

**List of examination questions on the educational program
8D07103 / 8D07107 – «Chemical technology of organic substances»**

Module 1

1. What is an organic substance?
2. What is the essence of the cracking process?
3. What is obtained during catalytic reforming?
4. Name the main raw material sources for chemical technology of organic substances
5. What is isomerization?
6. What is the purpose of pyrolysis?
7. What are the products of hydrocracking?
8. What is alkylation?
9. Name the main types of plastics.
10. What is the difference between thermoplastics and thermosetting plastics?
11. What is formed during the dehydrogenation of alkanes?
12. What catalysts are used in chemical technology of organic substances?
13. What is sulfochlorination?
14. Name the methods of ethylene production.
15. What is the advantage of gas-phase processes?
16. Glycerin synthesis
17. Synthesis of cumene
18. Complexes by azeotropic, extractive rectification
19. Analysis of the statics of continuous combined reaction-rectification processes
20. What is formed during dehydration?
21. Reaction and mass transfer processes
22. Alkylation of aromatic amines
23. Alkylation of benzene with ethylene
24. What is the dehydrogenation process?
25. How to get styrene from ethylbenzene?
26. What are the main stages of the styrene production process by dehydrogenation of ethylbenzene?
27. How can ethylbenzene be obtained?
28. How can styrene be obtained from ethylbenzene in two stages?
29. How to get ethylene oxide?
30. What is made from ethylene?
31. How is ethylene oxide produced?
32. Is it possible to get phenol from benzene?
33. In which method of obtaining phenol is acetone obtained together with it?
34. How to get phenol reaction from chlorobenzene?
35. Technological design of the methanol synthesis process
36. Principles in methanol production technology
37. Principles in oxosynthesis technology
38. Sulfuric acid hydration of olefins
39. Theoretical Foundations of Direct Hydration of Lower Olefins

40. Low Olefin Direct Hydration Technology
41. Obtaining acetaldehyde from acetylene
42. Preparation of acetaldehyde from ethylene
43. Principles in the technology of ethylene oxidation to acetaldehyde
44. Principles in technology for the production of vinyl acetate from acetylene
45. Theoretical foundations of the liquid-phase method for the production of vinyl acetate
46. Obtaining 1,2-dichloroethane
47. Obtaining 1,2-dichloroethane by oxidative chlorination of ethylene
48. Obtaining vinyl chloride from acetylene
49. Production of vinyl chloride from ethylene
50. Combined process for the production of vinyl chloride

Module 2

1. Explain why zeolite catalysts are used in catalytic cracking and name the main products of the process.
2. Calculate the mass yield of ethylene if 330 kg of ethylene is obtained from 1 ton of n-hexane during pyrolysis.
3. Which alkylating agent and catalyst are preferred for the alkylation of isobutane with butylene?
4. Compare the Wacker process and ethanol oxidation as methods of producing acetaldehyde.
5. Describe the dehydrogenation stage of ethylbenzene. What are the conditions and catalysts used?
6. What are the typical by-products of phenol production by the cumene process, and how are they disposed of?
7. Write the equation for the sulfochlorination of methane.
8. Why has industrial production of vinyl chloride from acetylene been replaced by the method using ethylene?
9. List the key stages of caprolactam production from benzene.
10. Determine the molar ratio of monomers in the synthesis of polyethylene terephthalate (PET).
11. Describe the conditions and the product of mononitration of toluene.
12. What is the mechanism of ethanol dehydration to ethylene?
13. Indicate the difference between direct and indirect hydration of ethylene.
14. What by-product is formed in the cumene method of phenol production and how is it utilized?
15. What parameters must be controlled to optimize the oxidation of cyclohexane to cyclohexanol and cyclohexanone?
16. Arrange in order of increasing boiling point of the compound: $\text{CH}_3\text{CH}_2\text{Br}$, $\text{CH}_2=\text{CHBr}$, $\text{CH}\equiv\text{CBr}$.
17. A compound of composition $\text{C}_{18}\text{H}_{10}\text{N}_2$ containing two unsubstituted phenyl rings reacts with an excess of chlorine to give a single product of composition $\text{C}_{18}\text{H}_{10}\text{N}_2\text{Cl}_2$. What is the structure of the starting compound and the resulting product? What explains the high dipole moment of the original compound ($\mu=7.9\text{D}$)?

