gulnaz Fakhretdinova is a Fulbright alumnus, an expert in English language teaching for professional communication. She is a researcher in Engineering Education, International Communication, Philology, Foreign Languages Teaching Methodology.

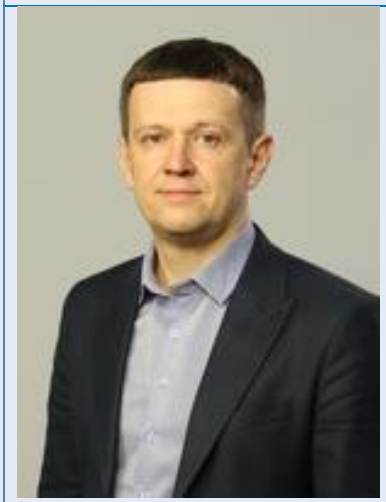
Gulnaz Fakhretdinova is a co-author of the course on:
- *Academic Writing and Critical Thinking*

***Professor ELENA L. GAVRILOVA,***
***Dr.Sc. in Chemistry***

Professor Gavrilova is an expert in the area of organic chemistry – the special fields: phosphororganic chemistry and supramolecular chemistry.

Certificate of Honor of the Ministry of Education and Science of the Russian Federation, 2005
Professor Gavrilova took part in more than 10 grants and research projects, including DAAD, Russian Foundation for Basic Research, and Russian Science Foundation.

Professor Gavrilova has developed a course on:
- *Organic and Supramolecular Chemistry*.



***Professor ANDREY A. KNYAZEV,***
***Dr.Sc. in Chemistry***

Andrey A. Knyazev is an international researcher in the area of magnetic and luminescent properties in lanthanide containing compounds including liquid crystal.

He took part in more than 20 grants, including projects of Russian Foundation for Basic Research, Government of the Republic of Tatarstan "Algarysh", grant of the President of the Russian Federation, grant of Carl Zeiss company, and etc.

Professor Knyazev has developed a course for the Program:
- *Supramolecular Materials in Organic Electronics*

***Associate Professor IRINA V. KUZNETSOVA***
***Ph.D. in Engineering***

Irina Kuznetsova won V, VI, XII republican competition "Fifty best innovative ideas for the Republic of Tatarstan" in 2009, 2010, 2015. She was awarded a grant from the Russian Foundation for Basic Research (RFBR) in 2014 and the Russian Science Foundation (RSF) in 2018.

Irina Kuznetsova developed a course for the Program on:
- *Process Intensification in Chemical Engineering*

***Associate Professor KSENIA A. ROMANOVA***
***Ph.D. in Chemistry***

Ksenia A. Romanova is an expert in fundamental issues of physical and theoretical chemistry.

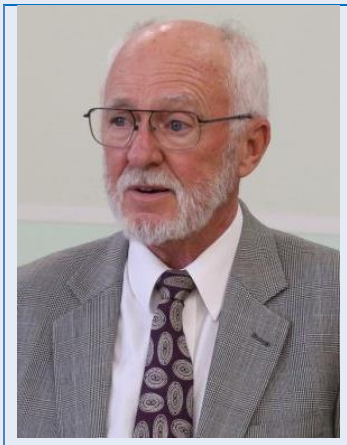
She studies lanthanide-containing liquid crystals, semiconductor quantum dots and conjugated polymers. Ksenia took part in more than 15 grants and scientific projects, including Russian Science Foundation, Russian Foundation for Basic Research and others.

Ksenia A. Romanova has developed two courses for the Program:
- *Simulation Methods of Smart Materials*
- *Computer Simulation of Nanocomposite Materials*

***Associate Professor LILIYA Z. RYAZAPOVA***
***Ph.D. in Engineering***

Liliya Z. Ryazapova is a researcher in the fields of Russian language, professional communication culture, innovative educational technologies.
She authored over 80 papers in academic journals and has 1 patent.

The Program includes a workshop for international students:
- *Russian as a foreign language*



***Professor PHILLIP A. SANGER***
***Professor Emeritus, Purdue University***

Phillip A. Sanger is a champion for the integration c challenging real-world projects from industry into engineerin education.

Prior to joining the academic community, Professor Sanger spent twenty-five years in industry developing new products in the areas of superconductivity, power electronics and semi-conductors for both commercial and military applications. He has lead and managed 64 grants and has generated 4 patents.

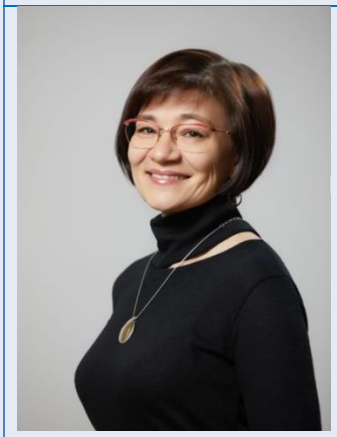
Dr. Sanger delivers a course on:
- *Project Management for Research*

***Professor NATALIA M. SELIVANOVA***
***Dr.Sc. in Chemistry***

Natalia M. Selivanova is an expert in the area of physical chemistry of self-assembling systems based on surfactant, polymers, bloc-copolymers and macrocyclic compounds.

She took part in more than 20 research projects, including grants of the Russian Foundation for Basic Research, grant of the Russian Science Foundation, "Erasmus+" and etc.

Dr. Selivanova delivers a course on *Soft matter: Fundamental and Applied Aspects*



***Associate Professor JULIA N. ZIYATDINOVA***
***Dr.Sc. in Education***

Julia Ziyatdinova is a researcher in global education. Her research focuses on internationalization of higher education worldwide. She explores and compares similarities and difference in higher education in different countries.

Julia Ziyatdinova is a member of the Russian team of Higher Education Reform Experts, notably in the context of the Bologna process. She is a senior member of International Society of Engineering Pedagogy (IGIP).

Dr. Ziyatdinova is an author and a teacher of the Program Course:
- *Academic Writing and Critical Thinking*

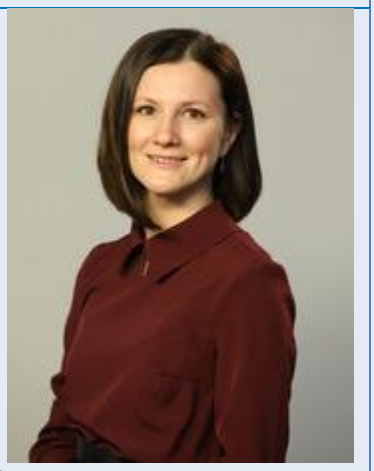
***Professor YURIY F. ZUEV***
***Dr.Sc. in Chemistry***

Honored Scientist of the Republic of Tatarstan.
Awarded with the State Prize in Science and Technology of the Republic of Tatarstan

Author and co-author of 300 scientific articles (143 cited by Scopus), 7 book chapters, 11 textbooks and manual textbooks, 3 patents.
Professor Zuev is a reviewer of Russian Scientific Foundation and Russian Foundation for Fundamental Research.

Professor Zuev has developed a course for the Program on:
- *Physico-Chemical Studies in Structure of Matter including Nanosystems*

***Associate Professor ELVIRA R. VALEYEVA***
***Ph.D. in Education***



RESEARCH INTERESTS

• Intellect, Intellectual Skills, Intellectual Development
• Cognition and Metacognition
• Critical Thinking
• Self-management, Self-control, Self-development

The Program includes a course developed by
Elvira Valeeva: *Psychological Basis for Teamwork and Self-Development*

# Courses Description

## PHYSICOCHEMICAL FUNDAMENTALS OF NANOTECHNOLOGY

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|---|---|
| **Course provider (institution/ Project)** | Kazan National Research Technological University, Russia |
| **Course title** | Physicochemical Fundamentals of Nanotechnology |
| **Target group** | MSc students |
| **Type (compulsory/optional)** | optional |
| **Cycle (short/first/second/third)** | second cycle - for MSc students |
| **Year of study when the component is delivered, semester** | Fall (3rd) semester of MSc studies. |
| **Number of ECTS credits allocated (if applicable); estimated workload** | 5 ECTS<br>180 academic hours of estimated workload (lectures, lab works, seminars, independent work) |
| **Name of lecturer(s)** | Yuriy G. Galyametdinov, professor, Dr.Sc. in Chemistry, Head of Physical and Colloid Chemistry Department; Radik R. Shamilov, Associate Professor, PhD in Elementorganic Chemistry, Department of Physical and Colloid Chemistry |
| **Number of contact hours** | lectures – 8 hours, lab works – 16 hours, seminars – 24 hours |
| **Language of instruction** | English |
| **Course aims** | The course is aimed at mastering theoretical and practical knowledge of nanotechnology, the principles underlying the development and use of nanomaterials. |
| **Learning outcomes** | By the end of this course, MSc students will be able:<br>LO 1. to select the best methods for the preparation of nanomaterials with desired properties;<br>LO 2. to choose research methods and establish the properties of nanotechnology objects;<br>LO 3. to determine the correlation between the dimensional and physicochemical characteristics of nanosystems;<br>LO 4. to apply theoretical approaches to the development and research of new types of nanomaterials for applications. |
| **Prerequisites and co-requisites (if applicable)** | BSc or BEng background |
| **Course content** | 1. General bases of nanotechnology, classification and terminology.<br>2. Basic principles of the formation of nanosystems<br>3. Dependence of physicochemical properties of nanomaterials on size.<br>4. Thermodynamic and kinetic characteristics of chemical processes on the surface of the nanomaterials.<br>5. Methods of study of nanomaterials |

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| **Recommended or required reading and other learning resources/tools** | **Books:**<br>1. Shanmugam S. Nanotechnology. – Great Britain : MJP Publisher, 2019, P. 296.<br>2. Hornyak G. L., Dutta J., Moore J. J., Tibbals H. Fundamentals of Nanotechnology. – Great Britain: CRC Press, 2018, P. 786.<br>3. Naveen Kumar J R, Prasad P. Physical and Chemical Principles of Nanotechnology. Germany: GRIN Verlag, 2019, P. 96.<br>4. Ramsden J. (2016). Nanotechnology: An Introduction. Great Britain: Elsevier Science, 2016, P. 358.<br>**Open access articles/via university access:**<br>1. https://www.nature.com/articles/nature04165<br>2. https://www.sciencedirect.com/science/article/pii/S0032386108003157<br>3. https://www.sciencedirect.com/science/article/pii/S0169409X02000443<br>4. https://setac.onlinelibrary.wiley.com/doi/full/10.1897/08-090.1<br>5. https://faseb.onlinelibrary.wiley.com/doi/full/10.1096/fj.04-2747rev<br>6. https://onlinelibrary.wiley.com/doi/full/10.1002/smll.200800841<br>**Internet Resources:**<br>1. Chemistry database of compounds and related properties, reaction and synthesis information: https://www.reaxys.com/<br>2. Abstract and citation database: https://www.scopus.com |
| **Planned learning activities and teaching methods** | **Teaching**: giving lectures and presentations, arranging seminars, receiving feedback on course from students, giving practical exercises (class/home) – individual and for groups/ teams, promoting critical and constructive thinking, stimulating students to formulate own opinions, supporting personal responsibility<br>**Learning active**: interactions between professor and students including participation in discussions, team/group exercises, collaborative teamwork, laboratory works, sharing experiences with peers, self-evaluation, prepare reports<br>**Learning passive**: attending lectures and seminars, listening, watching and reading learning materials, remembering/ memorizing, repeating |
| **Assessment methods and criteria** | Individual control exercises on using the knowledge of preparation of nanomaterials with desired properties (LO1):<br>- A (excellent) > 90% correct answers;<br>- B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers;<br>Individual control exercises on using the knowledge of research methods and the properties of nanotechnology objects (LO2):<br>- A (excellent) > 90% correct answers;<br>- B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers;<br>Presentation of prepared report and reflective classroom discussion on dimensional and physicochemical characteristics of nanosystems |

