Society of Chemists and Technologists of Macedonia
Chemistry competitions for elementary and high schools

NATIONAL CHEMISTRY COMPETITION

May 14, 2026

1) The tests are stapled with an envelope on the top. In the envelope there is piece of paper on which you should fill in the requested data: name and surname, school, supervisor etc. and then close and **seal the envelope!**
2) Do not put any signature, or a mark on the envelope and on the test (the code should be filled in by the jury). If any signature or mark is found on the test or envelope, the competitor will be disqualified.
3) You should write on the test using a **blue pen**, answers written with pencil will not be considered.
4) It is not allowed to use textbooks, any other book, notebook, paper, the periodic table, cell phone etc. Cell phones should be left on the teacher's desk or out of the test room.
5) Any conversation between the competitors is forbidden. If you have any question, then the teacher in the room should call the responsible person for the competition.
6) Read the test carefully and answer the questions following the instructions by writing down the solution and answer in the designated space in the test. The jury **will evaluate only the answers written in the designated space for it**, and the procedures for solving the problems will be checked. The back of every page of the test, that is empty, can be used for free writing and it will not be checked and evaluated!
7) The maximal number of points is **50**: 40 from the theoretical problems and 10 from the experimental problem.
8) The competition lasts **180 minutes**. The tests that are handed after the given time will not be considered for scoring.

We wish you success!

For the jury only

Теориски проблеми: _____

Замислен експеримент: _____

Вкупно поени:_____ Прегледал (Име и презиме)

_____

Problem 1 (8 points) Organic Reaction Mechanisms

Organic reactions proceed via different mechanisms. This problem concerns substitution reactions.

An example of a substitution reaction is the chlorination of ethane under ultraviolet light.

A) (*1 point*) Write a chemical equation for the chlorination of ethane.

B) (*0.5 point*) State the type of reaction mechanism.

Answer: _____

- (*3 points*) Write the chemical equations for each step of the mechanism: initiation, propagation, and termination.

Initiation: Propagation: Termination:

The alkyl halide obtained in reaction A is used to prepare an alcohol in alkaline medium.

C) (*1 point*) Write a chemical equation for the preparation of the alcohol.

– (*0.5 point*) State the type of reaction mechanism.

Answer: _____

– (*2 points*) Represent schematically the reaction mechanism for the preparation of the alcohol.

Problem 2 (9 points) Isomerism and Synthesis of Organic Compounds

Many organic compounds have the same molecular formula but display different physical and chemical properties. This is due to differences in the way atoms or groups of atoms are bonded and/or their spatial arrangement. This problem presents examples of different types of isomerism.

The molecular formula $C_4H_{10}O$ is given.

A) (*3 points*) Write all alcohol isomers corresponding to this molecular formula and name them.

B) (*1.5 points*) Which of these isomers can be oxidized to carboxylic acids? Represent the corresponding reactions with chemical equations.

C) (*1.5 points*) Explain which alcohol isomer(s) with molecular formula $C_4H_{10}O$ exhibit optical stereoisomerism. Draw the corresponding optical antipodes.

Explanation: Optical antipodes:

D) (*3 points*) The alcohol referred to in part C can be obtained in several ways:

- by reduction,
- by nucleophilic substitution, and
- by hydration.

Represent these reactions with chemical equations for the preparation of this alcohol. Choose appropriate reagents.

by reduction: by nucleophilic substitution: by hydration:

Problem 3 (7 points) Representation of Organic Compounds

For organic compounds, the use of empirical formulae is not convenient because many compounds may have the same empirical formula. Therefore, molecular formulae are used in organic chemistry. However, due to the occurrence of isomerism, structural formulae are most commonly employed.

This problem presents examples of different ways of representing organic compounds.

Chemical analysis of an unknown compound with a characteristic rum-like odor and partially responsible for the flavor of raspberries showed that it consists of 48.6% carbon, 8.2% hydrogen, and the remainder oxygen. Another type of analysis determined its relative molecular mass to be approximately 74.

A) (*1 point*) Determine the molecular formula of the organic compound.

Calculation:

The molecular formula is:_____

B) (*2 points*) Write the structural formulas of the two ester isomers and name them.

C) (*2 points*) Write chemical equations for the preparation of the corresponding esters.

D) (*2 points*) One of the isomeric compounds that is not an ester reacts with Mg, releasing H_2 gas. Name the isomer and represent the reaction with a suitable chemical equation.

Problem 4 (8 points) Reactivity of Organic Compounds

During the development of organic chemistry, compounds were classified into groups according to their structural characteristics and similar chemical properties. The structural characteristics responsible for the classification of organic compounds according to reactivity are called functional groups.

In this problem, the class of an unknown organic compound is determined based on its characteristic chemical behavior.

An organic compound found in tobacco and blue cheese as a metabolic product of the mould *Penicillium* has the molecular formula $C_5H_{10}O$. Its reactivity was investigated through several chemical reactions, and the following observations were made:

- The compound with molecular formula $C_5H_{10}O$ does not react with Tollens' reagent.
- Reaction with 2,4-dinitrophenylhydrazine produces a yellow-orange precipitate of the corresponding hydrazone.
- Reaction with iodine in the presence of KOH produces a yellow precipitate of iodoform with a characteristic antiseptic odor.
- Reduction with $NaBH_4$ yields a secondary alcohol.
- Instrumental analysis showed that the structure of the compound contains no branching in the carbon chain.

A) (*1.5 points*) To which class of compounds does the investigated compound belong? Explain your answer.

class of compounds: _____

Explanation:

B) (*1.5 points*) Write the structural formula and name the compound.

C) (*3 points*) Represent the positive reactions with chemical equations.

D) (*2 points*) Write the structural formulae of the skeletal isomers of the investigated compound in which chain isomerism and positional isomerism are present. Name the compounds.

Problem 5 (8 points) Planning a Synthesis

When designing the synthesis of an organic compound, chemists often use a retrosynthetic approach, in which the target molecule is analyzed backwards through known reactions until simple and readily available starting compounds are reached.

In this problem, you are required to propose a synthetic pathway for the preparation of the given organic compound.

The organic compound shown below is given:

(8 points) Design a synthesis of this compound using alkenes as the only organic starting materials.

In your answer:

- show the complete sequence of reactions with structural formulae of all intermediates,
- specify the necessary reagents and conditions for each step,
- indicate the type of each reaction (for example: addition, oxidation, substitution).

THOUGHT EXPERIMENT (10 points)

Identification of Organic Compounds

Six test tubes (A–F) are provided in the laboratory, each containing a pure organic compound. The compounds belong to the following classes:

- saturated hydrocarbon
- alcohol
- phenol
- aldehyde
- ketone
- carboxylic acid

The following reagents are available:

- bromine water
- $FeCl_3$ solution
- Tollens' reagent
- 2,4-dinitrophenylhydrazine
- Na_2CO_3
- acidified $K_2Cr_2O_7$

Each reagent may be used more than once.

A) (*3 points*) Propose a logical sequence of tests that would allow you to identify all compounds with certainty. State the purpose of each test.

B) (*3 points*) Complete the table with the expected observations (+ / – or description).

Reagent	Saturated hydrocarbon	Alcohol	Phenol	Aldehyde	Ketone	Carboxylic acid

C) (*2 points*) Write the corresponding chemical equations for three selected positive tests.

D) (*2 points*) Explain how should one distinguish between:
– an aldehyde and a ketone:
– a phenol and an alcohol: