Министерство образования и науки Российской Федерации

ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ АВТОНОМНОЕ ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ

“НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ ИТМО”

Р А С П О Р Я Ж Е Н И Е

«11» июля 2025 года № 3

О порядке проведения аттестационного испытания

Для осуществления переводов/восстановлений обучающихся ПРИКАЗЫВАЮ:

Утвердить порядок проведения аттестационного испытания в рамках осуществления переводов/восстановлений обучающихся в подразделение Химико-биологический кластер по направлению подготовки магистратуры 18.04.02 Энерго- и ресурсосберегающие процессы в химической технологии, нефтехимии и биотехнологии.

ПРИЛОЖЕНИЯ 1-2. Банки аттестационных заданий с критериями оценивания.
ПРИЛОЖЕНИЕ 3. Система перевода показателей учебно-научной активности студентов в балльно-рейтинговую систему.

И.о. директора ХБК _____ (подпись) П.П. Хапаева (ФИО)

ПРИЛОЖЕНИЕ 1

Приложение к распоряжению от 11.07.2025 № 3

Банк аттестационных заданий

по образовательной программе 18.04.02 «Химия для энергетических технологий / Sustainable Chemistry For Energy Technologies»

Аттестационные задания состоят из двух разделов.

В первом разделе необходимо дать ответ на 4 вопроса, состоящих из нескольких пунктов/подпунктов. Каждый подпункт имеет свою весомость в баллах.

Номер вопроса	**Содержание пункта/подпункта вопроса**	**Количество баллов**
1	**1.1.** $X_{(aq)}$ is the designation of a solute in a chemical reaction after hydration. Explain the process of hydration for soluble ionic compounds and for soluble covalent compounds using X = KBr and X = C_2H_5OH, respectively.	3
	1.2.1. Giving examples of each, characterize strong electrolytes, weak electrolytes, and nonelectrolytes. **1.2.2.** How would you experimentally determine whether a solute is a strong electrolyte, weak electrolyte, or nonelectrolyte.	3 3
	1.3. Distinguish between the terms *slightly soluble* and *weak electrolyte*.	2
	1.4. The molarity of a solution shows the relationship between the number of moles of solute in solution and the volume of the solution. With the aid of equations, describe how molarity can be used as a conversion factor to convert from **1.4.1.** moles of solute to volume of solution **1.4.2.** volume of solution to moles of solute	 2 2
	Итого по Вопросу 1	**15**
2	**2.1.** Hydrogen is a very diverse element that can form various compounds. Giving examples and commenting on the different types of bonding involved and their relative stabilities, discuss three ways in which hydrogen can form compounds.	6
	2.2. Giving an example of each kind, state the differences between electron rich, electron deficient, and electron precise p-block hydrides.	6
	2.3.1. In your own words, describe how a hydrogen bond is formed. **2.3.2.** What are the differences between inter- and intra-molecular hydrogen bonding?	2 1
	Итого по Вопросу 2	**15**
3	**3.1.1.** What is the second law of thermodynamics? **3.1.2.** There are four possible sign combinations for ΔS_{system} and $\Delta S_{surroundings}$. **3.1.2.1.** Which sign combination(s) always give a spontaneous reaction?	2 1

	3.1.2.2. Which sign combination(s) always give a nonspontaneous reaction? **3.1.2.3.** Which sign combination(s) may or may not give a spontaneous reaction?	1 1
	3.2.1. What is the standard free energy change (ΔG^0) for a reaction? **3.2.2.** What is the standard free energy of formation (ΔG_f^0) of a substance? **3.2.3.** How are ΔG_f^0 values used to calculate $\Delta G_{reaction}^0$? **3.2.4.** How can $\Delta G_{reaction}^0$ be determined using Hess's law? **3.2.5.** How can $\Delta G_{reaction}^0$ be calculated using ΔH^0 and ΔS^0? **3.2.6.** Of ΔH^0, ΔS^0, and ΔG^0, which one is most dependent on temperature?	1 1 1 1 1 1
	2.3. Gas A_2 reacts with gas B_2 to form gas AB at a constant temperature. The bond energy of AB is much greater than that of either reactant. **2.3.1.** Explain how potential energy changes for this process. **2.3.2.** Explain how random kinetic energy changes during the process. **2.3.3.** What can be said about the sign of ΔH and ΔS?	 1 1 2
	Итого по Вопросу 3	**15**
4	**4.1.** Distinguish between the following pairs of terms: 4.1.1. crystalline solid, amorphous solid 4.1.2. ionic solid, molecular solid 4.1.3. molecular solid, network solid 4.1.4. metallic solid, network solid	4
	4.2. In your own words, define *lattice* and *unit cell*.	2
	4.3.1. Describe a simple cubic unit cell. **4.3.2.** How many net atoms are contained in a simple cubic cell unit? **4.3.3.** How is the radius of the atom related to the cube edge length for a simple cubic unit cell.	1 2 2
	4.3.4. Answer the questions in (c) above for the face-centered and body-centered cubic unit cells.	4
	Итого по Вопросу 4	**15**
	ИТОГО ПО РАЗДЕЛУ 1	**60**

Второй раздел состоит из 6 вопросов, состоящих из нескольких пунктов/подпунктов. Необходимо дать ответ на любые три вопроса.

Номер вопроса	Содержание пункта/подпункта вопроса	Количество баллов
1	**1.1.** Draw the electrochemical cell in which the following reaction occurs: $Cu_{(aq)}^{2+} + 2\,Cl_{(aq)}^{-} + 2\,Ag_{(s)} \rightarrow 2AgCl_{(s)} + Cu_{(s)}$	3
	1.2. Write the half-cell reactions for the corresponding electrodes and the Nernst equation.	3

	1.3. Given that the $\Delta_f G^0$ for $Cu^{2+}_{(aq)}$, $Cl^{-}_{(aq)}$, and $AgCl_{(s)}$ are 65.5, -131, and -110 kJ/mol, respectively, calculate the **1.3.1.** standard Gibbs free energy for the cell reaction **1.3.2.** equilibrium constant **1.3.3.** standard potential of the cell	 3 3 3
	1.4. Calculate the standard potential of the $Cu_{(s)}/Cu^{2+}_{(aq)}$ electrode given that the standard potential of the $Ag_{(s)}/AgCl_{(s)}$ electrode is 0.22 V.	3
	1.5. Using the answer obtained in (d), determine the standard potential for the reaction $Cu^{2+}_{(aq)} + e \rightarrow Cu_{(s)}$, given that the standard potential of the $Cu^{2+}_{(aq)}/Cu^{+}_{(aq)}$ redox couple is 0.16 V.	3
	1.6. If the temperature coefficient of the cell $(dE^0/dT) - 8.8 \times 10^{-4}$ V/K, calculate $\Delta_f S^0$ and $\Delta_f H^0$.	4
	Итого по Вопросу 1	**25**
2	**2.1.** With the aid of a diagram, explain how spontaneous chemical reactions in galvanic cells generate electricity.	5
	2.2.1. What is the difference between *E* and E^0 in redox reactions? **2.2.2.** For a complete cell in equilibrium, does *E* or E^0 approach zero? Explain your answer.	2 3
	2.3. What is a junction potential and how does it affect the accuracy of potentiometric analysis? Use a diagram to explain your answer.	5
	2.4.1. Describe the following terms - over potential - ohmic potential - concentration polarization **2.4.2.** What can be done to minimize these issues during electrolysis?	3 3
	2.5. Give TWO advantages and TWO disadvantages of the dropping mercury electrode (DME).	4
	Итого по Вопросу 2	**25**
3	**3.1.** The Nernst equation allows the cell potential for a galvanic cell under nonstandard conditions to be determined. Write out the Nernst equation and define each term. What are nonstandard conditions?	6
	3.2. What does the Nernst equation reduce to when a redox reaction is at equilibrium? Explain why this is so.	5
	3.3. What are the signs of ΔG^0 and E^0 when **3.3.1.** $K < 1$? **3.3.2.** $K > 1$? **3.3.3.** $K = 1$?	 2 2 2
	4.1. Explain what is meant by '*E* determines spontaneity while E^0 determines the equilibrium position.' **4.2.** Under what conditions can E^0 be used to predict spontaneity?	4 4
	Итого по Вопросу 3	**25**
4	**4.1.** Give three differences between bulk materials and nanoparticles	6