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|---|---|
| | (LO3):<br>- A (excellent) the report meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>- B (good) the report generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; a student participates in discussion demonstrating good knowledge of the topic;<br>- C (satisfactory) the report partially meets one or more of the basic requirements, relying on commonly accepted ideas; a student participates in discussion demonstrating basic knowledge of the topic;<br>- D (failing) the report fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear; a student fails to participate in discussion.<br>Presentation of prepared report and reflective classroom discussion on development and research of new types of nanomaterials for applications (LO4):<br>- A (excellent) the report meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>- B (good) the report generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; a student participates in discussion demonstrating good knowledge of the topic;<br>- C (satisfactory) the report partially meets one or more of the basic requirements, relying on commonly accepted ideas; a student participates in discussion demonstrating basic knowledge of the topic;<br>- D (failing) the report fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear; a student fails to participate in discussion. |
| **Prepared/amended by** | Radik R. Shamilov, Associate Professor, PhD in Elementorganic Chemistry, Department of Physical and Colloid Chemistry |

# LIQUID CRYSTAL POLYMERS (LCP) AND METALLOMESOGENS

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|---|---|
| **Course provider (institution/ Project)** | Kazan National Research Technological University, Russia |
| **Course title** | Liquid Crystal Polymers (LCP) and Metallomesogens |
| **Target group** | MSc students |
| **Type (compulsory/optional)** | compulsory |
| **Cycle (short/first/second/thid)** | second cycle - for MSc students |
| **Year of study when the component is delivered, semester** | Spring (2d) semester of MSc studies. |
| **number of ECTS credits allocated (if applicable); estimated workload** | 5 ECTS<br>180 academic hours of estimated workload (lectures, seminars, practicums, independent work) |
| **Name of lecturer(s)** | Yuriy G. Galyametdinov, Professor, PhD in Physical&Colloid Chemistry, Department of Physical and Colloid Chemistry |
| **Number of contact hours** | lectures – 8 hours, seminars – 24 hours, practicum-16 hours |
| **Language of instruction** | English |
| **Course aims** | The course aims to develop effective skills in analysis of chemical and physical phenomena in a liquid crystal polymers and metallomesogens |
| **Learning outcomes** | By the end of this course, MSc students will be able:<br><br>LO 1. To have understanding in classification different kinds of liquid crystal<br>LO 2. to explain the basic laws definite LCP behavior; to predict the composition and properties of the resulting products;<br>LQ 3 to solve problems in synthesis and technologies of liquid crystalline polymers and metallomesogens;<br>LO 4. To know which physical methods are necessary to recognize and detect liquid crystal behavior<br>LO 5. To explain connection between structure and properties of LCP<br>LO 6. to demonstrate understanding of present and future fields of applications of LCP and metsllomesogens in smart materials. |
| **Prerequisites and co-requisites (if applicable)** | BSc or BEng background |
| **Course content** | 1.General fundamentals about LC state of matter<br>2.Fundamentals of the ways of chemical synthesis and modifications LCP and Metallomesogens<br>3.Fundamentals methods on investigations of LCP and metallomesogens; |

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|---|---|
| | 4.Fundamentals in physical and chemical properties of LCP;<br>5.Fundamentals of applications of LCP composites in industry and smart materials. |
| **Recommended or required reading and other learning resources/tools** | **Books:**<br>1. P.J.Collings. Liquid Crystals. Princeton University Press, 2002. – 204 p.<br>2. D.Demus et.c., Handbook of Liquid Crystals. Wiley-VCH. 2003. V. 1-4.<br>3. F.M.Donald. Liquid Crystal Polymers. Cambridge University Press (2010). 165 p.<br>4. Vijay Kumar Thakur and Michael R. Kessler. Liquid Crystalline Polymers. Springer International Publishing Switzerland (2016).626 p.<br>5. HL. Serrano. Metallomesogens. Springer International Publishing Switzerland (1996).326 p<br>6. Yu.Galyametdinov, A.Knyzev.Magnetic properties of Metallomesogens. Kazan Research Technological University (2019). 371 p.<br>**Open access articles/via university access:**<br>1. Polymer materials: https://www.tandfonline.com/<br>2. Smart materials: https://www.springer.com/<br>3. Liquid Crystal Polymers: https://www.springer.com/<br>**Internet Resources:**<br>1. Polymer Dispersed Liquid Crystals – materiability: https:// materialabiliy.com<br>2. Liquid Crystalline Polymers \| springerprofessional.de<br>3. Commercial Uses of Liquid Crystalline Polymers \| SpringerLink<br>4. Smart Material - an overview \| ScienceDirect Topics |
| **Planned learning activities and teaching methods** | **Teaching**: giving lectures and presentations, arranging seminars, receiving feedback on course from students, giving practical exercises (class/home) – individual and for groups/ teams, promoting critical and constructive thinking, stimulating students to formulate own opinions, supporting personal responsibility<br>**Learning active**: interactions between professor and students including participation in discussions, team/group exercises, collaborative teamwork, sharing experiences with peers, self-evaluation, prepare reports<br>**Learning passive**: attending lectures and seminars, listening, watching and reading learning materials, remembering/ memorizing, repeating |
| **Assessment methods and criteria** | Individual control exercises on using the knowledge of thermodynamics and reaction kinetics in hydrocarbon processing for solving practical problems (LO1):<br>- A (excellent) > 90% correct answers;<br>- B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers;<br>Individual control exercises on using the knowledge of chemistry and mechanisms of hydrocarbon processing technologies for solving practical problems (LO2):<br>- A (excellent) > 90% correct answers; |

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| | - B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers;<br>Presentation of prepared report and reflective classroom discussion on current state and prospects of hydrocarbon gas processing technologies (LO3):<br>- A (excellent) the report meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>- B (good) the report generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; a student participates in discussion demonstrating good knowledge of the topic;<br>- C (satisfactory) the report partially meets one or more of the basic requirements, relying on commonly accepted ideas; a student participates in discussion demonstrating basic knowledge of the topic;<br>- D (failing) the report fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear; a student fails to participate in discussion.<br>Presentation of prepared report and reflective classroom discussion on current state and prospects of solid fossil fuel processing technologies (LO4):<br>- A (excellent) the report meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>- B (good) the report generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; a student participates in discussion demonstrating good knowledge of the topic;<br>- C (satisfactory) the report partially meets one or more of the basic requirements, relying on commonly accepted ideas; a student participates in discussion demonstrating basic knowledge of the topic;<br>- D (failing) the report fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear; a student fails to participate in discussion. |
| **Prepared/amended by** | Yuriy G. Galyametdinov, Professor, PhD in Physical&Colloid Chemistry, Department of Physical&Colloid Chemistry |

# MICROFLUIDIC METHODS FOR SMART MATERIALS

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| **Course provider (institution/ Project)** | Kazan National Research Technological University, Russia |
| **Course title** | Microfluidic Methods for Smart Materials |
| **Target group** | MSc students |
| **Type (compulsory/optional)** | optional |
| **Cycle (short/first/second/third)** | second cycle - for MSc students |
| **Year of study when the component is delivered, semester** | Fall (1st) semester of MSc studies |
| **Number of ECTS credits allocated (if applicable); estimated workload** | 5 ECTS<br>180 academic hours of estimated workload (lectures, lab works, seminars, independent work) |
| **Name of lecturer(s)** | Artem N. Bezrukov, Associate Professor, Ph.D. in Chemistry, Department of Physical and Colloid Chemistry |
| **Number of contact hours** | lectures – 9 hours, lab works – 24 hours, seminars – 12 hours |
| **Language of instruction** | English |
| **Course aims** | The course aims at overviewing a microscale approach to fabrication, modification, and characterization of smart materials, fabricating microfluidic chips, simulating microfluidic processes, and synthesizing smart soft matter systems in confinement |
| **Learning outcomes** | By the end of this course, MSc students will be able:<br>LO1. Apply microfluidic instruments to fabrication of smart materials.<br>LO2. Summarize the steps required for design and fabrication of microfluidic devices.<br>LO3. Model the processes of microfluidics soft matter synthesis with numerical software.<br>LO4. Illustrate the benefits of microfluidics for smart materials science and technology. |
| **Prerequisites and co-requisites (if applicable)** | BSc or BEng background |
| **Course content** | 1. Introduction to microfluidics<br>2. Microfluidics and its relevance to smart materials<br>3. Correlation between microfluidics and nanoscale systems<br>4. Fabrication of microfluidic devices<br>5. Modeling microfluidic processes<br>6. Introduction to Matlab programming |
| **Recommended or required reading and other learning resources/tools** | **Books:**<br>1. J. Berthier and P. Silberzan, Microfluidics for Biotechnology, Second Edition, Artech House, London, 2009.<br>2. P. Tabeling, Introduction to Microfluidics, Oxford University Press, 2005. |

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| | 3. K. Holmberg, B. Jönsson, B. Kronberg and B. Lindman, Surfactants and Polymers in Aqueous Solution, Second Edition, 2003.<br>**Open access articles/via university access:**<br>1. Bezrukov A.N., Galyametdinov Yu.G. Physicochemical aspects of smart materials / Kazan, KNRTU, 2020, 104 p.<br>2. Bezrukov A.N., Galyametdinov Yu.G. Introduction to smart materials / Kazan, KNRTU 2018, 84 p.<br>**Internet Resources:**<br>1. Microfluidics - a General Overview https://www.elveflow.com/microfluidic-reviews/general-microfluidics/a-general-overview-of-microfluidics/<br>2. Lab on Chip - Latest Research and News https://www.nature.com/subjects/lab-on-a-chip<br>3. Microfluidic Emulsions - Dolomite Microfluidics https://www.dolomite-microfluidics.com/applications/single-emulsions/<br>4. Lab on Chip for Smart Materials https://www.coursera.org/lecture/smart-materials-microscale-and-macroscale-approaches/introduction-to-microfluidics-hAdfj |
| **Planned learning activities and teaching methods** | **Teaching**: giving lectures and presentations, arranging seminars, receiving feedback on course from students, giving practical exercises (class/home) – individual and for groups/ teams, promoting critical and constructive thinking, stimulating students to formulate own opinions, supporting personal responsibility<br>**Learning active**: interactions between professor and students including participation in discussions, team/group exercises, collaborative teamwork, laboratory works, sharing experiences with peers, self-evaluation, prepare reports<br>**Learning passive**: attending lectures and seminars, listening, watching and reading learning materials, remembering/ memorizing, repeating |
| **Assessment methods and criteria** | Individual control exercises on applying microfluidic instruments to fabrication of smart materials (LO1):<br>- A (excellent) > 90% correct answers;<br>- B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers;<br>Individual control exercises on the steps required for design and fabrication of microfluidic devices (LO2):<br>- A (excellent) > 90% correct answers;<br>- B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers<br>Reports on developing models of microfluidic systems for smart materials to be solved with the numerical software (LO3):<br>- A (excellent) the report meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>- B (good) the report generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; a student participates in discussion |

