

Questions 1-3 should be solved together.

A 4.31 g sample of a white powder of a highly water-soluble salt **X** was heated to 160°C. Complete decomposition resulted in the formation of a white, heavy powder **Y**, insoluble in water and acids, and the release of a pungent-smelling gas **Z**, which discolored an acidified solution of potassium permanganate.

This gas was quantitatively absorbed by 650.00 mL of a solution containing 0.64 g of NaOH. The pH of the resulting solution was 6.16. No other products were formed during the decomposition of **X**. For the acid formed when **Z** dissolves in water, $pK_{a2} = 7.10$.

1. Write the chemical formula of the salt **X**.
2. Write the chemical formula of powder **Y**.
3. Write the chemical formula of the gas **Z**.

Questions 4-5 should be solved together.

In the weathering zone of primary minerals, rhombic crystals of **A** and hexagonal crystals of **B** can be found. Both minerals are completely soluble in nitric acid and potassium hydroxide solutions. The properties of these minerals are listed in the table.

Mineral	Color	Density, g/cm ³	Δm, % upon dissolution		Thermal decomposition in air		
			HNO ₃	KOH	T, °C	Δm, %	Color
A	White/grey	6.35	16.5	0	400	16.5	dark red
					480 long	14.1	orange red
					600	16.5	yellow
B	White/grey	6.80	11.3	0	400	13.7	dark red
					480 long	11.6	orange red
					600	13.7	yellow

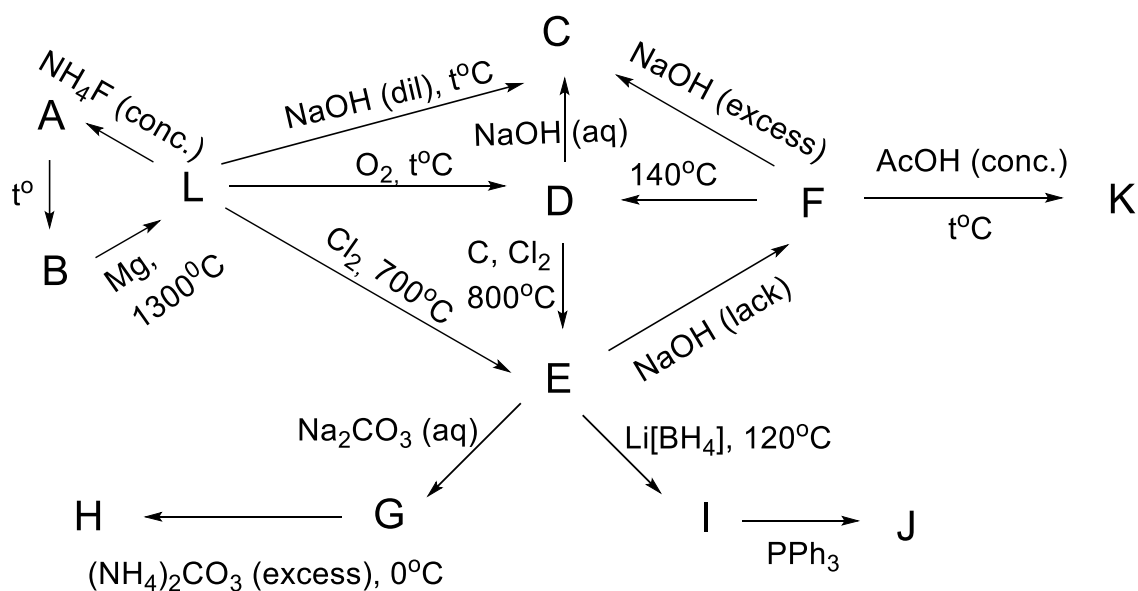
4. Write the chemical formula of the mineral **A**.

5. Write the chemical formula of the mineral **B**.

Questions 6-11 should be solved together.

Metal **L**, formed by element **X**, was first obtained in pure form by the German chemist Friedrich Wöhler in 1828. It is one of the lightest metals, having one of the highest melting points among them. This metal is used as an alloying additive to various alloys, in rocket engineering, and it is also used in nuclear energy.

