

The numbers in parentheses given after the numbers of the tasks indicate the grades of Russian school to which the task is recommended. The 8th grade is the first year of chemistry in Russian school and the 11th grade is the last year before graduation.

**Task 1.** (8)

An aqueous solution of starch containing 99% water by mass was allowed to stand in an open vessel, so that some water evaporated. After some period of time, the solution contained 98% water by mass. By what factor did the solution mass change? Write down your calculations.

**Task 2.** (8)

Anhydride of an acid is the oxide that forms this acid upon the addition of water. For example,  $\text{SO}_3$  is the anhydride of sulfuric acid  $\text{H}_2\text{SO}_4$ . Write down the formulae of anhydrides for the following acids: 1)  $\text{H}_2\text{SO}_3$ , 2)  $\text{H}_3\text{PO}_4$ , 3)  $\text{HBrO}_3$ , 4)  $\text{H}_2\text{CrO}_4$ . Indicate the oxidation states of elements in the oxides.

**Task 3.** (8–9)

Pieces of lithium, sodium, and potassium metals were completely dissolved in dilute hydrochloric acid (in three different vessels). In all three cases, the same amount of hydrogen was obtained upon the reaction. Determine the mass ratio of the three metals taken for the reaction. Write down the equations for all reactions involved. Is it possible to predict what medium will be in the solution after the reaction — acidic, alkaline, or neutral? What does it depend on?

**Task 4.** (8–9)

According to analysis, a solution contains the following ions in the following concentrations:

Ion	Concentration, mg/L
$\text{Na}^+$	80,5
$\text{K}^+$	117,0
$\text{Cl}^-$	106,5
$\text{NO}_3^-$	155,0

Is the electroneutrality condition met for this solution? (write down the calculations). What other ions can be present if phenolphthalein is known to turn pink in this solution? Calculate the concentration of the additional ions (in mg/L).

What compounds could be taken to prepare this solution?

A 10 mL portion of this solution was mixed with 20 mL of a solution of silver nitrate with the concentration of silver ions of 270 mg/L. Calculate the mass of the precipitate that will form.

**Task 5.** (9–10)

Compound **A** (a nonmetal oxide) weighing 2.4 g was dissolved in 30 mL of water. The oxide completely dissolved with no gas evolution or precipitation. This gave a solution containing a single compound with a mass fraction of 9.074%. Determine the formula of oxide **A**. Write down your calculations.

**Task 6.** (9–10)

Oxygen (20 mL) was added to 60 mL of a mixture of nitrogen and nitrogen(II) oxide. The gas mixture thus formed was passed through a solution containing excess potassium hydroxide. After that, the volume of the gas mixture was 44 mL. Determine the volumes of components in the initial (60 mL) and final (44 mL) gas mixtures. Write down your reasoning and calculations. All gas volumes refer to the same conditions ( $P$ ,  $T$ ).

**Task 7.** (10–11)

Black-coloured compound **F** was once used in cosmetics and now it is used in electronics. For the synthesis of 10 g of **F** it is necessary to pour together two colourless 1 M water solutions (approximately 42 mL of each solution). The addition of a solution of zinc sulfate to either of these 1 M solutions results in the formation of a white precipitate. Identify compound **F**. Write down the equations of all mentioned reactions and also your reasoning and calculations.

**Task 8.** (10–11)

Burning in an oxygen flow of 22.0 g of a white crystalline compound **A** gave 13.44 liters (STP) of carbon dioxide and 7.6 g of green powder **B**, insoluble in either acids or bases. Compound **B** is an oxide of metal **X**, with metal mass fraction of 68.4%. Heating of the same mass (22.0 g) of compound **A** above  $150^\circ\text{C}$  resulted in its complete decomposition to give two products: gas **C** (13.44 liters at STP) and metal **X**. Determine compounds **A**, **B**, **C** and **X**, write down the reaction equations and also your reasoning and calculations.

**Task 9.** (11)

A mixture of two isomers  $\text{C}_6\text{H}_{10}\text{O}_4$  was heated in a solution of sodium hydroxide. After completion of the reaction and subsequent acidification, a compound  $\text{CH}_4\text{O}$  and a mixture of two isomers  $\text{C}_4\text{H}_6\text{O}_4$  were obtained. When the mixture was kept at  $200\text{--}230^\circ\text{C}$ , two products were formed:  $\text{C}_4\text{H}_4\text{O}_3$  and  $\text{C}_3\text{H}_6\text{O}_2$ . Determine all compounds and draw their structural formulae; write down the reactions. It is additionally known that  $\text{C}_4\text{H}_6\text{O}_4$  and  $\text{C}_3\text{H}_6\text{O}_2$  are acids.

**Task 10.** (11)

A mixture of cyclopropane and hydrogen with the relative density with respect to hydrogen of 13.0 was passed with heating over a nickel catalyst. The density with respect to hydrogen of the gas mixture at the reactor outlet was 16.25. Determine the fraction (by volume) of cyclopropane that has reacted. Write down the reaction and your calculations.

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Don't forget to **sign** your work (please, write the card number, your last name, school and grade) before **submitting** the work. You do not have to submit the sheet with the tasks. The tasks, their solutions and the results of the competition will be published at <http://turlom.olimpiada.ru> after November