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| | demonstrating good knowledge of the topic;<br>- C (satisfactory) the report partially meets one or more of the basic requirements, relying on commonly accepted ideas; a student participates in discussion demonstrating basic knowledge of the topic;<br>- D (failing) the report fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear; a student fails to participate in discussion.<br>Presentations on illustrating the benefits of microfluidics for smart materials science and technology (LO4):<br>- A (excellent) the presentation meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>- B (good) the presentation generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; a student participates in discussion demonstrating good knowledge of the topic;<br>- C (satisfactory) the presentation partially meets one or more of the basic requirements, relying on commonly accepted ideas; a student participates in discussion demonstrating basic knowledge of the topic;<br>- D (failing) the presentation fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear; a student fails to participate in discussion. |
| **Prepared/amended by** | Artem N. Bezrukov, Associate Professor, Ph.D. in Chemistry, Department of Physical and Colloid Chemistry |

# SMART MATERIALS: EXPERIMENTAL AND THEORETICAL APPROACHES

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| **Course provider (institution/ Project)** | Kazan National Research Technological University, Russia |
| **Course title** | Smart Materials: Experimental and Theoretical Approaches to Design and Characterization of Smart Materials |
| **Target group** | MSc students |
| **Type (compulsory/optional)** | optional |
| **Cycle (short/first/second/third)** | second cycle - for MSc students |
| **Year of study when the component is delivered, semester** | Fall (1st) semester of MSc studies. |
| **Number of ECTS credits allocated (if applicable); estimated workload** | 5 ECTS<br>180 academic hours of estimated workload (lectures, lab works, seminars, independent work) |
| **Name of lecturer(s)** | Artem N. Bezrukov, Associate Professor, Ph.D. in Chemistry, Department of Physical and Colloid Chemistry |
| **Number of contact hours** | lectures – 9 hours, lab works – 12 hours, seminars – 24 hours |
| **Language of instruction** | English |
| **Course aims** | This course aims at providing a structured overview of theoretical approaches and experimental techniques for design and characterization of smart materials as well as offering tools for development of smart materials by correlating their nanoscale and microscale structure with the desired properties. |
| **Learning outcomes** | By the end of this course, MSc students will be able:<br>LO1. Identify correlations between properties of smart materials and the analytical methods suitable for their characterization.<br>LO2. Define appropriate spectroscopy, microscopy, and numerical methods for characterization of smart materials.<br>LO3. Apply theoretical approaches to designing soft matter smart materials.<br>LO4. Select specific analytical methods to study the behavior of smart materials. |
| **Prerequisites and co-requisites (if applicable)** | BSc or BEng background |
| **Course content** | 1. Design of smart materials: nanoscale<br>2. Correlation between nanoscale structure and properties of smart materials<br>3. Design of smart materials: microscale<br>4. Introduction to scaling laws<br>5. Characterization of smart materials: spectroscopy methods |

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| | 6. Characterization of smart materials: microscopy methods |
| **Recommended or required reading and other learning resources/tools** | **Books:**<br>1. Shwartz, M. Smart Materials / M. Shwartz. – Taylor & Francis Group, 2008. – 556 p.<br>2. Sun, B. Smart Materials and Structures / B. Sun. – Capetown: C.P. University of Technology, 2015. – 101 p.<br>3. Design, fabrication, Properties and Applications of Smart and Advanced Materials / Ed. by H. Hou. – Taylor & Francis Group, 2016. – 491 p.<br><br>**Open access articles/via university access:**<br>1. Bezrukov A.N., Galyametdinov Yu.G. Introduction to smart materials / Kazan, KNRTU 2018, 84 p.<br>2. Bezrukov A.N., Galyametdinov Yu.G. Physicochemical aspects of smart materials / Kazan, KNRTU, 2020, 104 p.<br><br>**Internet Resources:**<br>1. Encyclopedia of smart materials https://onlinelibrary.wiley.com/doi/book/10.1002/0471216275?tabActivePane=<br>2. Soft Matter - Materials of the Future https://www.youtube.com/watch?v=Xe4H3UTiQOk<br>3. Malvern Zetasizer User Manual https://www.malvernpanalytical.com/en/learn/knowledge-center/user-manuals/MAN0485EN<br>4. Lab on Chip for Smart Materials https://www.coursera.org/lecture/smart-materials-microscale-and macroscale-approaches/introduction-to-microfluidics-hAdfj |
| **Planned learning activities and teaching methods** | **Teaching**: giving lectures and presentations, arranging seminars, receiving feedback on course from students, giving practical exercises (class/home) – individual and for groups/ teams, promoting critical and constructive thinking, stimulating students to formulate own opinions, supporting personal responsibility<br>**Learning active**: interactions between professor and students including participation in discussions, team/group exercises, collaborative teamwork, laboratory works, sharing experiences with peers, self-evaluation, prepare reports<br>**Learning passive**: attending lectures and seminars, listening, watching and reading learning materials, remembering/ memorizing, repeating |
| **Assessment methods and criteria** | Individual control exercises on identifying correlations between properties of smart materials and the analytical methods suitable for their characterization. (LO1):<br>- A (excellent) > 90% correct answers;<br>- B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers<br>Individual control exercises on defining appropriate spectroscopy, microscopy, and numerical methods for characterization of smart materials. (LO2):<br>- A (excellent) > 90% correct answers; |

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| | - B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers<br>Report on applying theoretical approaches to designing soft matter smart materials (LO3):<br>- A (excellent) the report meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>- B (good) the report generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; a student participates in discussion demonstrating good knowledge of the topic;<br>- C (satisfactory) the report partially meets one or more of the basic requirements, relying on commonly accepted ideas; a student participates in discussion demonstrating basic knowledge of the topic;<br>- D (failing) the report fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear; a student fails to participate in discussion.<br>Presentations on selecting specific analytical methods to study the behavior of smart materials (LO4):<br>- A (excellent) the presentation meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>- B (good) the presentation generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; a student participates in discussion demonstrating good knowledge of the topic;<br>- C (satisfactory) the presentation partially meets one or more of the basic requirements, relying on commonly accepted ideas; a student participates in discussion demonstrating basic knowledge of the topic;<br>- D (failing) the presentation fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear; a student fails to participate in discussion. |
| **Prepared/amended by** | Artem N. Bezrukov, Associate Professor, Ph.D. in Chemistry, Department of Physical and Colloid Chemistry |

# ACTUAL PROBLEMS OF PHYSICAL CHEMISTRY

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| **Course provider (institution/ Project)** | Kazan National Research Technological University, Russia |
| **Course title** | Actual Problems of Physical Chemistry (APPC) |
| **Target group** | MSc students |
| **Type (compulsory/optional)** | compulsory |
| **Cycle (short/first/second/third)** | second cycle - for MSc students |
| **Year of study when the component is delivered, semester** | Spring (2d) semester of MSc studies. |
| **Number of ECTS credits allocated (if applicable); estimated workload** | 5 ECTS<br>126 academic hours of estimated workload (lectures, practicum, independent work) |
| **Name of lecturer(s)** | Azat Bilalov, Professor, Dr.Sc. in Physical Chemistry, Department of Physical and Colloid Chemistry |
| **Number of contact hours** | lectures – 12 h, practicum – 24 h |
| **Language of instruction** | English |
| **Course aims** | The aim of the APPC course is for the student to acquire knowledge of modern physical chemistry for chemical engineering of materials with advanced functions for their applications to current problems in renewable energy, materials science, biology, and medicine. |
| **Learning outcomes** | By the end of the APPC course, MSc students will be able to:<br>LO 1. Use physics and mathematics to answer fundamental questions about the structure of molecules and how chemical reactions take place;<br>LO 2. Present and discuss the cutting edge of research in physical chemistry;<br>LO 3. Reveal informatics tools and its impact on Physical Chemistry;<br>LO 4. Use physical principles and mathematical techniques for chemical engineering of materials with advanced functions (transparent dielectric, superconducting, piezoelectric, electromagnetic shielding, nanofibrous, genotoxic, anti-infective, low-cost etc.);<br>LO 5. Write and submit paper on original research results. |
| **Prerequisites and co-requisites (if applicable)** | BSc or BEng background |
| **Course content** | Actual Problems of Physical Chemistry focuses on topics in modern physical chemistry including nanoscience, laser spectroscopy and chemical dynamics, optical and scanning probe microscopy, nonlinear optics and plasmonics, bioinspired and biomimetic materials. |

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| | In the APPC course, basic principles of intermolecular interactions and thermodynamics are linked to applications in medicine, biology, technical applications, including gen delivery, cell membranes, electrochemistry, drug formulations, etc. We will discuss the structure−property−function relationships of materials in nature. Additionally, this course involves a semester-long research project where student becomes an expert in an active research area in one of the Ph.D programs in physical chemistry at the Department of Physical and Colloid Chemistry. |
| **Recommended or required reading and other learning resources/tools** | **Books:**<br>1. Modern Physical Chemistry: Engineering Models, Materials, and Methods with Applications (Innovations in physical chemistry: monograph series) Ed. by R. Haghi, E. Besalú, M. Jaroszewski, S. Thomas, Praveen K. M., Apple Academic Press, 2018, 541 p.<br>2. P.W. Atkins and J. DePaula, Physical Chemistry, 8-th ed., Oxford Univ. Press, 2006, 1053 p.<br>**Open access articles:**<br>1. M. Tanaka, H. Seto, Interfacial Water: A Physical Chemistry Perspective, Front. Chem., 02 September 2020 / https://www.frontiersin.org/articles/10.3389/fchem.2020.00760<br>2. M. Galizia, K. P. Bye, Advances in Organic Solvent Nanofiltration Rely on Physical Chemistry and Polymer Chemistry, Front. Chem., 23 October 2018 / https://doi.org/10.3389/fchem.2018.00511<br>3. E. Mendoza, N. Duronea, D. Ronso, L. Corazza, F. Van der Tak, S. Paron, L-A Nyman, Interrelations Between Astrochemistry and Galactic Dynamics, Front. Astron. Space Sci., 28 May 2021 \| https://doi.org/10.3389/fspas.2021.655450<br>**Internet Resources:**<br>List of articles: https://www.frontiersin.org/search?query=modern+physical+chemistry&tab=topresults&origin=https%3A%2F%2Fwww.frontiersin.org%2Farticles%2F10.3389%2Ffpls.2014.00490%2Ffull |
| **Planned learning activities and teaching methods** | **Teaching**: Giving lectures, arranging practicum, giving instructions in a research project portfolio generation, help prepare students for exams and research projects, receiving feedback on course from students, giving practical assignments or exercises (individual and for groups/teams). This course is designed to give students an opportunity to explore topics in advanced physical chemistry through instruction, discussion, and collaboration.<br>**Learning active**: The main objective for the student group in APPC course is to learn advanced physical chemistry concepts and the current state of the field, develop problem-solving skills, gain experience in the peer review and response process, and enhance written and oral communication skills. Developing writing skills, evaluating the work of peers, composing a response to reviewers, and creating effective presentation slides, all of which play an important role in manuscript and grant writing process as well as professional presentations.<br>**Learning passive**: Attending lectures and labs, listening, watching |

