

Chemistry Competition

The numbers in parentheses given after the numbers of the problems indicate the grades of Russian school. The 8th grade pupils are supposed to solve 1 or 2 problems and 9th to 11th grade pupils solve 3 to 4 problems. The 8th grade is the first year of chemistry in Russian school and the 11th grade is the last year before graduation.

1. (8) The chemical formula of a well-known medicine can be written as follows: $(\text{CH}_3\text{OCO})\text{C}_6\text{H}_4\text{COOH}$.

Using the Periodic Table, calculate the molecular weight of this compound. Write a balanced equation for the combustion (reaction with oxygen) for this compound.

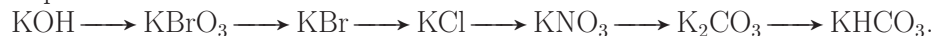
2. (8–9) A 1.0 cm-edge cube made of magnesium metal was completely dissolved in excess hydrochloric acid. The reaction gave 1.62 litres of H_2 (STP).*

Calculate the density of magnesium. What would be the volume of hydrogen formed in the reaction if the cube edge was 2 cm? What would be the volume of hydrogen formed in the reaction if a 1-cm cube was made of zinc, the density of which is 4.1 times greater than the magnesium density?

* For those who do not know Avogadro's law: at standard conditions (STP), 1 mole of any gas occupies a volume of 22.4 litres.

3. (8–11) In an aqueous solution of sulfuric acid, the number of hydrogen atoms is 1.5 times greater than the number of oxygen atoms. What is the mass fraction of sulfuric acid in this solution? (in percent).

4. (9–10) Write the balanced equations of reactions for the following sequence of transformations.



Each arrow corresponds to one reaction.

5. (9–10) On treatment of 10.0 g of a two-metal alloy with dilute hydrochloric acid, the alloy weight decreased by 2.3 g and 1.12 litres of a gas (STP) was evolved. When 1.0 g of the remaining metal was dissolved in concentrated nitric acid, 224 ml of nitrogen(IV) oxide was obtained (the volume corresponds to STP, dimerization of NO_2 is neglected).

What are the metals forming the alloy? Determine their mass fractions in the alloy (in percent). Write balanced equations of the mentioned reactions and equations for the reaction of the alloy with dilute nitric acid.

6. (9–10) Substance **M** (black powder) was placed in a glass tube, the tube was heated, and gas **N** was passed through it. The chemical reaction in the tube gave red-coloured substance **O**. When **O** was made to react with acid **P**, gas **R** was evolved and dissolved substance **S** was formed. After isolation from the solution, **S** was a blue crystalline solid. On heating, it decomposed to give, apart from other products, substances **M** and **R**.

Name the substances mentioned in the text. Give your reasoning. Write equations for the reactions described in the text.

7. (10–11) A 1.9-g sample of compound **A** (consisting of three elements) vigorously reacts with hydrochloric acid to give 4.48 litres of gas **B** (STP) (elemental substance) and dissolved salts **C** and **D**. Upon addition of excess aqueous ammonia to the solution, precipitate **E** is formed (salt **D** remains in the solution). The isolation of **E** followed by calcination gives 2.55 g of oxide **F** containing 47.06% oxygen (by mass).

Name these substances, write balanced reaction equations. Present your reasoning and required calculations.

8. (11) Complete combustion of 1 mole of a hydrocarbon requires 2.5 times less oxygen than the complete combustion of 1 mole of a homolog containing 2 carbon atoms more.

Determine the formulas of these hydrocarbons. Present the required calculations.

9. (11) A mixture of three alkanes that are gaseous at room temperature with a relative density to H_2 of 16.4 (that is, 16.4 times heavier than H_2) reacts with chlorine in the light to give a mixture of only three monochlorinated products.

What are these hydrocarbons? Give your reasoning. Find the volume fractions of the hydrocarbons in the mixture (in percent) if it is known that the volume fractions of the heaviest and the lightest components are equal.

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 20th.