18. Propose the structure of a compound with the molecular formula $C_4H_{10}O$, which does not react with metallic sodium, but reacts with concentrated sulfuric acid when heated, forming an alkene.
19. What product is formed during the hydrogenation of 1-pentene?
20. Write the equation of the reaction of bromination of benzene in the presence of a catalyst.
21. Describe the method of obtaining ethyl acetate from ethanol and acetic acid.
22. What product is formed during the oxidation of 2-propanol (isopropanol) with chromic acid ($K_2Cr_2O_7/H_2SO_4$)?
23. How can acetylene be obtained from methane?
24. 30 kg of water was added to 500 kg of sulfuric acid. Determine the concentration of the resulting acid and the temperature rise due to the dilution
25. Calculate the volume of dry air required to burn 100 kg of pyrites and the volume of roasting gas obtained if pyrites contains 43% S, pyrites moisture content is 6.8%, SO_2 in the roasting gas is 11% by volume. Excess air coefficient $\alpha = 1.5\%$. Air composition: 21% oxygen and 79% nitrogen by volume.
26. Determine the theoretical calorific value (calorific value in kJ/kg) of carbonaceous pyrites containing 42% sulfur and 5% carbon. It is known that 1 kg of pure pyrite during combustion gives 7060 kJ/kg, and 1 kg of carbon - 32700 kJ/kg.
27. The oleum absorber receives 30,500 m³/h of gas containing 10% SO_3 . The absorber is irrigated with oleum containing 19% SO_3 ; the effluent oleum contains 21.5% SO_3 . Determine the mass of oleum required for irrigation
28. absorber in kg/h if the SO_3 absorption rate is 40%.
29. Calculate the composition of the gas at the inlet and outlet of the synthesis column in the production of 1 ton of ammonia, if the concentration of ammonia at the inlet and outlet is 4 and 16% by volume, respectively.
30. Calculate the grid diameter Pt/Rh of the catalyst for a contact apparatus that provides 82 tons of nitric acid per day. The degree of conversion of ammonia to NO is 0.96, and the degree of absorption of NO_2 is 0.98. Ammonia oxidation occurs at a pressure of 105 Pa. The intensity of the catalyst is 605 kg/m² per day. The content of ammonia in the mixture is 11.2% (by volume). The active surface of one square meter of the grid is 1.82 m². The apparatus contains four grids.
The decomposition of 1000kg of apatite concentrate containing 39.8% P_2O_5 consumes 1950kg of 54% phosphoric acid (in terms of P_2O_5). Determine how much lime is added until the excess of phosphoric acid is completely neutralized and what is the concentration of P_2O_5 total and P_2O_5 in the finished product. The degree of decomposition of the apatite concentrate is 80%. The content of $CaCO_3$ in limestone is 95%. Its utilization rate is 90%. Phosphorus in apatite is in the form $Ca_5F(PO_4)_3$.
31. There is magnesium in the amount of 36 g. 128.25 g of $MgCl_2$ is obtained from it. What proportion does this amount make up of the theoretically calculated product yield?
32. From a diaphragm-type chlorine electrolyzer with a load of 40 kA per day, liquor with a volume of 10.6 m³ containing 130 kg/m³ of caustic soda was obtained. Determine the alkali output by current.
33. Calculate the energy utilization factor in the BGK electrolyzer -17-25, if during the electrolysis of an aqueous solution of common salt at a current of 25 kA per day, the volume of electrolytic liquor was obtained 7.19 m³ with a sodium

hydroxide content of 120 kg/m^3 . The anode and cathode potentials are 1.32 and 0.82 V, respectively;

34. Portland cement clinker contains 54% $3\text{CaO} \cdot \text{SiO}_2$, 21% $2\text{CaO} \cdot \text{SiO}_2$, 12% $3\text{CaO} \cdot \text{Al}_2\text{O}_3$, 10% $4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$, 2% CaO, 0.5% SiO_2 , 0.5% SO_3 . Calculate the values of the saturation factor and modules.

35. In catalytic cracking of kerosene, the mass fraction of gas is 18% of the raw material. Determine the mass of methane that will be obtained from 1 ton of kerosene if the volume fractions of the cracking gas components are: H_2 - 9, CH_4 - 27, C_2H_6 - 12, C_3H_8 - 3.5, C_2H_4 - 25, C_3H_6 - 15, C_4H_8 - 8.5%.