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| | and reading learning materials, remembering/ memorizing, repeating. |
| **Assessment methods and criteria** | Research Project Portfolio (40%) (LO1 - LO5): A major component of the APPC course involves a semester-long research project. Students must complete a project individually. Projects will culminate in a research paper and class presentation.<br>Points Breakdown:<br>1. Choose Two Project Ideas (10 pts)<br>2. Annotated Bibliography (30 pts)<br>3. Create & Revise a Slide (15 pts)<br>4. Research Paper "Draft" (30 pts)<br>5. Peer Review a Paper (15 pts)<br>6. Practice Presentations & Peer Feedback (30 pts)<br>7. Class Presentations and Discussion (50 pts)<br>8. Response to Reviewers (10 pts)<br>9. Final Research Paper (50 pts)<br>10. Self/Group Evaluation (10 pts)<br>Total = 250 pts (40% of final grade)<br>Practicum (30%) (LO1 - LO5): To help prepare students for exams and research projects, there will be several in-class practice problem-sets. Collaboration on in-class exercises is encouraged. However, to facilitate the development of independent problem-solving skills, problem sets must be completed individually.<br>Exam (30%) (LO1-LO4): Exam is open note (in-class handouts, exercises, textbooks, and Blackboard materials), but using additional resources (e.g., the internet, other students, publications, etc.) is not permitted.<br>Grading rubrics for the research project will be posted on Blackboard in advance of the assignment deadline. In general, class scores and grades will be scaled with the following considerations:<br>A = Excellent performance and mastery of the material<br>B = Very good understanding of the material<br>C = Adequate performance<br>D = Poor performance<br>F = Unsatisfactory performance |
| **Prepared/amended by** | Azat Bilalov, Professor, Dr.Sc. in Physical Chemistry, Department of Physical and Colloid Chemistry |

# RESEARCH METHODS AT CHEMICAL TECHNOLOGY

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| **Course provider (institution/ Project)** | Kazan National Research Technological University, Russia |
| **Course title** | Research Methods at Chemical Technology (RMCT) |
| **Target group** | MSc students |
| **Type (compulsory/optional)** | compulsory |
| **Cycle (short/first/second/third)** | second cycle - for MSc students |
| **Year of study when the component is delivered, semester** | Spring (2d) semester of MSc studies. |
| **Number of ECTS credits allocated (if applicable); estimated workload** | 4 ECTS<br><br>144 academic hours of estimated workload (lectures, labs, independent work) |
| **Name of lecturer(s)** | Azat Bilalov, Professor, Dr.Sc. in Chemistry, Department of Physical and Colloid Chemistry |
| **Number of contact hours** | lectures – 18 h, labs – 18 h |
| **Language of instruction** | English |
| **Course aims** | The aim of the RMCT course is for the student to acquire fundamental knowledge and understanding of different instrumental methods used to study structural and dynamic properties of materials for obtaining information in diverse areas of science and technology. |
| **Learning outcomes** | By the end of the RMCT course, MSc students will be able to:<br>LO 1. Identify the problem (determine type of information needed: qualitative and quantitative characterization, identify context of the problem);<br>LO 2. Design the experimental procedure: establish design criteria (accuracy, precision, scale of operation, sensitivity, selectivity, cost, speed); identify interferent factors; select method; establish validation criteria; establish sampling strategy;<br>LO 3. Conduct experiment (calibrate instruments, take measurements, gather data);<br>LO 4. Analyze the experimental data (reduce or transform data, analyze statistics, verify results, interpret results);<br>LO 5. Propose a solution of the problem, conduct external evaluation, estimate perspectives. |
| **Prerequisites and co-requisites (if applicable)** | BSc or BEng background |

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| **Course content** | We will consider the basics of the most popular physical methods in chemistry, such as chromatography, mass spectrometry, optical spectroscopy (microwave, terahertz, IR, UV, visible region, X-ray), including magnetic resonance methods (NMR, EPR). Practical advice will be given on the interpretation of the spectra. General provisions are illustrated with specific examples on study of simple and complex compounds. We will talk about obtaining of the most important characteristics of materials using thermal methods, methods for studying of rheological properties, atomic force microscopy, and electron microscopy. The practice of applying physical research methods to study the phase behavior and structure of phases, liquid crystals, and quantum dots will be shown. Quantum-mechanical approaches and theoretical methods for studying the structure of substances will be considered. The methodology of experimental work will be given and tasks for independent work of students will be proposed. |
| **Recommended or required reading and other learning resources/tools** | Books:<br>1. C.N. Banwell, E.M. McCash, Fundamentals of Molecular Spectroscopy, 4-th ed., McGraw-Hill , 1994, 308 p.<br>2. E.D. Becker, High resolution NMR, Theory and chemical applications, 3-rd ed., Academic Press, 2000, 424 p.<br>3. Handbook of thermal analysis and calorimetry, V.1: Principles and practice, M.E. Brown (Ed.), Elsevie, 1998, 691 p.<br>4. P.W. Atkins and J. DePaula, Physical Chemistry, 8-th ed., Oxford Univ. Press, 2006, 1053 p.<br>Open access articles:<br>1. Breakthrough Potential in Near-Infrared Spectroscopy: Spectra Simulation. A Review of Recent Developments, Front. Chem., 22 February 2019 \| https://doi.org/10.3389/fchem.2019.00048<br>2. Vibrational Spectroscopy: A Valuable Screening and Diagnostic Tool for Obstetric Disorders, Front. Glob. Womens Health, 28 January 2021 https://doi.org/10.3389/fgwh.2020.610582<br>3. Information flow and protein dynamics: the interplay between nuclear magnetic resonance spectroscopy and molecular dynamics simulations, Front. Plant Sci., 05 May 2015 \| https://doi.org/10.3389/fpls.2015.00306<br>4. Micro-Raman Spectroscopy Analysis of Optically Trapped Erythrocytes in Jaundice, https://doi.org/10.3389/fphys.2020.00821<br>5. Rapid Label-Free Analysis of Brain Tumor Biopsies by Near Infrared Raman and Fluorescence Spectroscopy—A Study of 209 Patients, https://doi.org/10.3389/fonc.2019.01165<br>6. 1064 nm FT-Raman spectroscopy for investigations of plant cell walls and other biomass materials, https://doi.org/10.3389/fpls.2014.00490<br>7. A Review of Recent Solar Type III Imaging Spectroscopy, |

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| | https://doi.org/10.3389/fspas.2020.00056<br>Internet Resources:<br>List of articles:<br>https://www.frontiersin.org/search?query=molecular+spectroscopy&tab=topresults&origin=https%3A%2F%2Fwww.frontiersin.org<br>1) Site of electronic textbooks and manuals on chemistry, including physical and chemical methods for the analysis of organic substances:<br>http://www.rushim.ru/books/books.htm<br>2) Educational portal: http://www.orgchemlab.com<br>Search database of spectral data of organic substances:<br>http://riodb01.ibase.aist.go.jp/sdbs/cgibin/cre_index.cgi?lang=eng<br>3) Website of Aldrich and Sigma companies:<br>http://www.sigmaaldrich.com/homepage/Site_level_pages/CatalogHome.html<br>4) International tables for X-ray crystallography:<br>http://www.chem.msu.ru/rus/cryst/cryschem/welcome-cryschem.html<br>5) Presentations of lectures on mass spectrometry, Novosibirsk State University:<br>http://fen.nsu.ru/posob/organic/physmethods/ms.html<br>6) Electron probe microanalysis:<br>http://geo.web.ru/db/msg.html?mid=1183034)<br>7)Atomic absorption analysis Internet tutorial (there are films about sample preparation):<br>http://www.cord.edu/dept/chemistry/analyticallabmanual/experiments/aa/method.html# http://www.cord.edu/dept/chemistry/analyticallabmanual/experiments/icpaes/intro.html http://www.personal.psu.edu/hxg3/MCL/icpaes.htm 4.<br>8) Internet tutorial (there are films illustrating the processes): http://people.whitman.edu/~dunnivfm/<br>http://www.saugstelle.de/60.html<br>9) ISP-MS:<br>http://minerals.cr.usgs.gov/icpms/intro.html<br>http://www.icp-ms.ru/basics.html#6<br>10) EC UNITS KNITU: http://ruslan.kstu.ru<br>11) EBS Znanium.com: http://znanium.com<br>12) EBS Lan: https://e.lanbook.com<br>13) EBS Student Consultant<br>http://www.studentlibrary.ru%2Fsubjects%2Fstress-management |
| **Planned learning activities and teaching methods** | **Teaching**: Giving lectures, arranging labs, receiving feedback on course from students, giving practical assignments or exercises (individual and for groups/teams), promoting critical thinking, constructive critics and self-criticism, stimulating students to formulate own opinions, supporting personal responsibility and promoting ethical principles.<br><br>**Learning active**: The main objective for the student group in RMCT course is to learn about physical research methods and synthetic strategies for self-assembly in order to be able to |

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| | investigate properties/prepare interesting nano-structured materials. The transfer of this knowledge will be achieved by an efficient interaction between Senior teacher and Students including participation in discussions, group exercises, collaborative teamwork on the labs, sharing experiences with peers, essay writing.<br><br>**Learning passive**: Attending lectures and labs, listening, watching and reading learning materials, remembering/ memorizing, repeating. |
| **Assessment methods and criteria** | Multiple choice test on Instrumental Research Methods (LO1, LO2):<br>A (excellent) > 90% correct answers;<br>B (good) >75% correct answers;<br>C (satisfactory) >60% correct answers<br>D (failing) <60% correct answers<br>Carrying out of laboratory work, processing of results, report preparation and defense of laboratory work (LO3, LO4):<br>A The student participates in all lab work discussions demonstrating deep knowledge of the topics, gives original interpretation of verified results of conducted experiments on all required lab works;<br>B The student participates in some lab work discussions, gives reports on all laboratory works, which were submitted and defended;<br>C The student has completed all required lab works, reports on all laboratory work were submitted and a grade is reported;<br>D The student fails to participate in the lab works.<br>Essay on RMCT (LO5):<br>A The student demonstrates strong knowledge in the field during presentation/report/discussion of the essay, the essay meets the basic requirements (topic, purpose, length, organization, references) and demonstrates originality and complexity of thought;<br>B The essay generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations;<br>C The essay partially meets one or more of the basic requirements, relying on commonly accepted ideas;<br>D The essay fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear. |
| **Prepared/amended by** | Azat Bilalov, Professor, Dr.Sc. in Chemistry, Department of Physical and Colloid Chemistry |