	and state their influence on the chemical-colloidal and physicochemical properties of a system.	
	4.2. Using the effects of quantum confinement, explain the advantages of using nanoparticles over bulk materials.	8
	4.3. What are the main advantages of using biopolymers over synthetic polymers? Support your answer using the advantageous properties of biopolymers.	5
	4.4. The main synthetic approach to nanoparticle synthesis is sol gel synthesis. **4.4.1.** Define sol gel synthesis. **4.4.2.** Name three different types of sol-gel synthesis and state what type of nanoparticles they are used to obtain.	 2 4
	Итого по Вопросу 4	**25**
5	**5.1.1.** In your own words, define chemisorption and physisorption. **5.1.2.** Give **<u>three</u>** differences between chemisorption and physisorption.	4 6
	5.2. Explain, in detail, why the adsorption of a gas on a solid surface is usually exothermic.	5
	5.3. What are the three main assumptions of the Langmuir adsorption isotherm model?	6
	5.4. Considering the rates of adsorption and desorption of a gas on a solid surface, derive the Langmuir adsorption isotherm.	4
	Итого по Вопросу 5	**25**
6	6.1. List the five additive manufacturing processes.	**3.5**
	6.2. Three-dimensional (3D) printing is the most common type of additive manufacturing. 3D printing can be further categorized into stereolithography and extrusion-based 3D printing. 6.2.1. Define **6.2.1.1.** stereolithography **6.2.1.2.** extrusion-based 3D printing 6.2.2. Give TWO advantages and TWO disadvantages of **6.2.2.1.** stereolithography **6.2.2.2.** extrusion-based 3D printing	 2 2 4 4
	6.3. One of the main advantages of extrusion-based 3D printing is that unique inks can be created. What are the benefits of creating your own inks?	3
	6.4. Stereolithography is limited to the use of photoresist, which often requires post-processing treatment. What is photoresist? What are common post processing treatment methods for objects fabricated using stereolithography.	3.5
	6.5. Give 5 industrial applications of additive manufacturing.	3
	Итого по Вопросу 6	**25**
	ИТОГО ПО РАЗДЕЛУ 1 (3 вопроса из 6)	**75**

Неправильный либо отсутствующий ответ по пункту/подпункту приравнивается к 0 баллов.

Формат проведения аттестационного задания: опрос посредством Гугл-формы

Время выполнения аттестационного задания: 150 минут

Минимальное количество баллов за выполнение варианта аттестационного задания равно 0.
Максимальное количество баллов за выполнение варианта аттестационного задания равно 135.

Студент, набравший 50 % и более баллов (68 и более баллов из 135 возможных), успешно проходит аттестационное испытание.
Студент, набравший менее 50 % баллов (менее 68 баллов из 135 возможных), считается не прошедшим аттестационное испытание и не готовым к освоению образовательной программы.

ПРИЛОЖЕНИЕ 2

Приложение к распоряжению от 11.07.2025 № 3

Банк аттестационных заданий

по образовательной программе 18.04.02 «Химия и искусственный интеллект / Chemistry and Artificial Intelligence»

Каждый вопрос имеет свою весомость в баллах, которая указана в скобках.

Раздел «Химия»

1. Which of the following is an example of a Diels-Alder reaction? (3 балла)

A. The reaction of ethylene oxide with water to form ethylene glycol
B. The reaction of benzene with ethene to form phenylethene
C. The reaction of maleic anhydride with 1,3-butadiene to form cyclohexene-1,2-dicarboxylic anhydride
D. The reaction of ethanol with acetic acid to form ethyl acetate

2. Arrange the following compounds in descending order of acidity. (4 балла)

A. Methanol
B. Methanesulfonic acid
C. Methylamine
D. Methanethiol
E. Acetic acid

3. Which of the following statements are true regarding the acidity of carboxylic acids? (3 балла)

A. The acidity of carboxylic acids increases with increasing electron-withdrawing groups on the carboxylate anion
B. The acidity of carboxylic acids decreases with increasing size of the alkyl group attached to the carboxylic acid
C. The acidity of carboxylic acids increases with increasing resonance stabilization of the carboxylate anion
D. The acidity of carboxylic acids decreases with increasing electron-donating groups on the carboxylate anion

