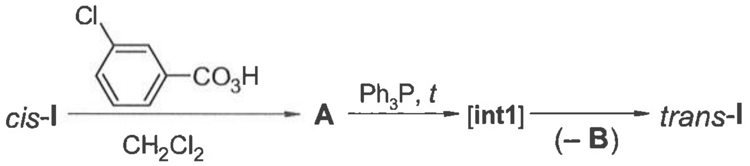
Problem I-1

Question	I-1.1	I-1.2	I-1.3	I-1.4	I-1.5	I-1.6	I-1.7
Points	1	1.5	3.5	0.5	1	2	0.5

The geometric isomerism of alkenes (π-diastereomerism) is among the key concepts of modern stereochemistry. To designate the geometric isomers, both the *cis/trans* and *Z/E* nomenclatures are used. The former is based on the relative arrangement of identical substituents with respect to the C=C bond, while the latter takes into account the positions of the groups with higher priority (according to the Cahn–Ingold–Prelog priority rules).

I-1.1 The chlorocyclodecane framework is provided in the Answer Sheet. Insert the C=C bond at the appropriate position of the framework to obtain: a) (*Z*)-1-chlorocyclodecene; b) (*E*)-1-chlorocyclodecene; c) (*Z*)-5-chlorocyclodecene; d) (*E*)-5-chlorocyclodecene.

In synthetic practice, it is important to have a procedure, which allows interconverting π-diastereomers. One such approach (***Method 1***) is given below:



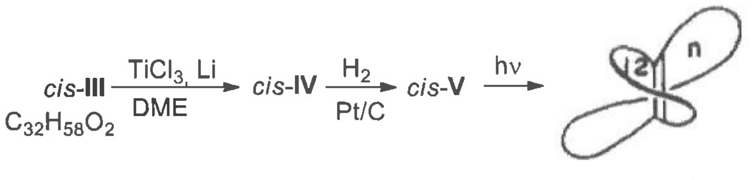
I-1.2 Draw the structures of *cis*-**I**, **A**, **B**, *trans*-**I**, and the zwitterionic intermediate [**int1**]. Starting alkene *cis*-**I** exhibits three signals with an intensity ratio of 1 : 2 : 3 in the ^{1}H NMR spectrum.

To convert one diastereomer into another, unsaturated hydrocarbons can be heated in the presence of catalytic amounts of iodine (***Method 2***). For example, if 6.48 g of *cis*-**II** (C_nH_m; n and m are even) is dissolved in xylene (boiling point 138°C), a small amount of I_2 is added, and the mixture is refluxed for several hours, then 0.0356 mol of *trans*-**II** can be isolated from the mixture upon reaching the equilibrium.

I-1.3 For the equilibrium *cis*-**II** ⇄ *trans*-**II** ($\Delta_rG = -15.5$ kJ/mol), calculate the equilibrium constant K and the mole fractions of *cis*-**II** and *trans*-**II** in the equilibrium mixture. Determine M_r(**II**) and deduce the molecular (MF) and structural (SF) formulae of the substances. Provide your calculations. Draw the structure of the radical intermediate [**int2**] that explains the catalytic action of I_2.

I-1.4 Propose ***Method 3*** for converting *cis*-**I** into *trans*-**I** in three steps, if it is known that excess KOH, alcohol, and heat is used at one of the steps. *If you failed to decipher* **I** *in question* ***I-1.2****, use any cis- and trans-isomers of hydrocarbons.*

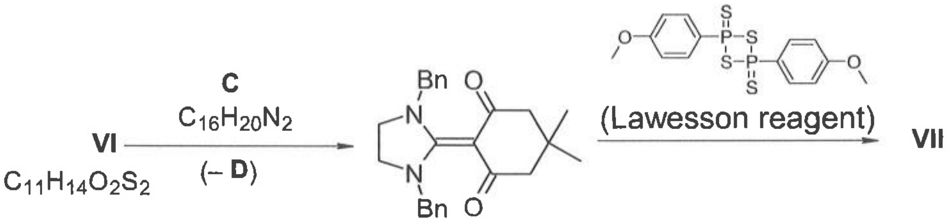
In 1977, compounds containing overlapping *trans*-substituted C=C bonds, "betweenanenes" (from the English "*between*"), were described. One of the syntheses of a betweenanene is given below. The numbers inside the molecule (12 and n in the scheme) indicate the number of carbon atoms in each ring.



trans-**V**

I-1.5 Determine *n* and draw the structures of the dialdehyde *cis*-**III** and compounds *cis*-**IV** and *cis*-**V**.