# FUNDAMENTALS OF CHEMICAL ENGINEERING FOR HYDROCARBON PROCESSING

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| **Course provider (institution/ Project)** | Kazan National Research Technological University, Russia |
| **Course title** | Fundamentals of Chemical Engineering for Hydrocarbon Processing |
| **Target group** | MSc students |
| **Type (compulsory/optional)** | compulsory |
| **Cycle (short/first/second/third)** | second cycle - for MSc students |
| **Year of study when the component is delivered, semester** | Spring (2d) semester of MSc studies. |
| **Number of ECTS credits allocated (if applicable); estimated workload** | 5 ECTS<br>107 academic hours of estimated workload (lectures, seminars, independent work) |
| **Name of lecturer(s)** | Elena A. Emelyanycheva, Associate Professor, PhD in Petrochemistry and Colloid Chemistry, Department of Chemical Technology of Petroleum and Gas Processing |
| **Number of contact hours** | lectures – 24 hours, seminars – 24 hours |
| **Language of instruction** | English |
| **Course aims** | The course aims to develop effective skills in analysis of chemical phenomena occurring during hydrocarbon processing based on the knowledge of thermodynamics and chemical kinetics |
| **Learning outcomes** | By the end of this course, MSc students will be able:<br><br>LO 1. to solve problems in the thermodynamics and kinetics of hydrocarbon processing technologies;<br><br>LO 2. to explain the basic laws underlying petroleum processing technologies; to appraise the influence of main factors on the chemical processes of petroleum processing, to choose the most favorable conditions for chemical processes of petroleum processing; to predict the composition and properties of the resulting products;<br><br>LO 3. to explain the basic laws underlying hydrocarbon gas processing technologies; to appraise the influence of main factors on the chemical processes of hydrocarbon gas processing, to choose the most favorable conditions for the chemical processing of hydrocarbon gas; to predict the composition and properties of the resulting products;<br><br>LO 4. to demonstrate understanding of solid fossil fuel processing |

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| | technologies. |
| **Prerequisites and co-requisites (if applicable)** | BSc or BEng background |
| **Course content** | 1. General fundamentals of thermodynamics, chemical kinetics and catalysis of hydrocarbon processing;<br>2. Fundamentals, chemistry and mechanisms of petroleum processing technologies;<br>3. Fundamentals, chemistry and mechanisms of natural and petroleum gas processing technologies;<br>4. Fundamentals, chemistry and mechanisms of solid fossil fuel processing technologies. |
| **Recommended or required reading and other learning resources/tools** | **Books:**<br>1. Emelyanycheva E. A. Fundamentals of chemical engineering of hydrocarbon processing: Study Guide / E. A. Emelyanycheva, A. I. Abdullin. — St. Petersburg: Prospekt Nauki, 2018. — 96 p.<br>2. Emelyanycheva E. A. Chemical Engineering of Natural Fuels and Carbon Materials: Study Guide / E. A. Emelyanycheva [et al]; The Ministry of Education and Science of the Russian Federation, Kazan National Research Technological University. – Kazan: KNRTU Publishing House, 2016. – 96 p.<br>3. Uttam Ray Chaudhuri (2011) Fundamentals of Petroleum and Petrochemical Engineering. CRC Press, Taylor & Francis Group,New York, 380 p.<br>4. Martin Bajus (2020) Petrochemistry: Petrochemical Processing, Hydrocarbon Technology and Green Engineering. John Wiley & Sons Limited, New York, 336 p.<br>5. Robert A. Meyers (2004) Handbook of petroleum refining processes. The McGrow Hill Companies, Inc (русскоязычное издание книги: Роберт А. Мейерс Основные процессы нефтепереработки: [перевод с английского] / Роберт А. Мейерс; под ред. О. Ф. Глаголевой, О. П. Лыкова. - СПб: ЦОП «Профессия», 2011. - 944 с.)<br>**Open access articles/via university access:**<br>1. Petroleum Science and Technology: https://www.tandfonline.com/loi/lpet20<br>2. Petroleum Chemistry: https://www.springer.com/journal/11494<br>3. Chemistry and Technology of Fuels and Oils: https://www.springer.com/journal/10553<br>**Internet Resources:**<br>1. Hydrocarbon Processing: https://www.hydrocarbonprocessing.com/<br>2. Oil Refining: https://www.sciencedirect.com/topics/chemical-engineering/oil-refining<br>3. Solomon, Lee H. , Carruthers, John E. and Waddams, |

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| | A.L. "Petroleum refining": https://www.britannica.com/technology/petroleum-refining<br>4. UPO.Honeywell: https://uop.honeywell.com/ |
| **Planned learning activities and teaching methods** | **Teaching**: giving lectures and presentations, arranging seminars, receiving feedback on course from students, giving practical exercises (class/home) – individual and for groups/ teams, promoting critical and constructive thinking, stimulating students to formulate own opinions, supporting personal responsibility<br><br>**Learning active**: interactions between professor and students including participation in discussions, team/group exercises, collaborative teamwork, sharing experiences with peers, self-evaluation, prepare reports<br><br>**Learning passive**: attending lectures and seminars, listening, watching and reading learning materials, remembering/ memorizing, repeating |
| **Assessment methods and criteria** | Individual control exercises on using the knowledge of thermodynamics and reaction kinetics in hydrocarbon processing for solving practical problems (LO1):<br><br>- A (excellent) > 90% correct answers;<br>- B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers;<br>Individual control exercises on using the knowledge of chemistry and mechanisms of hydrocarbon processing technologies for solving practical problems (LO2):<br><br>- A (excellent) > 90% correct answers;<br>- B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers;<br>Presentation of prepared report and reflective classroom discussion on current state and prospects of hydrocarbon gas processing technologies (LO3):<br><br>- A (excellent) the report meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>- B (good) the report generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; a student participates in discussion demonstrating good knowledge of the topic;<br>- C (satisfactory) the report partially meets one or more of the basic requirements, relying on commonly accepted ideas; a student participates in discussion demonstrating basic knowledge of the topic; |

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| | - D (failing) the report fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear; a student fails to participate in discussion.<br>Presentation of prepared report and reflective classroom discussion on current state and prospects of solid fossil fuel processing technologies (LO4):<br>- A (excellent) the report meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>- B (good) the report generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; a student participates in discussion demonstrating good knowledge of the topic;<br>- C (satisfactory) the report partially meets one or more of the basic requirements, relying on commonly accepted ideas; a student participates in discussion demonstrating basic knowledge of the topic;<br>- D (failing) the report fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear; a student fails to participate in discussion. |
| **Prepared/amended by** | Elena A. Emelyanycheva, Associate Professor, PhD in Petrochemistry and Colloid Chemistry, Department of Chemical Technology of Petroleum and Gas Processing |

# ACADEMIC WRITING AND CRITICAL THINKING

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| **Course provider (institution/ Project)** | Kazan National Research Technological University, Russia |
| **Course title** | Academic Writing and Critical Thinking |
| **Target group** | MSc students |
| **Type (compulsory/optional)** | compulsory |
| **Cycle (short/first/second/third)** | second cycle - for MSc students |
| **Year of study when the component is delivered, semester** | Spring (2d) semester of MSc studies. |
| **Number of ECTS credits allocated (if applicable); estimated workload** | 4 ECTS<br>144 academic hours of estimated workload (seminars, independent work) |
| **Name of lecturer(s)** | Gulnaz Fakhretdinova, Associate Professor, PhD in Linguistics, Department of Foreign Languages for Professional Communication<br><br>Julia Ziyatdinova, Associate Professor, PhD in Education, Department of Foreign Languages for Professional Communication |
| **Number of contact hours** | seminars – 36 hours |
| **Language of instruction** | English |
| **Course aims** | The course aims to provide students with key principles of effective and efficient academic writing and public presentations |
| **Learning outcomes** | By the end of this course, MSc students will be able:<br><br>LO 1. identify, analyze and summarize assigned reading material with an understanding of structure and mechanics from print and electronic environments;<br>LO 2. demonstrate and apply knowledge of basic essay structure (introduction, body and conclusion) and present logical arguments to support an effective thesis statement;<br><br>LO 3. develop, prepare and propose abstract writing model including pre-writing, planning, drafting, revising, editing, re-writing and proof reading;<br>LO 4: conduct a literature review using international research databases;<br>LO 5: demonstrate presentation skills for participation in international conferences. |

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| **Prerequisites and co-requisites (if applicable)** | Fluent English |
| **Course content** | 1. Introduction, Course Description, Grades and Assignments<br>2. Planning the Writing<br>3. Literature Review. Finding Suitable Sources<br>4. Critical Analysis of Texts<br>5. Managing the Sources<br>6. Essay Planning. Effective Note-taking<br>7. Summarizing and Paraphrasing. References.<br>8. Paragraph Development<br>9. Structure of Introduction, Discussion and Conclusion<br>10. Writing Elements. Argument and Discussion<br>11. Writing Elements. Cause and Effect<br>12. Academic Writing Grammar and Vocabulary<br>13. Actual Writing Process<br>14. International Research Databases. Research Methods.<br>15. Using Electronic Resources and Websites<br>16. Methods of Presentation Organization<br>17. Speech Outline<br>18. Handling Questions and Answers |
| **Recommended or required reading and other learning resources/tools** | **Books:**<br>1. Bailey S. Academic Writing: a Handbook for International Students. — 4 ed. — Routledge, London, UK, New York, NY. — 2015. — 303 p.<br>2. Boxman R., Boxman E. Communicating Science. A Practical Guide for Engineers and Physical Scientists. – World Scientific Publishing Co. Pte. Ltd. – 2016. – 287 p. https://www.worldscientific.com/doi/epdf/10.1142/10145<br>3. Bezrukov A.N., Making a successful presentation / Otechestvo. 2019, c.84<br>4. Валеева Э.Э., Зиятдинова Ю.Н., Газизулина Л.Р. , How to present a research project? — КНИТУ. — 2020. — 84 с.<br>5. Валеева Э.Э., Зиятдинова Ю.Н., Безруков А.Н. Подготовка материалов для публикации в международных научных изданиях— КНИТУ. — 2016. — 120 с.<br><br>**Open access articles:**<br>1. Kennedy, Toni. (2009). Academic Research & Writing Skills Part 1 & 2. Australasian Journal Of Correctional Staff Development. 4.<br>2. USC Libraries: https://libguides.usc.edu/writingguide/academicwriting<br>3. Scribbr Writing Tool: https://www.scribbr.com/category/research-paper/<br><br>**Internet Resources:**<br>1. Purdue Online Writing Lab: |