4. What is the mechanism of the reaction of 2-methylpropene with HBr in the presence of peroxide? (2 балла)

A. Markovnikov addition

B. Anti-Markovnikov addition
C. Radical addition
D. Electrophilic addition

5. Which of the following is not a method for synthesizing alcohols? (3 балла)

A. Reduction of aldehydes or ketones
B. Hydrogenation of alkenes
C. Addition of water to alkenes
D. Oxidation of alkenes

6. What is the pH of a buffer solution prepared by adding 20mL of 0.10M acetic acid (Ka = 1.8 x 10^-5) to 10mL of 0.2M sodium acetate? (5 баллов)

A. 3.74
B. 4.74
C. 5.74
D. 6.74

7. What is the Gibbs free energy change (ΔG) of a spontaneous reaction? (2 балла)

A. $\Delta G < 0$
B. $\Delta G = 0$
C. $\Delta G > 0$
D. ΔG can be either positive or negative depending on the reaction conditions

8. Which of the following is not a state function? (2 балла)

A. Internal energy
B. Entropy
C. Work
D. Enthalpy
E. Heat

9. What is the maximum number of electrons that can occupy an orbital with the following quantum numbers: n=3, l=1, ml=0? (4 балла)

A. 2
B. 4
C. 6
D. 8

10. What is the Gibbs free energy change for a process at constant pressure and standard temperature if ΔH = -50 kJ/mol and ΔS = 100 J/mol-K? (5 баллов)

A. -50 kJ/mol

B. 298 kJ/mol
C. -79.8 kJ/mol
D. 79.8 kJ/mol

11. Calculate the pH of HCl acid when the concentration of [H]+ ions is 0.1 M. (5 баллов)

A. 2
B. 1
C. 6
D. 10

12. Write an equation for the reaction between (1 балл за каждый пункт, итого 3 балла)

A. MgO and HNO3
B. Na2O and H3PO4
C. SiO2 and NaOH

13. What is the Molecular Orbitals (MO) method used for in chemistry? (3 балла)

A. Calculating the properties of molecules based on their molecular orbitals
B. Analyzing the crystal structure of materials
C. Predicting the rate of chemical reactions
D. Synthesizing new compounds

14. What is the correct order for filling atomic orbitals for atoms and cations? (4 балла)

A. 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, 7p
B. 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d
C. 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 6d, 7p
D. 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 6d, 5f, 7p

15. What is Crystal Field Stabilization Energy in coordination complexes? (3 балла)

A. The energy required to break the metal-ligand bonds in a coordination complex
B. The energy difference between the ground state and excited states of a coordination complex
C. The difference in energy between the d-orbitals in a free metal ion and those in a coordination complex
D. The energy released when a coordination complex forms

16. What is the relationship between Crystal Lattice Energy and Madelung Constant in ionic compounds? (3 балла)

A. The Madelung constant is equal to the crystal lattice energy
B. The Madelung constant is proportional to the crystal lattice energy

C. The Madelung constant is inversely proportional to the crystal lattice energy
D. The Madelung constant is not related to the crystal lattice energy

17. What is the significance of quantum numbers in the electronic structure of atoms? (3 балла)

A. They describe the arrangement of atoms in molecules
B. They describe the energy levels and sublevels of electrons in atoms
C. They describe the types of chemical bonds that atoms can form
D. They describe the physical properties of atoms, such as density and melting point

18. Match the crystal system with its corresponding shape: (4 балла)

A) Cubic
B) Tetragonal
C) Orthorhombic
D) Rhombohedral
E) Monoclinic
F) Triclinic

1. Rectangular prism
2. Cube
3. Rhombohedron
4. Rectangular prism with square base
5. Trapezoidal prism
6. Irregular shape

Раздел «Программирование»

1. Match programming paradigms and the concepts behind it: (2 балла)

A. Declarative
B. Functional
C. Object-oriented
D. Imperative

1. Uses data structures consisting of attributes and methods along with their interactions
2. Focuses on realization details, defines control flow as statements that change a program state
3. Input flows through a set of functions, outputs are independent on data structures updated as a program runs
4. Focuses on the task to be solved, defines logic rather than control flow