Alkenes that contain both donor and acceptor substituents can exhibit a low barrier to rotation about the C=C bond, while the bond length increases significantly. **VII** is an example of such a compound:



I-1.6 Draw the structures of **VI**, **C**, **D**, and **VII**.
I-1.7 Using structural formulae, demonstrate why the barrier to rotation about the C=C bond is relatively low in **VII** and why its length is much greater than that in ethylene.

Problem I-2

Question	I-2.1	I-2.2	I-2.3	I-2.4	I-2.5	I-2.6	I-2.7	I-2.8	I-2.9
Points	0.5	0.5	0.5	1	1	3	2	0.5	1

The beginning of organic chemistry as a science can be dated to 1828, when Friedrich Wöhler first synthesized the organic compound **A** (20.00 wt% carbon, 46.65 wt% nitrogen, and 26.64 wt% oxygen) under laboratory conditions. Remarkably, it was obtained from an inorganic substance that is an isomer of **A**. Today, **A** is a multi-ton industrial product, widely used in agriculture as the mineral fertilizer richest in nitrogen.

I-2.1 Provide the structure of **A**.
I-2.2 Provide the structure of the compound from which **A** was first synthesized.
I-2.3 **A** is currently produced on industrial scale via a two-step process. Provide the chemical equations of the reactions involved.

A exhibits basic properties and reacts with acids.

I-2.4 Arrange **A**, ammonia (NH_3), and hydrazine (N_2H_4) in the order of increasing their base strength in aqueous solution.

When **A** reacts with concentrated nitric acid, compound **B** is formed (34.14 wt% of nitrogen).

I-2.5 Determine the formula of **B**. Provide your calculations.

B decomposes upon heating: the composition of the products significantly depends on the temperature. In one study, it was found that, with heating at 450°C the components of air are not involved in the decomposition of **B**. Mass spectrometry revealed that there were 0.78 mol of NH_3, 0.49 mol of HNO_3, 0.22 mol of CO_2, and 0.69 mol of H_2O in the decomposition products of 1 mol of **B**. After passing all the decomposition products of 1 mol of **B** through a column containing solid NaOH, the residual (unabsorbed) gaseous mixture contained three binary compounds and had a mass of 36.37 g and a volume of 34.12 dm^3 (at 20.0°C and 100.0 kPa).

I-2.6 Which compounds are present in the unabsorbed gaseous residue obtained after passing the decomposition products of **B** through a column with a solid base? Calculate the volume fractions of these substances, given that, according to quantitative analysis, $w(N) = 66.26\%$ in the residue, and that it changes color upon exposure to air. Provide your calculations.

In the described experiment, substance **C** was detected in the decomposition products of **B** in addition to the listed above compounds. Under other experimental conditions (at a lower temperature), compounds **D1–D4** were detected among the decomposition products of **B**. **D1−D4** each have a more complex structure than that of **C**.

I-2.7 Determine the formula of **C** and provide the structures of its isomers. Show your calculations.
I-2.8 Which of the isomers of **C** is present in the decomposition products of **B**?
I-2.9 Provide the structural formula of at least one of the compounds **D1–D4** that are formed during the decomposition of **B** at a lower temperature.

Problem I-3

Question	I-3.1	I-3.2	I-3.3	I-3.4	I-3.5	I-3.6
Points	1	1.5	2.5	1.5	1	2.5

A highly fascinating class of organic non-heterocyclic compounds is produced by some herbaceous plants. This class includes five compounds **(X1–X5)**, which are liquids at standard temperature and pressure and serve as the five starting members of the corresponding homologous series.
To determine their composition, equimolar amounts of each of **X1**–**X5** were taken. Half of the mass of each compound was burnt in an excess of oxygen, with the combustion products (gaseous at 150°C, 1 atm) being completely absorbed by aqueous solutions of calcium hydroxide (identical in composition and mass) taken in deliberate excess, which resulted in the formation of white precipitates (***Experiment No. 1***). The other halves of compounds were subjected to a similar experiment except that the combustion products were first passed through phosphorus(V) oxide, which led to decreased volumes of supernatants (***Experiment No. 2***). The results of the experiments are presented in the table below.