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| | https://owl.purdue.edu/owl/general_writing/common_writing_assignments/research_papers/index.html<br>2. The University of Wisconsin Writing Center: https://writing.wisc.edu/handbook/assignments/planresearchpaper/ |
| **Planned learning activities and teaching methods** | **Teaching**: giving presentations, arranging seminars, practicums and trainings, receiving feedback on course from students, giving practical assignments or exercises (class/home) – individual and for groups/ teams, promoting critical thinking, constructive critics and self-criticism, stimulating students to formulate own opinions, supporting personal responsibility and promoting ethical principles<br><br>**Learning active**: interactions between professor and students including participation in discussions, team/group exercises, collaborative teamwork, sharing experiences with peers, self-evaluation, essay writing<br><br>**Learning passive**: attending seminars, listening, watching and reading learning materials, remembering/ memorizing, repeating |
| **Assessment methods and criteria** | summary writing (LO1);<br>test on paragraph development; reflection paper (LO2)<br>test on writing elements; cause-and-effect essay; research essay (LO3);<br>presentation; final test (LO4) |
| **Prepared/amended by** | Gulnaz Fakhretdinova, Associate Professor, PhD in Linguistics, Department of Foreign Languages for Professional Communication<br><br>Julia Ziyatdinova, Associate Professor, Doctor of Science in Education, Department of Foreign Languages for Professional Communication |

# ORGANIC AND SUPRAMOLECULAR CHEMISTRY

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| **Course provider (institution/ Project)** | Kazan National Research Technological University, Russia |
| **Course title** | Selected Chapters of Organic and Supramolecular Chemistry |
| **Target group** | MSc students |
| **Type (compulsory/optional)** | compulsory |
| **Cycle (short/first/second/third)** | first cycle - for MSc students |
| **Year of study when the component is delivered, semester** | Fall (1st) semester of MSc studies. |
| **Number of ECTS credits allocated (if applicable); estimated workload** | 5 ECTS<br>180 academic hours of estimated workload (lectures, practicums, independent work) |
| **Name of lecturer(s)** | Elena L. Gavrilova, Professor, Head of Department of Organic Chemistry |
| **Number of contact hours** | lectures – 18 hours, practicums – 36 hours |
| **Language of instruction** | English |
| **Course aims** | The course is designed to introduce to the basic concepts of organic chemistry and supramolecular chemistry. |
| **Learning outcomes** | By the end of this course, MSc students will be able:<br>LO1. To know: a) principles of classification and nomenclature of organic compounds, structure of organic compounds, classification of organic reactions, chemical and physical properties of hydrocarbons, main methods of hydrocarbon synthesis;<br>b) the methodology of supramolecular chemistry; objects of supramolecular chemistry;<br>c) practical use of the results of supramolecular chemistry in human life.<br>LO2. a) provide experimental methods of organic compounds purification and determination of their physicochemical properties,<br>b) analyze organic compounds using chemical and physicochemical methods of analysis.<br>LO3. a) determine supramolecular objects according to certain criteria,<br>b) apply certain physicochemical methods for the analysis of supramolecular systems. |
| **Prerequisites and co-requisites (if applicable)** | BSc or BEng background |
| **Course content** | 1. Hydrocarbons. Characterization of alkanes;<br>2. Hydrocarbons. Characterization of alkenes, alkynes, alkadienes;<br>3. Hydrocarbons. Aromatic compounds;<br>4. Electronic effects in organic chemistry;<br>5. Oxygenated hydrocarbon derivatives; |

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| | 6. Supramolecular chemistry. Introduction;<br>7. Supramolecular chemistry. Main types of intermolecular interactions;<br>8. Supramolecular chemistry. Macrocyclic compounds in supramolecular chemistry;<br>9. Potencial drug delivery systems on the base of calix[4]resorcines (own research). |
| **Recommended or required reading and other learning resources/tools** | **Books:**<br>1. Robert V. Hoffman / Organic chemistry an intermediate text second edition. Textbook - Wiley & Sons, Inc. 2004 - 476 p.<br>2. V.F. Traven / Organic Chemistry. Textbook for High Schools - Akademkniga. – Vol.1 -2004. - 727 p.<br>3. V.F. Traven / Organic Chemistry. Textbook for High Schools Schools -Akademkniga. – Vol.2 -2004. - 582 p.<br>4. Lehn J.-M. / Supramolecular Chemistry, Concepts and Perspectives. – Weinheim – 1995.<br>5. Gavrilova E.L., Sajfutdinova M.N., Tarasova R.I., Shatalova N.I., Semina I.I., Gubajdullin A.T. / Complexation of calix [4] resorcinol with phosphorylacetic acidhydrazides possessing neurotrophic activity // Russian Chemical Bulletin. 2016.V. 65. № 5. P. 1372-1376.<br>**Open access articles/via university access:**<br>When studying the discipline "Selected chapters of organic and supramolecular chemistry" it is recommended to use electronic sources of information:<br>1. Electronic catalog of UNITS KNRTU - Access mode: http://ruslan.kstu.ru/<br>2. Electronic library of UNITS KNRTU - access mode: http://ft.kstu.ru/ft/<br>3. Portal on organic chemistry: http://www.organic-chemistry.org/;<br>4. Official site of the American Chemical Society. Provides access to the texts of articles in many journals (issues of recent years), and also provides information about the events taking place in the scientific world: www.acs.org;<br>5. A useful portal containing a large amount of useful educational and scientific information in the field of chemistry: www.liv.ac.uk/Chemistry/Links/links.html;<br>6. A website providing information on what research is currently being carried out by various scientific groups: www.uark.edu/campus-resources/mcintosh/organiclinks.html.<br>7. EBS Lan - Access mode: https://e.lanbook.com/ |
| **Planned learning activities and teaching methods** | **Teaching**: giving lectures and presentations, arranging practicums, receiving feedback on course from students, giving practical assignments and exercises (class/home)<br>– individual and for groups/teams, promoting critical and constructive thinking,<br>– stimulating students to formulate own opinions, supporting personal responsibility.<br>**Learning active**: interactions between professor and students including participation in discussions, team/group exercises, collaborative teamwork, sharing experiences with peers, self-evaluation, preparation of reports.<br>**Learning passive:** attending lectures, practicums; listening, watching |

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| | and reading learning materials; remembering, analyzing and repeating. |
| **Assessment methods and criteria** | (LO1):<br>A (excellent) the report meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; report contains accurate simulation results and physically correct interpretation of data; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>B (good) the report generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; report reflects good accuracy and interpretation of simulation results; a student participates in discussion demonstrating good knowledge of the topic;<br>C (satisfactory) the report partially meets one or more of the basic requirements, relying on commonly accepted ideas; report contains partially correct simulation results; a student participates in discussion demonstrating basic knowledge of the topic;<br>D (failing) the report fails to fulfill one or more of the basic requirements, it contains incorrect simulation results, the thesis and ideas are unclear; a student fails to participate in discussion.<br>Individual presentation and reflective classroom discussion on specific simulation methods and techniques for the study a) Provide experimental methods of organic compounds purification and determination of their physicochemical properties, b) analyzing of organic compounds using chemical and physicochemical methods of analysis; c) determine supramolecular objects according to certain criteria, d) apply certain physicochemical methods for the analysis of supramolecular systems.<br>(LO2, LO3):<br>A (excellent) the presentation meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought; a student participates in discussion demonstrating deep knowledge of the topic, grounded judgements and complexity of thought;<br>B (good) the presentation generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations; a student participates in discussion demonstrating good knowledge of the topic;<br>C (satisfactory) the presentation partially meets one or more of the basic requirements, relying on commonly accepted ideas; a student participates in discussion demonstrating basic knowledge of the topic;<br>D (failing) the presentation fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear; a student fails to participate in discussion. |
| **Prepared/amended by** | Elena L. Gavrilova, Prof., Head of Department of Organic Chemistry |

# SUPRAMOLECULAR MATERIALS IN ORGANIC ELECTRONICS

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| **Course provider (institution/ Project)** | Kazan National Research Technological University, Russia |
| **Course title** | Supramolecular Materials in Organic Electronics |
| **Target group** | MSc students |
| **Type (compulsory/optional)** | compulsory |
| **Cycle (short/first/second/third)** | first cycle - for MSc students |
| **Year of study when the component is delivered, semester** | Fall (3rd) semester of MSc studies. |
| **Number of ECTS credits allocated (if applicable); estimated workload** | 5 ECTS<br>180 academic hours of estimated workload (lectures, practicums, independent work) |
| **Name of lecturer(s)** | Andrey Knyazev, Professor, PhD in Chemical Science, Department of Physical and Colloid Chemistry |
| **Number of contact hours** | lectures –8 hours, seminars – 24 hours, practicums – 16 hours |
| **Language of instruction** | English |
| **Course aims** | a) Formation of knowledge about modern problems of molecular electronics and optoelectronic devices; b) training in the technology of obtaining molecular electronics devices based on supramolecular materials; c) training in the use of modern methods of physical and chemical research of supramolecular materials. |
| **Learning outcomes** | By the end of this course, MSc students will be able:<br>1. LO 1. to demonstrate understanding of the relationship between structure of organic compounds and physicochemical properties required for use as optoelectronic materials.;<br>2. LO 2. to define physical chemistry methods to study the optical properties of supramolecular materials;<br>3. LO 3. To apply theoretical approaches for design of supramolecular structures;<br>4. LO 4. to demonstrate knowledge of modern technologies of molecular electronics devices creation. |
| **Prerequisites and co-requisites (if applicable)** | BSc or BEng background |
| **Course content** | 1.Introduction in molecular electronic.<br>2. Structure, properties, classification and application of polymers. Supramolecular organization of polymers. The main types of semiconducting and conductive polymers. The use of polymer materials in optoelectronics.<br>3. Liquid crystals. Supramolecular organization of liquid crystals. How LCD devices work.<br>4. Modern technologies for creating molecular electronics devices. |