2. What are NOT the common built-in data types in Python? (2 балла)

A. Float

B. Table
C. Array

Set

D. Boolean
E. Binary

3. How does break, continue, and pass commands work? (2 балла)

A. break
B. pass
C. continue
    1. exits the loop
    2. goes to the next iteration
    3. does nothing

4. What is the difference between list and tuples in Python? (1 балл)

A. Lists and tuples are essentially the same thing in Python. There is no difference between them.
B. Lists are used to store ordered collections of data, while tuples are used for unordered data.
C. List items can be taken by their index in the list, whereas tuple elements cannot.
D. The only difference between lists and tuples is their syntax. Lists use square brackets and tuples use parentheses.
E. Lists are mutable, meaning you can change the elements in the list after it has been created. Tuples are immutable, meaning you cannot change the elements in the tuple after it has been created.

5. What advantages do NumPy arrays offer over (nested) Python lists? (2 балла)

A. NumPy arrays are slower than nested Python lists because they require more memory allocation.
B. NumPy arrays are more flexible than nested Python lists because they can store different data types within a single array.
C. NumPy arrays are easier to use than nested Python lists because they have simpler syntax and require fewer lines of code.
D. NumPy arrays allow vectorization, which means that operations can be performed on entire arrays at once instead of on individual elements.
E. NumPy arrays are less memory-efficient than nested Python lists because they store data in separate memory locations.

6. Write a code with the function squared_sequence(A: int, B: int) which takes two numbers and returns a list of the squared numbers in range(A, B+1). (3 балла)

7. Write a code that takes two stings of the same length containing symbols separated by a space and prints combinations of two symbols having the same index. (3 балла)

8. Write a code with the function count_sequence_sum() which takes a string of two numbers A and B separated by a comma, and returns the sum of all the numbers from A to B (A, A+1, A+2, …, B-1, B). (2 балла)

Неправильный либо отсутствующий ответ по пункту/подпункту приравнивается к 0 баллов.

Формат проведения аттестационного задания: опрос посредством Гугл-формы

Время выполнения аттестационного задания: 150 минут

Минимальное количество баллов за выполнение варианта аттестационного задания равно 0.

Максимальное количество баллов за выполнение варианта аттестационного задания равно 78.

Студент, набравший 50 % и более баллов (39 и более баллов из 78 возможных), успешно проходит аттестационное испытание.

Студент, набравший менее 50 % баллов (менее 39 баллов из 78 возможных), считается не прошедшим аттестационное испытание и не готовым к освоению образовательной программы.

ПРИЛОЖЕНИЕ 3

Приложение к распоряжению от 11.07.2025 № 3

Система перевода показателей в балльно-рейтинговую систему

Показателем учебно-научной активности студентов является наличие достижений в учебной, научно-исследовательской, общественной, культурно-творческой и спортивной деятельности.

Для осуществления ранжирования студентов в общем списке в случае конкурса на вакантные бюджетные места при условии одинакового балла по тестированию и среднему баллу, а также при условии равенства академической разницы, показатель учебно-научной активности студентов переводится в балльно-рейтинговую систему согласно таблице ниже.

В случае если студент не проходит аттестационное тестирование, он считается не прошедшим аттестационное испытание, и баллы по показателю не учитываются.

Система перевода показателя учебно-научной активности студентов в балльно-рейтинговую систему

№	Показатель	Критерий измерения	Балл
1	Наличие достижений	победитель или призер международных олимпиад / соревнований	3 за каждое достижение
		наличие статьи в журнале, рецензируемом базой Scopus, Web of Science	3 за каждое достижение
		участие в международной конференции/симпозиуме	3 за каждое достижение
		победитель или призер всероссийских олимпиад / соревнований	2 за каждое достижение
		наличие статьи в журнале, рецензируемом ВАК	2 за каждое достижение
		участие во всероссийской конференции/симпозиуме	2 за каждое достижение

		победитель или призер региональных или внутривузовских олимпиад / соревнований	1 за каждое достижение
		наличие статьи в журнале, рецензируемом РИНЦ	1 за каждое достижение
		участие в региональной/внутривузовской конференции/симпозиуме	1 за каждое достижение
		прочие достижения	1 за каждое достижение
		нет достижений	0