Compound	Mass of precipitate, g (in both ***Experiments No. 1*** and ***No. 2***)	Difference in masses of the supernatant solutions for $\mathbf{X}_{i+1}$ and $\mathbf{X}_i$, $[m_s(\mathbf{X}_{i+1}) - m_s(\mathbf{X}_i)]$, g (in both ***Experiments No. 1*** and ***No. 2***)
X1	108.2	–
X2	126.2	8.4
X3	144.2	8.4
X4	162.2	8.4
X5	180.2	8.4

It is known that the molecules **X1–X5** do not contain any halogen atoms or oxygen.

I-3.1 Using only mathematical and chemical equations, provide a general proof that the sums of all the coefficients in the reaction equations of complete combustion of compounds **X1–X5** are five consecutive terms of an arithmetic progression.

I-3.2 The data in the table are sufficient to unambiguously determine the ratio of the number of atoms of one (and only one!) element (**E**) in the molecules of compounds **X1–X5**, as $N_\mathbf{E}(\mathbf{X1}) : N_\mathbf{E}(\mathbf{X2}) : N_\mathbf{E}(\mathbf{X3}) : N_\mathbf{E}(\mathbf{X4}) : N_\mathbf{E}(\mathbf{X5})$. Determine this ratio, showing your calculations.

Let's indulge in a bit of imagination: assume that the precipitates in each experiment represent individual compounds and that **X1–X5** are not homologs; moreover, disregard the specific mass difference value given in the table (8.4 g). All other information provided above must be taken into account!

I-3.3 Draw the hypothetical structures of **X1–X5**, using the ratio obtained in your answer to the previous question.

In reality, the precipitates obtained in the experiment are mixtures.

I-3.4 Determine the molar ratio of the components of the precipitate in ***Experiment No. 1*** for **X1**. Show your calculations.

It is known that in the molecule of at least one of the compounds **X1–X5** the sum of the numbers of atoms of two certain elements equals 12, and in at least one of other compounds, the sum of the numbers of atoms of two certain elements equals 16. The pairs of elements need not be identical.

I-3.5 Determine the molecular formulae of **X1–X5**.

I-3.6 Propose all possible finally determined structural formulae for **X1–X5**, if, according to NMR spectroscopy data, each of the five compounds contains three types of hydrogen atoms and three types of carbon atoms.

Problem I-4

Question	I-4.1	I-4.2	I-4.3	I-4.4	I-4.5	I-4.6	I-4.7
Points	1	2.25	1.25	1	1	3	0.5

Binary explosive compound **X** consists of atoms of elements **A** and **B** from the same group of the periodic table. **X** contains 8.77 wt% of **A**. The synthesis of **X** is shown in the scheme below.

$$N_2F_2 + SbF_5 \longrightarrow \mathbf{P} \xrightarrow[-HF]{HN_3} \mathbf{Q} \xrightarrow[-\mathbf{S}]{\mathbf{R}} \mathbf{X}$$

$$PCl_5 + NaN_3 \longrightarrow \mathbf{R} + NaCl$$

I-4.1 Determine elements **A** and **B**. Show your calculations.

I-4.2 a) Write the equations of the reactions in the scheme. b) Write the formulae of **P**–**S** and **X** reflecting their structure (spatial structure is not required).

The oxygen balance Ω of an explosive compound is the mass of oxygen involved in the reaction of its complete combustion, relative to the mass of an explosive compound. If combustion of the compound requires oxygen, the value of Ω is considered negative; if decomposition of the compound leads to the evolution of oxygen, $\Omega > 0$. Specific (relative to the compound mass) heat evolved during the explosion is directly proportional to the oxygen balance of the explosive compound.

I-4.3 Calculate Ω (%) for a) trinitroglycerin, b) tetryl (*N*-methyl-*N*,2,4,6-tetranitroaniline), and c) compound **X**.