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| | Organic light emitting diode (OLED) displays. |
| **Recommended or required reading and other learning resources/tools** | **Books:**<br>1. Metzger, R. M. (Ed.). (2012). Unimolecular and Supramolecular Electronics I: Chemistry and Physics Meet at Metal-Molecule Interfaces (Vol. 312). Springer Science & Business Media. doi:10.1007/9783642272844<br>2. Petty, M. C. (2019). Organic and molecular electronics: from principles to practice. John Wiley & Sons. doi:10.1002/9780470723890<br>3. Galyametdinov Yu.G., Selivanova N.M., Knyazev A.A., Phase behaviours and luminescence properties of metallomesogens / KNRTU Press. 2020, 292 p.<br>4. Galyametdinov Yu.G., Knyazev A.A., Magnetic Properties of Metallomesogens / KNRTU Press. 2019, 372 p.<br>**Open access articles:**<br>1. Zotti, L.A. Molecular Electronics. Appl. Sci. 2021, 11, 4828. https://doi.org/10.3390/app11114828<br>2. Yannick J. Dappe Attenuation Factors in Molecular Electronics: Some Theoretical ConceptsAppl. Sci. 2020, 10(18), 6162; https://doi.org/10.3390/app10186162<br>**Internet Resources:**<br>The mind-bending future of flexible electronics https://www.science.org.au/curious/technology future/flexible-electronics |
| **Planned learning activities and teaching methods** | **Teaching**: giving lectures and presentations, practicums, receiving feedback on course from students, giving practical assignments or exercises (class/home) – individual and for groups/ teams, promoting critical thinking, constructive critics and self-criticism, stimulating students to formulate own opinions, supporting personal responsibility and promoting ethical principles.<br>**Learning active**: interactions between professor and students including participation in discussions, team/group exercises, collaborative teamwork, sharing experiences with peers, self-evaluation, essay writing.<br>**Learning passive**: attending lectures, listening, watching and reading learning materials, remembering/ memorizing, repeating. |
| **Assessment methods and criteria** | Multiple choice test on basic concepts of molecular electronics (LO1):<br>- A (excellent) > 90% correct answers;<br>- B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers<br>Practice for discussion on different types of organic light emitting materials (LO2):<br>- *A (excellent) the student participates in discussion demonstrating deep knowledge of the topic;* |

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| | - *B (good) the student participates in discussion demonstrating good knowledge of the topic;*<br>- *C (satisfactory) the student participates in discussion demonstrating basic knowledge of the topic;*<br>- D (failing) the students fails to participate in discussion.<br>Practice for discussion on different types of LC indicators (LO3);<br>- *A (excellent) the student participates in discussion demonstrating deep knowledge of the topic;*<br>- *B (good) the student participates in discussion demonstrating good knowledge of the topic;*<br>- *C (satisfactory) the student participates in discussion demonstrating basic knowledge of the topic;*<br>- D (failing) the students fails to participate in discussion.<br>The developing of molecular electronics devices creation technology (LO4):<br>- A (excellent) the essay meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought;<br>- B (good) the essay generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations;<br>- C (satisfactory) the essay partially meets one or more of the basic requirements, relying on commonly accepted ideas;<br>- D (failing) the essay fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear. |
| **Prepared/amended by** | Andrey Knyazev, Professor, PhD in Chemical Science, Department of Physical and Colloid Chemistry |

# PROCESS INTENSIFICATION IN CHEMICAL ENGINEERING

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| **Course provider (institution/ Project)** | Kazan National Research Technological University, Russia |
| **Course title** | Process Intensification in Chemical Engineering |
| **Target group** | MSc students |
| **Type (compulsory/optional)** | compulsory |
| **Cycle (short/first/second/third)** | first cycle - for MSc students |
| **Year of study when the component is delivered, semester** | Fall (1st) semester of MSc studies. |
| **Number of ECTS credits allocated (if applicable); estimated workload** | 3 ECTS<br><br>108 academic hours of estimated workload (lectures, practicums, independent work) |
| **Name of lecturer(s)** | Irina Kuznetsova, Associate Professor, PhD in Physics, Department of Heat Engineering |
| **Number of contact hours** | lectures – 18 hours, practicums – 36 hours |
| **Language of instruction** | English |
| **Course aims** | The course aims to form of modern knowledge about the basics of the intensification of chemical and technological processes by physical methods of exposure, taking into account the chemical and physical and chemical properties of processed materials, environmental standards and material and resource conservation. |
| **Learning outcomes** | By the end of this course, MSc students will be able:<br><br>1. LO 1. to identify the fundamentals of intensification of chemical-technological processes by physical methods of exposure, taking into account the chemical and physical-chemical properties of processed materials, environmental standards and resource conservation;<br>2. LO 2. to define modern methods of experimental and theoretical studies of processes and the physicochemical properties of the processed materials;<br>3. LO 3. to construct tasks for the development of design solutions related to the modernization of technological equipment for carrying out chemical and technological processes by physical methods of exposure, with measures to improve operational characteristics, increase environmental safety, save resources;<br>4. LO 4. to prepare and organize research work in the field of developing the foundations of innovative technologies based on |

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| | chemical-technological processes by physical methods of exposure. |
| **Prerequisites and co-requisites (if applicable)** | BSc or BEng background |
| **Course content** | 1.Introduction to the processes of intensification in Chemical Engineering<br>2. The use of technologies with ultrasonic processing for the intensification of heat and mass transfer processes in chemical technology<br>3. Theoretical and experimental studies of physicochemical processes in processed environments under the influence of magnetic fields<br>4. Theoretical and experimental studies of physicochemical processes in treated media under exposure and plasma chemistry<br>5. Review of modern results of nanotechnology as applied to the use of nanomaterials in various physical and chemical processes<br>6. Concepts and principles of green chemistry based on supercritical fluid technologies |
| **Recommended or required reading and other learning resources/tools** | **Books:**<br><br>1. Cavani, F., Centi, G., Perathoner, S., & Trifir, F. (Eds.). (2009). Sustainable Industrial Chemistry. doi:10.1002/9783527629114<br>2. Segovia-Hernández, J. G., & Bonilla-Petriciolet, A. (Eds.). (2016). Process Intensification in Chemical Engineering. doi:10.1007/978-3-319-28392-0<br><br>**Open access articles:**<br><br>1. Process Intensification: Transforming Chemical Engineering January 2000 Chemical Engineering Progress 96(1):22-33<br>2. Journal of Chemical Engineering and Processing: Process Intensification:https://www.sciencedirect.com/journal/chemical-engineering-and-processing-process-intensification<br><br>**Internet Resources:**<br><br>1. Department of Chemical Engineering and Chemistry Eindhoven University of Technology Chemical Process Intensification https://www.tue.nl/en/research/research-groups/chemical-process-intensification/ |
| **Planned learning activities and teaching methods** | **Teaching**: giving lectures and presentations, practicums, receiving feedback on course from students, giving practical assignments or exercises (class/home) – individual and for groups/ teams, promoting critical thinking, constructive critics and self-criticism, stimulating students to formulate own opinions, supporting personal responsibility and promoting ethical principles.<br><br>**Learning active**: interactions between professor and students including participation in discussions, team/group exercises, collaborative teamwork, sharing experiences with peers, self- |

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| | evaluation, essay writing.<br><br>**Learning passive**: attending lectures, listening, watching and reading learning materials, remembering/ memorizing, repeating. |
| **Assessment methods and criteria** | Multiple choice test on basic concepts of intensification of chemical-technological processes (LO1):<br>- A (excellent) > 90% correct answers;<br>- B (good) >75% correct answers;<br>- C (satisfactory) >60% correct answers<br>- D (failing) <60% correct answers;<br>Practice for calculation of the heat of chemical transformations;<br>Energy saving in production (LO2):<br>- *A (excellent) the student participates in discussion demonstrating deep knowledge of the topic;*<br>- *B (good) the student participates in discussion demonstrating good knowledge of the topic;*<br>- *C (satisfactory) the student participates in discussion demonstrating basic knowledge of the topic;*<br>- D (failing) the students fails to participate in discussion.<br>Drawing up a technological scheme using the example of a verbal description of a real chemical technological process (LO3):<br>- *A (excellent) a precise evaluation of* technological scheme for real chemical technological process, gave a description of examples of energy saving;<br>- *B (good) a good evaluation of* technological scheme for real chemical technological process*;*<br>- *C (satisfactory) a fair evaluation of* technological scheme for real chemical technological process*;*<br>- *D (failing) no evaluation* technological scheme for real chemical technological process;<br>Essay on innovative technologies based on chemical-technological processes by physical methods of exposure (LO4):<br>- A (excellent) the essay meets the basic requirements (topic, purpose, length, organization, and sources), supporting its thesis with a thorough development of ideas demonstrating originality and complexity of thought;<br>- B (good) the essay generally meets the basic requirements, supporting its thesis with a thorough development of ideas combined with original observations;<br>- C (satisfactory) the essay partially meets one or more of the basic requirements, relying on commonly accepted ideas;<br>- D (failing) the essay fails to fulfill one or more of the basic requirements, the thesis and ideas are unclear. |
| **Prepared/amended by** | Irina Kuznetsova, Associate Professor, PhD in Technical Science, Department of Heat Engineering |

# ADMISSION PROCEDURE

When submitting an application for admission to KNRTU, an international student must provide the following **documents:**

- Certificate of completion of the preparatory course;
- Copy of the applicant's identify document or a document certifying the identity of a foreign citizen in the Russian Federation and a notarized translation of the passport (applicant's identity document);
- Copy of the visa (for citizens of the countries that require a visa to enter the Russian Federation) or a notarized translation of the applicant's passport (identity document);
- Copy of Diploma (or its duly certified copy), or a foreign country's original education document, which is recognized in the Russian Federation. According to Russian law, it must be legalized in the country of issue (for more information on legislation procedure, please visit our website https://studyinrussia.ru/en/study-in-russia/certification/foreign-diplomas/);
- Duly certified translation of a foreign country's education document and its transcripts (if the latter is provided by law of the state where this document was issued);
- Copies of documents or other evidence proving that you are a Russian compatriot living abroad and belong to a group as provided for in article 17 of the Federal Law No. 99-FZ
- One photo, 3×4 cm

# MIGRATION REGISTRATION


Tatarstan has the same statutory regulations as the entire Russian Federation. For migration registration, international students have **7 business days** from the date of crossing the Russian Federation border, including the day of arrival, or from the date of arrival in Kazan.

**Dormitory check-in**

- Students checking in and living in the dormitory are registered by the university
- Students must contact the Faculty of International Educational Programs within 3 days after entering Russia
- You must submit your passport, migration card, current residential lease agreement, a certificate from the student HR department, and a current health insurance

**Registration in the apartment**

- Students living in the apartment are registered by the landlord
- For this purpose, students get an application at the Faculty of International Educational Programs if they have a certificate from the student HR department and health insurance
- After a student gets an application, certificate, and other documents, a landlord should contact the regional office of the Directorate for Migration Affairs
- Students living in the hostel/hotel are registered by the hostel/hotel staff

# STUDENT VISA EXTENSION

At least **50 days** before your valid visa expires, you must contact the Faculty of International Educational Programs at 68 Karl Marx Street, Room 255, and submit the following documents:

- Passport and copies of its pages with photos and all visas available
- Migration card and its copy
- 1,600 RUB stamp duty payment receipt
- Copy of the enrollment contract (for fee-paying students) or the certificate from the student HR department (for state-funded students)
- Current health insurance
- Students pursuing Master's degree must submit a copy of their preparatory course completion certificate/copy of Bachelor's diploma
- Registration certificate and its copy
- One photo, 3×4 cm

# HEALTH AND SAFETY

## Municipal Student Polyclinic No. 21


95 Orenburg Tract

+7(843)237-99-56;

+7(843)237-55-14

https://studpolik.ru/

**Mon- Fri**: 8 a.m. – 8 p.m.

**Sat**: 8 a.m. – 6 p.m.

In case you have been hospitalized for a few days, you must inform the tutor of your group, as well as the Faculty of International Educational Programs. After discharge, get back your hospital registration certificate and submit it to the Faculty of International Educational Programs to get new registration at the dormitory address within 3 days. If you live in the apartment, you must get a new application and get registered at your place of residence. You must do it within 7 business days.