Below is a diagram of the transformations of compounds containing element **X** in their composition:



- when compound **F** is calcinated at 140 °C (reaction **F** → **D**), the mass loss is 41.86% of the mass of the initial sample;
- compound **G** is a basic salt;
- 1.55 g of compound **I** is formed at 120 °C as a result of the interaction of 3.25 g of substance **E** and 1.77 g of $\text{Li}[\text{BH}_4]$ in a sealed tube;
- compound **J** is a binary amorphous white substance that quickly decomposes in acids with the release of hydrogen;
- the molar mass of compound **A** is 11 times greater than the molar mass of substance **J**;
- when substance **F** is boiled with CH_3COOH , complex **K** is formed, containing 8.87% of element **X** by mass

6. Write the chemical symbol of the element **X**.
7. Write the chemical formula of the compound **A**.
8. Write the chemical formula of the compound **C**.
9. Write the chemical formula of the compound **H**.
10. Write the chemical formula of the compound **I**.
11. Write the chemical formula of the compound **K**.

Questions 12-14 should be solved together.

79 g of iodine were dissolved in 100 g of a 25% sodium hydroxide solution. 60 g of a 20% barium chloride solution was added to the resulting colorless mixture. The white precipitate **A**, formed upon addition, was filtered and dried. Its mass was found to be 26 g.

Product **A** was calcined to a constant weight at 400 °C, resulting in a mass loss of 55.2%. Cooling the gaseous decomposition products yielded 10.5 g of a dark powder **B**.

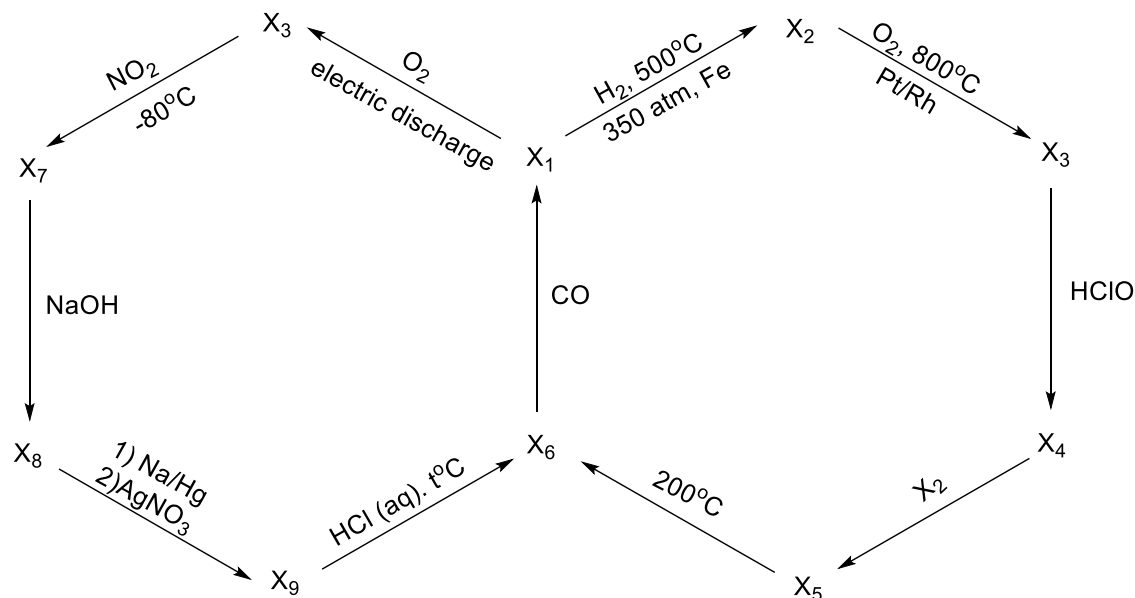
A 1.000 g sample of the decomposition residue **C** was dissolved in 25 g of 20% potassium iodide solution, acidified with hydrochloric acid. The resulting solution was brought to 100.0 ml. Complete decolorization of a 10 ml aliquot required 14.1 ml of 0.1 M sodium thiosulfate solution.

12. Write the chemical formula of the precipitate **A**.
13. Write the chemical formula of powder **B**.
14. Write the chemical formula of the solid decomposition residue **C**.

Questions 15-18 should be solved together.

In the diagram below, substances **A₁-A₇** contain element **Y**, **B₁-B₆** – element **X**. **C₁** and **C₂** are isomers, containing both **X** and **Y**.