I-4.4 Specific heat of explosion *Q* of trinitroglycerin and tetryl equals 6228 and 4340 kJ/kg, respectively. Calculate specific heat of explosion of **X** (kJ/kg).

I-4.5 Calculate the enthalpy of formation of **X** (kJ/mol). The enthalpies of formation of the combustion products of elementary substances of **A** and **B** are −746 and 0 kJ/mol (per 1 mol of atoms of **A** and **B**), respectively. *If you failed to determine either the composition of* **X** *and/or its heat of explosion, use* A_2B_3 *as the formula and* $Q = 5000$ *kJ/kg.*

I-4.6 Using the data provided in the problem, estimate the minimum pressure (Pa) developed in a 10-L closed vessel containing oxygen (pressure 10^5 Pa), 100 g of ice, and 35 g of **X** at temperature −10°C, upon explosion of **X**. Consider the heat capacities of ice (2.0 J/(g·K)), liquid water (4.2 J/(g·K)), and gaseous compounds (12.5 J/(mol·K)) independent of temperature; the heat of melting for ice is 332 J/g; the heat of evaporation for water is 2256 J/g. The volume of any condensed phase and heat capacity of condensed products of explosion of **X** can be neglected.

I-4.7 Write the equation of a chemical reaction occurring in the system described in **I-4.6**. Accounting for this reaction would improve the estimate of the developed pressure.

Problem I-5

Question	I-5.1	I-5.2	I-5.3	I-5.4	I-5.5	I-5.6
Points	2	1	4	1	1.5	0.5

Inorganic salts **A**, **B**, **C**, and **D** are white substances. **A** and **B** are formed from diprotic acid $H_2\mathbf{X}$, while **C** and **D** are formed from diprotic acid $H_2\mathbf{Y}$. The following experiments were carried out to determine the composition of the salts and the acidity constants of the acids:

1) All the salts give a yellow color in the flame test.
2) **A** reacts with both **C** and **D**. In both cases a colorless and odorless gas is released.
3) Barium chloride solution reacts with both **A** and **B**, forming a white precipitate in both cases.
4) Calcium chloride solution does not react with **C**, but reacts with **D**, forming a white precipitate.
5) The pH values of 0.100 M solutions of the salts are:

Solution	**A**	**B**	**C**	**D**
pH	1.57	7.52	8.34	11.65

6) When the solutions are diluted by the factor of 10, only the pH of the solution of **C** remains nearly unchanged.

I-5.1 Write the formulae of the salts **A**–**D**.
I-5.2 Write the equations of the five reactions mentioned above.
I-5.3 Determine the acidity constants $pK_{a,1}(H_2\mathbf{X})$, $pK_{a,2}(H_2\mathbf{X})$, $pK_{a,1}(H_2\mathbf{Y})$ and $pK_{a,2}(H_2\mathbf{Y})$. *If any of the acidity constants cannot be reliably determined from the given data, place a dash (–) in the corresponding box in the Answer Sheet.*
I-5.4 Calculate the pH of a 0.100 M solution of the diprotic acid $H_2\mathbf{Z}$ with the acidity constants $pK_{a,1}(H_2\mathbf{Z}) = -3.0$ and $pK_{a,2}(H_2\mathbf{Z}) = 1.0$.

An acid **E** is monoprotic ($pK_a = 3.17$), but can also form salts with a hydrogen-containing anion. When 120 mg of **E** reacts with 68 mg of NH_3 ($pK_b = 4.79$), an equimolar mixture of salts **F** and **G** is formed. **G** contains 8.83% hydrogen by mass.

I-5.5 Determine the composition of the acid **E** and the salts **F** and **G** and write their formulae.
I-5.6 Calculate the pH of the solution obtained by mixing equal volumes of 0.100 M solutions of **E** and NH_3.