## Emergency Service numbers

- Emergency telephone number – 112
- Fire-department– 101
- Police – 102
- Emergency ambulance service – 103

# AROUND KNRTU

## KNRTU's Surroundings

KNRTU is located in the central part of Kazan with many institutions nearby, such as Kazan National Research Technical University named after A.N. Tupolev -KAI; Kazan State Medical University; Kazan State Agrarian University, Kazan State Conservatoire named after N.G. Zhiganov. Besides, the infrastructure of this area is rather well developed, so you can easily get to the nearest supermarket, shop center or cafe. As for recreation zones, there are a few parks within walking distance from the university, the biggest and most popular of which is Gorky Central Park of Culture and Leasure. This is the perfect place to either stroll and ride a bike in summer or to skate and ski in winter.

## Post Office

The closest post-office to KNRTU is located on 44 Karl Marx Street.

The office is open Mondays to Fridays from 8 a.m. to 8 p.m. and Saturdays from 9 a.m. to 6 p.m. It closes for a lunch break from 1 p.m. to 2 p.m.

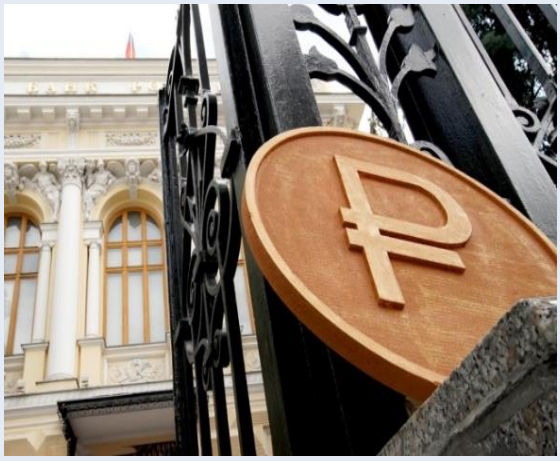
KNRTU postcode is 420015.


## Pharmacy

The "April" pharmacy is the nearest to KNRTU, it is located on 59 Karl Marx Street. There are also some other pharmacies not far from the university:

- Farmlend- 46 Karl Marx Street
- Sakura - 15 Gogol Street
- VITA Express - 54 Bolshaya

## Banks, Currency Exchange Offices, ATMs



The closest bank to KNRTU (Sberbank) is located on 44 Butlerov Street. Here you can also change the currency.

**Working hours:** Mondays to Fridays 8:30 a.m. to 6:00 p.m. ATMs are available 24/7/.

Generally, you can find exchange offices almost in any bank of Kazan.

**Other banks:**

- Ak Bars Bank – 1 Svobody Square;
- Energobank – 13/52 Pushkin Street;
- Otkrytie Bank – 9/51 Pushkin Street
- Gazprombank – 34 A Pushkin Street

## Supermarkets and Grocery Stores

The nearest grocery store from the main building of KNRTU (building "A") is "Pyaterochka". It is located on 50 Karl Marx Street. **Working hours**: 8 a.m. – 11 p.m. everyday

Another grocery store close to building "A" is "Khlebzavod" on 30 Mushtari Street, where you can buy bread, milk, snacks, and other basic food. **Working hours**: 7 a.m. – 7 p.m. everyday.

A wide range of food products, as well as books, household chemical goods and drugs can be found in "Universam" department store on 53 Bolshaya Krasnaya Street. **Working hours**: 8 a.m. – 9 p.m. everyday.

# THINGS TO DO IN KAZAN

**Kazan** is the capital of the Republic of Tatarstan and one of Russia's oldest cities, full of historical sights, outstanding pieces of architecture, cozy parks and streets.

## 1. Explore the UNESCO listed Kremlin

**Welcome to Kazan Kremlin! This is what to start with when exploring the history of the city.**

## 2. Gaze at the Kul-Sharif Mosque

**The main mosque of the Republic of Tatarstan and one of the city's most magnificent buildings is located on the Kremlin grounds.**

## 3. Learn about Kazan khanate history visiting Suyumbike Tower

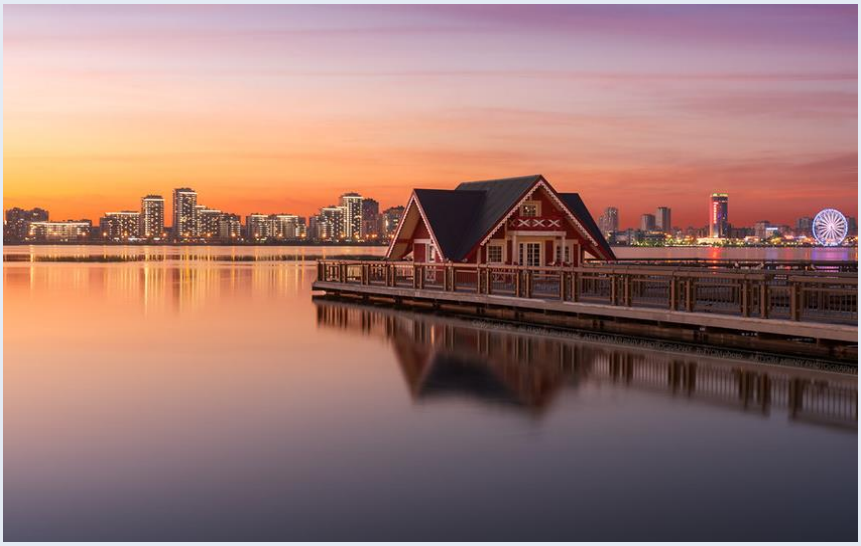
It's situated in the grounds of the Kazan Kremlin. Its height is 58 meters and as of today it leans by two meters, like the famous Leaning Tower of Pisa.

## 4. Admire the Palace of Farmers architecture

The Palace of Farmers is an impressive piece of architecture in eclectic style, that marries artistry with function. The building serves as the official residence for the Ministry of Agriculture and Food of the Republic of Tatarstan.

## 5. Enjoy sunset from Kremlin Embankment

If you go through the park adjacent to the Palace of Farmers, you'll find yourself on the Kremlin Embankment. The best time to come here is in the evening, as if you're lucky, you might catch one of the most fantastic sunsets in the city.



## 6. See Kazan at night from the other bank

The Kazan Family Center, which building houses a bureau of civil registration, is situated on the other side of the Kazanka river.

According to legend, the name of the city comes from the word "kazan" which means "cauldron", and the building does resemble a big cooking pot, symbolizing abundance and fertility.

## 7. Go to Sviyazhsk Island

**Sviyazhsk is a rural area with a great history, often described as a spiritual place. It is located about 58 km away from Kazan at the confluence of the Sviyaga and the Volga rivers. Founded as a fortress in 1551, it became the base of Russian troops during the siege of Kazan, the capital of the Kazan Khanate. Today Sviyazhsk has become one of Tatarstan's main tourist attractions.**

## 8. Watch a performance at the Theatre of Opera and Ballet

**Tatar State Academic Theatre of Opera and Ballet named after Musa Jalil is one of Tatarstan's leading theatres. The repertoire mainly consists of opera and ballet performances based on both international and Tatar works.**

# SPORT IN KAZAN

The city of Kazan for recent years is known as a place of big international and sports events. The most part of sports venues that we can see now have been built for Universiade 2013, among them are Water Sports Palace, Kazan Arena (now Ak Bars Arena) Stadium, Tennis Academy, Ak Bars Wrestling Palace, "Saint Petersburg" Volleyball Centre, Boxing and Table Tennis Center, Gymnastics Center, Rowing channel at the Middle Kaban Lake.


In June-July 2018, Kazan hosted the 2018 FIFA World Cup. The Kazan Arena Stadium with a capacity of around 45,379 seats and the world largest outside screen played stage to the matches. It is the first football stadium in Russia constructed in the build-up to the 2018 FIFA World Cup Russia™.

FINA World Championship was held in Kazan on July 24-August 9, 2015. The event brought together 2,413 athletes and 1,495 officials representing up to 190 nations. A record number of medal events (75) were contested across six aquatic disciplines. Now the Palace's facilities are used for a wide variety of competitions, as well as for training sessions in swimming, synchronized swimming, and both springboard and platform diving.

# CULTURE AND RELIGION

## Culture

As the capital of Tatarstan, Kazan is the cultural center for the ancient Tatar people and was once nicknamed the ‘Athens of the Volga’. Its cultural status has persisted in modern times too, as it is home to over 30 universities, 40 museums and galleries, and academic theatres. Among the republic’s famous cultural events are large international festivals such as Feodor Chaliapin International Opera Festival, Rudolf Nuriev International Classical Ballet Festival, the Europe-Asia Contemporary Music Festival, Rashit Vagapov Tatar Song Festival. Each fall, Kazan hosts the Kazan International Muslim Film Festival. The Creation of Peace Music Festival has been held here annually since 2008.

## Religion

Kazan is a place where the cultures of East and West are harmoniously intertwined and conversations in different languages can be heard in the streets. People with different historical and cultural traditions live peacefully here. The combination of at least three ethnic groups (Turkic, Russian-Slavic and Finno-Ugric) defines the uniqueness of this area, as well as the authenticity of its cultural and historical values.

Two major religions of the Republic of Tatarstan are Islam and Orthodox Christianity. Tatars and Bashkirs who make up nearly a half of the republic population confess Islam. The others, including Russians, Chuvash people, Maris, Udmurts and Mordovians are Orthodox Christians. Such confessions as Catholicism, Protestantism and Judaism are also presented in Tatarstan.

# CONTACT INFORMATION

## INTERNATIONAL AFFAIRS

**Head of International Affairs:** Anna Ebel

**Telephone:** +7(843)231-43-19

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**Address:** 68 Karl Marx Street, Office 236

## FACULTY OF INTERNATIONAL EDUCATIONAL PROGRAMS

**Dean of the Faculty of International Educational Programs**: Andrey Vasilyev

**Telephone:** +7(843)231-43-82

**Email**: fmop@kstu.ru

**Address:** 68 Karl Marx Street, Office 255

# CONTACT INFORMATION

## LOCATION OF EDUCATIONAL BUILDINGS:

### BUILDING “A”

68 Karl Marx Street

### BUILDING “B”

72 Karl Marx Street

### BUILDING “D”

12 Sibirskiy Trakt Street