36. Write the structural formulas and names of the following organic compounds: a) $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3$; b) $\text{CH}_3\text{-CH}_2\text{-COOH}$; c) $\text{CH}_3\text{-CH}_2\text{-OH}$

37. Write the equations of the reactions of ethylation and hydrolysis of ethyl acetate.

38. How many molules of water are formed when 2 mol of acetylene is completely hydrogenated?

39. Write the equation of the reaction of alkylation of benzene with bromoethane.

40. What is the number of water molecules formed during the complete hydrogenation of 1 mole of benzene?

41. Write the equations of the reactions of synthesis and hydrolysis of ether.

42. Write the equation of the reaction of alkylation of benzene with chloromethane.

43. Write the structural formulas and names of the following compounds: a) $\text{CH}_3\text{-CH=CH-CH}_2\text{-CH}_3$; b) $\text{CH}_3\text{-CHO}$; c) $\text{CH}_3\text{-C}\equiv\text{CH}$

44. How many molules of water are formed when 1 mole of butene is completely hydrogenated?

45. Write the equation of the toluene alkylation reaction with chloromethane.

46. Write the structural formulas and names of the following compounds: a) $\text{CH}_3\text{-CH}_2\text{-C}\equiv\text{CH}$; b) $\text{CH}_3\text{-COO-CH}_3$; c) $\text{CH}_3\text{-CH(Cl)-CH}_3$

47. How many molules of water are formed when 1 mole of propine is completely hydrogenated?

48. Write the equations of reactions of synthesis and hydrolysis of ethyl ether.

49. Write the equation of the reaction of alkylation of toluene with ethylene.

50. Write the structural formulas and names of the following compounds: a) $\text{CH}_3\text{-CH(Cl)-CH=CH}_2$; b) $\text{CH}_3\text{-COOH}$; c) $\text{CH}_3\text{-CHO}$.

Module 3

1. What raw materials are optimal for ethylene production via pyrolysis? What factors influence the product yield?

2. Describe the main stages of phenol production by the cumene method. What are the alternative methods?

3. What is the significance of radical and ionic mechanisms in hydrocarbon processing reactions?

4. Classify industrial catalysts used in organic technologies and provide examples of their application.

5. Analyze the thermodynamic and kinetic features of the dehydrogenation processes of alkyl aromatic hydrocarbons.

6. What principles underlie the design of reactors for high-temperature processes (e.g., pyrolysis, cracking)?
7. Describe methods to increase selectivity during the oxidation of aliphatic and aromatic compounds in industrial processes.
8. How is the ratio of monomers regulated in copolymer synthesis depending on the desired properties of the final product?
9. What is a closed-loop process flow diagram in CTOS, and how does it help reduce environmental impact?
10. Compare alkylation and acylation of aromatic compounds from an industrial perspective.
11. Describe methods of deep processing of oil and gas condensate to obtain feedstock for organic synthesis.
12. What are the main processes of synthesizing halogenated alkanes, and what is their role as intermediates in CTOS?
13. What is the olefination process, and what are its prospects in sustainable chemical manufacturing?
14. Explain the importance of physicochemical analysis methods (GC, HPLC, IR, NMR) in quality control within CTOS.
15. Analyze the principles of intensifying chemical-technological processes under conditions of modern industrial automation.
16. Production of oxygen-containing organic compounds by oxosynthesis
17. Production of ethyl and isopropyl alcohols
18. Preparation, properties and application of acetaldehyde
19. Vinyl acetate production. General characteristics of production methods
20. Production of organochlorine products. Production of 1,2-dichloroethane
21. Production of basic organic synthesis products
22. Description of reactor systems
23. Combination as a method of technology improvement
24. Principles in the technology of alkylation of benzene with olefins
25. Physico-chemical properties of ethylene
26. Halogenation processes
27. Radical chain chlorination
28. Ion catalytic halogenation
29. Hydrolysis, hydration, dehydration, esterification and amidation processes
30. Hydrolysis and alkaline dehydrochlorination of chlorine derivatives
31. Production of alcohols and phenols by alkaline hydrolysis
32. Theoretical foundations of the esterification process
33. Synthesis and transformations of nitrogen derivatives of acids
34. Thermodynamic models of complex chemical and chemical-technological processes
35. Kinetic models of complex chemical and chemical-technological processes
36. How does the polymerization process work?
37. What are polymer materials?
38. What are the types of polymer materials?
39. Chemical properties of acetylene
40. General principles of organic synthesis
41. What is the bond in the carbonyl group?