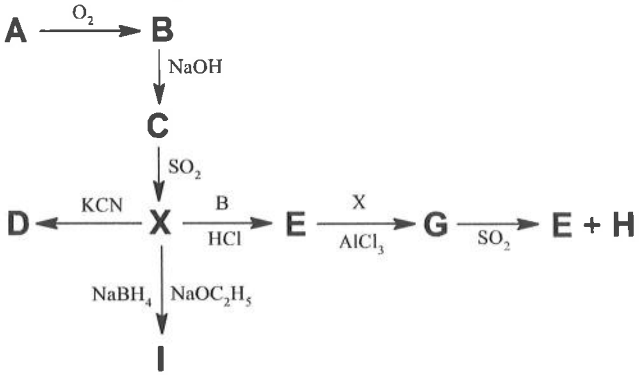
Problem I-6

Question	I-6.1	I-6.2	I-6.3	I-6.4	I-6.5	I-6.6
Points	2.5	2.5	1	1	2.25	0.75

After her adventures in Wonderland and Through the Looking-Glass, Alice became fascinated with chemistry and even took part in the Looking-Glass Mendeleev Olympiad. The Olympiad in Looking-Glass-land is organized somewhat differently from the one in which you participate. At the second exam, each problem should include questions from as many branches of chemistry as possible, but each problem is devoted to a single element. In the Looking-Glass Olympiad, the participants compose the problems while the Jury members solve them. We invite you to try your hand as a Jury member of the Looking-Glass Olympiad by solving the problem composed by Alice about element **X**.

Inorganic Chemistry

The elementary compound composed of **X** is obtained from the waste of copper production: compound **A** is subjected to calcination, during which substance **B** is formed. By reaction of **B** with alkali, substance **C** is obtained. Pure **X** is produced by the reduction of **C** with SO_2. A feature of **X** is its tendency to form **X**–**X** bonds, for example, in compounds **E** and **I**, as well as in cyclic polycations, such as in **G** and **H**. The ionic compound **G** is obtained in liquid SO_2 from a mixture of **E** and **X** taken in a molar ratio of 1 : 6, in the presence of $AlCl_3$. When **G** is washed with a large amount of SO_2, it disproportionates into **E** and **H**; **E** and **H** are formed in a molar ratio of 1 : 3. The synthesis of these compounds, as well as the mass composition of some of them, are shown in the scheme below.

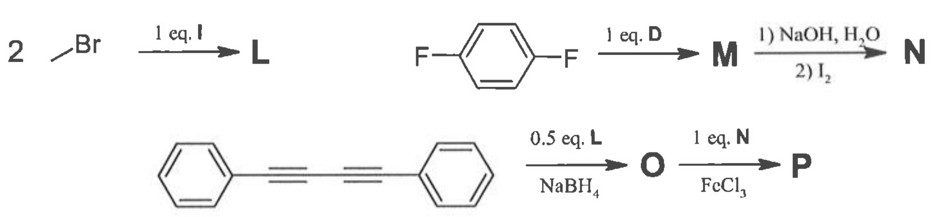


A: $w_{Cu} = 22.91\%$; $w_X = 56.95\%$;
D: $w_K = 27.14\%$; $w_X = 54.81\%$;
$w_C = 8.34\%$; $w_N = 9.72\%$;
E: $w_X = 69.02\%$; $w_{Cl} = 30.98\%$;
I: $w_{Na} = 22.55\%$; $w_X = 77.45\%$.

I-6.1 Using calculations, determine the element **X** and the compounds **A–E**, **G–I**.

Organic Chemistry

Heterocyclic aromatic compounds containing **X** have found several applications: synthesis of pharmaceuticals, materials for organic transistors, light-emitting diodes, and solar batteries. The scheme below displays the synthesis of the antidepressant **P**, which contains two atoms of **X**. One of the **X** atoms is part of an aromatic ring, while the other connects two aromatic rings together. In addition, it is known that compound **P** does not contain any aliphatic carbon atoms.



I-6.2 Draw the structures of **L–P**, given that compound **N** contains two atoms of **X**.

Physical Chemistry

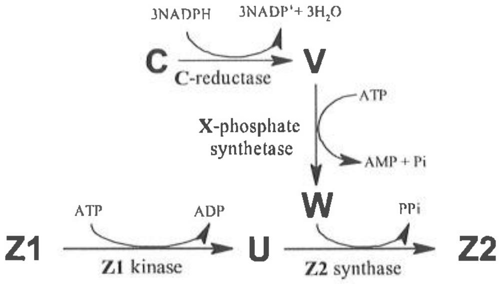
A series of molecules **Y(*N*)**, whose structure contains *N* fused aromatic heterocycles containing **X**, possess interesting electronic properties leading to their use as organic diodes or transistors. Increasing the number of cycles *N*, as well as introducing various substituents, makes it possible to vary the properties of these molecules.

