

Chemistry Competition

The numbers in parentheses given after the numbers of the problems indicate grades of Russian school. The 8th grade pupils are supposed to solve 1 to 3 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 11th grade is the last year before graduation. Solution of the problems meant for senior grades is welcome. The problems for junior grades do not affect the final score.

1. (8) How do we call atoms that contain different numbers of neutrons and equal numbers of protons in the nuclei?

Using the Periodic Table of elements, determine what atoms have the nuclei consisting of:

- 6 protons and 6 neutrons;
- 8 protons and 8 neutrons;
- 6 protons and 7 neutrons;
- 8 protons and 9 neutrons;
- 79 protons and 118 neutrons.

2. (8–9) For fruit tree nutrition, 8 measuring spoons of a nitrogen fertilizer — ammonium nitrate — was applied on an area of 10 square meters. This amount of the fertilizer is equivalent to introduction of 42 kg of nitrogen (N) per hectare (10 000 square meters). The ammonium nitrate formula is NH_4NO_3 . Calculate how many grams of this compound correspond to one measuring spoon.

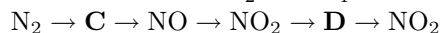
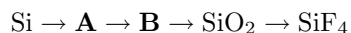
3. (8–10) One method for purification of crystalline compounds from impurities is called recrystallization, which is carried out in the following way. The compound to be purified is dissolved in hot water (or another appropriate solvent) and the resulting solution is put on ice or in a refrigerator for cooling. After some period, crystals of the purified compound precipitate from the solution.

1) Why does a solid precipitate upon cooling of the solution? Does it always happen?

2) Why the precipitated compound is pure (where are the impurities and why doesn't the compound contain them any longer?)

4. (9–10) A mixture of zinc and iron powders weighing 4.10 g was introduced into an aqueous solution containing an excess of copper(II) sulfate. After completion of the reaction, 4.48 g of copper metal was obtained. Determine the quantitative composition of the initial mixture (in grams or in weight percent).

5. (9–10) Write down balanced reaction equations corresponding to the schemes below (each arrow means one reaction). What compounds are designated by letters **A**, **B**, **C** and **D**? Indicate the conditions required for these reactions to proceed.



6. (9–11) Decomposition of the nitrate of a monovalent metal (weight 250.00 g) gave 158.75 g of a solid product. What is this metal? Write down the balanced equation of metal nitrate decomposition.

7. (10–11) Compound **A** completely decomposes on heating. Decomposition of 0.05 moles of compound **A** gave a gas mixture; after condensation (complete removal from the mixture) of water vapor, the volume of the mixture was 3.36 liters (STP). When this gas mixture was passed through an excess of aqueous KOH solution, the gas volume decreased by 1/3 and the solution weight in the bottle increased by 2.2 g.

The remaining gas was burned in excess oxygen in the presence of a catalyst. The products of burning were absorbed by excess fresh aqueous KOH to give a mixture of two salts with a total weight of 9.3 g.

What is the formula of compound **A**? Write down the equations of mentioned reactions.

8. (10–11) 4 ml of a gaseous hydrocarbon and 30 ml of oxygen were mixed in a closed vessel and burned. The volume of the gas present in the vessel after the reaction (excluding water vapor) was 24 ml. When the gas was passed through a solution of sodium hydroxide, 16 ml was absorbed (the chemical reaction proceeded to completion; the volumes of water vapor and dissolved gases are neglected). All gas volumes were measured under identical conditions. What is the hydrocarbon molecular formula? Draw the possible structural formulas.

9. (11) The molecule of organic compound **A** has a symmetrical structure. The molecular weight of **A** is in the range from 300 to 350 amu. Compound **A** does not change the color of an aqueous solution of potassium permanganate and does not react with bromine in the presence of light. Upon catalytic hydrogenation, 1 mole of **A** adds 12 moles of hydrogen. Burning of 1.28 g of compound **A** in oxygen affords 2.24 liters of carbon dioxide (STP) and 0.72 g of water. What is the molecular formula and the structural formula of **A**?