42. Organo-zinc compounds
43. How does alkylation occur?
44. What are cycloalkanes?
45. What are the main types of reactors used in the chemical technology of organic substances and their features?
46. What methods of cleaning organic products are used in chemical technology?
47. What are the main stages of the synthesis of organic compounds?
48. What are the characteristics of organic compounds?
49. Which industries are related to organic chemical technology?
50. How to identify an organic compound?

List of recommended literature for exam preparation

1. «Химическая технология органических веществ» - под ред. Л.И. Косарева (1998)
2. «Основы химической технологии органических веществ» - В.И. Голованов, Л.И. Косарев (2005)
3. «Химическая технология органических веществ: Учебник для вузов» - И.С. Александров, В.М. Дергачев (2012)
4. «Технология органических веществ» - И.А. Степанов (2007)
5. «Процессы и аппараты химической технологии органических веществ» - А.И. Лихарев (2010)
6. «Основы технологии органических веществ» - А.П. Горбунов (2003)
7. «Химическая технология органических соединений» - Е.Г. Голованова (2015)
8. «Химическая технология органических соединений: Учебное пособие» - В.А. Кузнецов, Н.В. Смирнова (2009)
9. «Справочник по химической технологии органических веществ» - П.И. Лисицын (2018)
10. «Химическая технология органических веществ: Процессы и оборудование» - А.А. Баранов (2011)
11. «Технология органических соединений» - В.С. Соколов (2006)
12. «Химическая технология органических соединений: Синтез, очистка, анализ» - Н.А. Кузнецова (2014)
13. «Основы химической технологии: Органические вещества» - Г.М. Иванов (2017)
14. «Химическая технология органических соединений: Учебное пособие» - А.В. Петров, Е.И. Смирнова (2013)
15. «Технология синтеза органических веществ» - Д.С. Сергеев (2004)
16. «Химическая технология органических веществ: Производство и применение» - К.В. Морозов (2016)
17. «Основы химической технологии органических соединений» - Л.А. Лебедева (2010)
18. «Химическая технология органических соединений: Теория и практика» - Е.Д. Иванова (2012)

19. «Технология органических веществ: Справочник» - В.П. Кузнецов (2008)

20. «Химическая технология органических соединений: Методы синтеза и анализа» - О.Н. Петров (2019)

Essay topics

1. What does organic chemistry study, and what classes of substances does it include?

2. How is organic chemistry applied in the development of pharmaceuticals and biomaterials?

3. What are polymers, and what are the main methods used for their synthesis (e.g., polymerization and polycondensation)?

4. What criteria must be considered when designing a synthetic route for organic compounds in both laboratory and industrial settings?

5. Describe the stages of industrial production of synthetic polymers and their areas of application.

6. What modern technologies are used to improve the environmental and energy efficiency of organic compound synthesis?

7. List the types of natural and secondary raw materials used in the chemical industry.

8. The profession of a young chemical technologist: challenges and prospects in a scientific career.

9. The role of nanotechnologies in the development of new functional materials based on organic compounds.

10. How do scientific and technological advances influence the development of organic chemical technology?

11. Biomaterials and composites as alternatives to traditional polymers: advantages and limitations.

12. Global trends in polymer consumption and the search for environmentally friendly alternatives.

13. What innovative technologies could revolutionize chemical manufacturing in the coming decades?

14. What challenges does the modern chemical industry face under conditions of globalization and climate change?

15. Propose modernization strategies for chemical plants considering digitalization and automation.

16. What structural and systemic issues hinder the development of the chemical industry in Kazakhstan?

17. Identify the key groups of chemical pollutants and their impact on the environment.

18. What indicators are used to assess the performance and sustainability of Kazakhstan's chemical industry?

19. Which types of chemical processing pose the greatest threat to the environment?

20. Greening chemical production: principles, approaches, and implementation examples from different countries.