To describe the π-electrons of molecules **Y(*N*)**, one can use the "particle on an ellipse" model. In this case the electron density of **Y(1)** is a circle with radius r_1, and the electron densities of all other **Y(*N*)** are ellipses with semiaxes r_1 and r_N.

I-6.3 It is known that the energy of the transition to the first excited state in molecule **Y(1)** is 4.989 eV, and that in molecule **Y(2)** is 4.106 eV. Calculate r_1 and r_2.
I-6.4 Assuming that r_N depends linearly on N, estimate for which values of N the transition to the first excited state corresponds to absorption of visible light (380–780 nm).

Note:
Energy of a particle on an ellipse: $E_n = \frac{h^2 n^2}{2m_e S^2}$, where $n = 0, \pm1, \pm2, \ldots$, is the number of the energy level, h is Planck's constant, m_e is the electron mass, and S is related to the semiaxes a and b of the ellipse as $S = 2\pi\sqrt{\frac{a^2+b^2}{2}}$.

Biochemistry
The α-amino acids **Z2** and **Z3** containing the element **X** can be incorporated into proteins in the process of translation on ribosomes (programmed or erroneous). The difference in the mass fractions of **X** in **Z2** and **Z3** is 6.72%. The scheme of the biosynthesis of **Z2** from the proteinogenic amino acid **Z1** and the inorganic salt **C** is given below.



I-6.5 Draw the possible structures of **Z1–Z3**.
I-6.6 Draw the structures of **U–W**.

Note:
A list of proteinogenic amino acids is provided in the reference information section.
NADP$^+$ and NADPH are, respectively, the oxidized and reduced forms of nicotinamide adenine dinucleotide phosphate; AMP, ADP, and ATP are adenosine mono-, di-, and triphosphate, respectively; Pi and PPi are inorganic phosphate and pyrophosphate, respectively.

Problem I-7

Question	I-7.1	I-7.2	I-7.3	I-7.4	I-7.5	I-7.6
Points	1	2	2	2	1.5	1.5

Polymer **A** was accidentally discovered in 1938 by chemists working on a project for the DuPont company. They found that gas **B**, pumped into a pressurized cylinder, kept escaping from the cylinder until instrumental control showed the cylinder to be empty; however, the weight of this "empty" cylinder turned out to be greater than that of a standard empty cylinder. The cylinder was cut open, and a slippery, wax-like material **A** was found inside. In 1954, the French engineer Marc Gregoire developed aluminum cookware coated with polymer **A**, which became so widely used that such cookware can now be seen in nearly every kitchen in every country worldwide. Polymer **A** found applications in various branches of human activity.

I-7.1 Draw the structure of **B** and the formula of the monomeric unit of polymer **A.**

Industrial production of **A** from **B** requires the use of special apparatuses to prevent the local overheating of the mixture, as this may lead to the explosive decomposition of **B** with the formation of binary gas **C** and elementary substance **D**. In industry, **B** is obtained by the reaction of chloroform with gas **E**, which forms product **F**, followed by **F** thermolysis. Along with **F**, compound **G** is formed in these conditions. Thermolysis of **G** leads to the elimination of **E** and formation of **B**. Gases **C** and **G** are used as refrigerants and in the production of electronics; they do not affect the ozone layer but are classified as greenhouse gases. **C** has extremely low solubility in water but is soluble in benzene and chloroform, while **G** is soluble in both water (1 g/L) and organic solvents.

I-7.2 Draw the structures of **C** and **E–G**.

G can be applied in organic synthesis. The first approach is based on its deprotonation in the presence of an electrophile. For example, the compound **H** is formed (after neutralization) in the presence of benzophenone, and the compound **I** is formed in the presence of trimethylchlorosilane. Organolithium or organomagnesium derivatives formed upon deprotonation of **G** are extremely unstable even at −80°C and readily convert into the unstable intermediate **J**, which reacts readily with various compounds. For example, it forms product **K** in the reaction with 1-butene, whereas in the absence of any reaction partners it converts into **B**.

I-7.3 Draw the structures of **H–K**.

The intermediate **J** may exist in two forms that have different electronic properties and different geometries.

I-7.4 Draw the structures of each form of **J**. For each form, choose the approximate value for the bond angle. Circle the more stable form.

I is actively used in organic synthesis. In the presence of tetrabutylammonium fluoride, **I** reacts with benzaldehyde to form product **L**. Upon treatment with dilute acid, **L** is converted into compound **M**. **M** can also be obtained in another way: methyl benzoate, **I**, and Bu_4NF with subsequent addition of dilute acid give product **N**; treatment of **N** with sodium borohydride gives **M**.

I-7.5 Draw the structures of **L–N**.

On the other hand, the treatment of **G** with potassium *tert*-butoxide in the presence of silver(I) acetate generated compound **O**. The reaction of **O** with 4-bromobenzonitrile afforded product **P**. However, the structure of **O** could not be determined. Very recently, a paper was published in *Organic Letters*, in which silver(I) trifluoromethanesulfonate was treated with two equivalents of potassium *tert*-butoxide; an excess of gas **G** was passed through the solution, followed by the addition of tetrabutylammonium bromide (1 eq.). The authors showed that that the resulting salt **Q** contained 22.09 wt% silver. **P** is also formed when **Q** reacts with 4-cyanophenyldiazonium tetrafluoroborate. In contrast, it was previously found that when **G** is heated under pressure with sodium *tert*-butylate in *tert*-butanol, it is converted into product **R**, containing 67.20 wt% carbon. **R** shows two signals in the ^{1}H NMR spectrum and three signals in the ^{13}C NMR spectrum.

I-7.6 Draw the structures of **P–R**.

Problem I-8

Question	I-8.1	I-8.2	I-8.3	I-8.4	I-8.5
Points	0.75	5.5	0.75	2	1

Like dissolves like
Chemical wisdom

A toxic binary compound **X**, which exhibits pronounced corrosive properties, is predominantly found in the hydrosphere. Therefore, the sanitary authorities of many countries have set indirect standards for the content of **X** in drinking water. Notably, compounds **Y** and **Z**, which are similar to **X** in chemical properties and have the same elemental composition, show diametrically opposite abundances in nature and toxicity: the poisonous **Y** is found in vanishingly small amounts, whereas the relatively safe **Z** is widespread. However, cases of human fatalities associated with the intake of certain quantities of **Z** are well-documented.
A single ingestion of a small amount of **X** may be practically harmless because its half-life in the human body is about 10 days.

I-8.1 Calculate the number of days t after a single ingestion of **X** when the amount of this compound in the body would decrease down to 10% of the initial dose. Assume that we are dealing with first-order pharmacokinetics.

X can be involved in various biochemical processes. For example, *in vitro* it enzymatically reacts with compound **A** to form three products **B1**, **B2**, and **B3**, gaseous at standard temperature and pressure. The ratio of densities of these gases is 2.59 : 1.12 : 1.00, respectively. The reaction is

$$\mathbf{A} + \mathbf{X} \rightarrow \mathbf{B1} + \mathbf{B2} + \mathbf{B3}$$

The molar masses of **B3**, **Z**, **B2**, and **X**, when rounded to whole numbers, form consecutive terms of an arithmetic progression.

I-8.2 Determine all the unknown substances described above. Where necessary, propose all possible variants of the formulae for the substances. Give your calculations.

I-8.3 Based on its physicochemical properties, estimate the solubility of **X** in water at 25°C. Write the number of the appropriate variant in the Answer Sheet.

No.	solubility	No.	solubility
1	less than 0.01 g in 100 g of water	3	1 g to 50 g in 100 g of water
2	0.01 g to 1 g in 100 g of water	4	unlimited

There are also other reactions in which an equimolar mixture of gaseous products is formed, with the same density ratio, as in the reaction of **A** + **X**.

I-8.4 Propose one reaction equation for each of the following two cases: a) both reactants are different from **A** and **X**; b) one of the reactants is either **A** or **X**.

I-8.5 Write the reaction equation that initiates (i.e., develops without the involvement of the metal) the corrosion process of aluminum container in which **X** is stored at room temperature.