- Substances **A** and **B** share a common structural fragment and are used as anti-dandruff agents. The antiseptic properties of **B** were known in ancient times.
- Powder **A** is composed of 45% **X** and 55% **Y**.
- Acid **B₂** is a product of large-scale production, the key step of which is the oxidation of gas **B₁** to **B₄**. Strong diprotic acid **A₄** dissolves gold.



19. Write the chemical formula of the compound X_5 .
20. Write the chemical formula of the compound X_7 .
21. Write the chemical formula of the compound X_9 .

Questions 22-24 should be solved together.

A wide range of binary chemical compounds can be obtained by combining solutions of simple substances in the same solvent. These compounds can crystallize from the solution upon standing or be isolated by evaporating the solvent. Another synthesis route is the fusion of simple substances, but this often results in mixtures. The composition and some properties of the compounds created upon heating the mixture of X and Y are presented in the table.

Compound	$\omega_x, \%$	Number of X-X bonds	Number of X-Y bonds	Color	Solubility in CS_2 , g/100g solvent
A_1	79.43	5	2		
A_2	65.88	4	4		
A_3	56.29	3	6	greenish yellow	100
A_4	49.13	2	8	yellow	
A_5	43.59	2	9	dark yellow	0.5
A_6	35.56	1	12	orange yellow	0.029
A_7	27.87	0	16	yellow	0.222

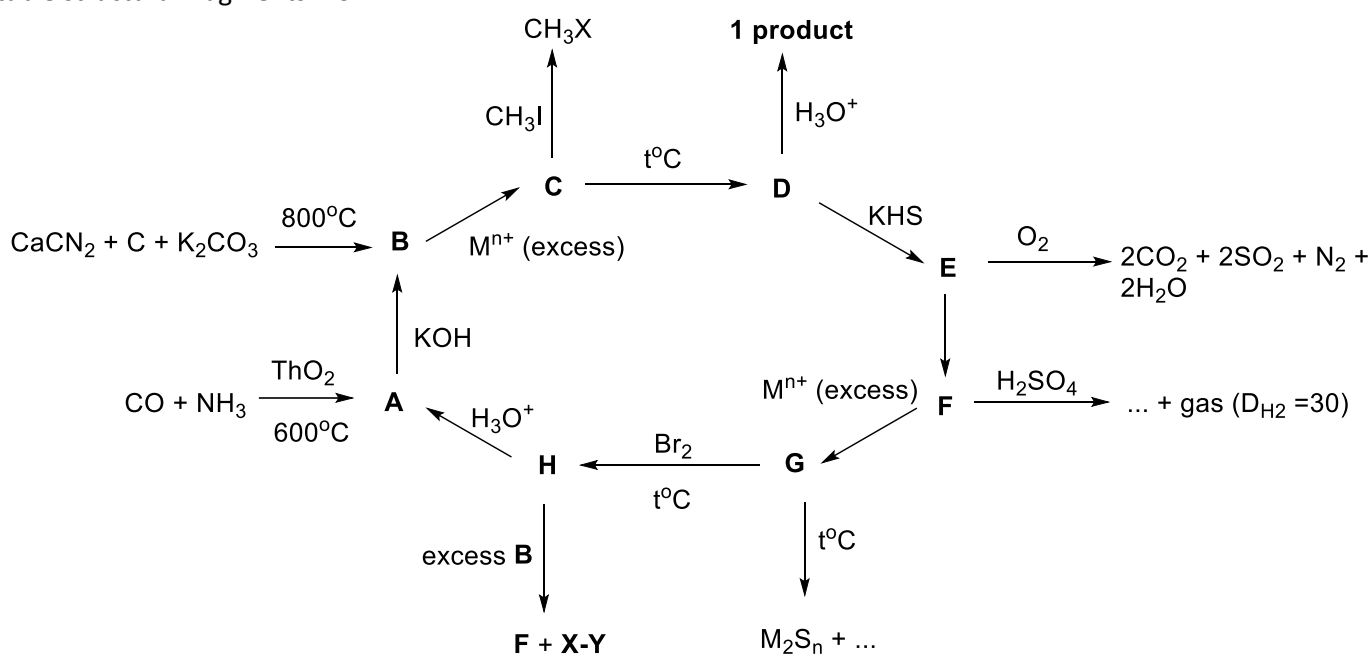
22. Write the chemical formula of the compound A_6 .

23. How many structural isomers are possible for **A**₁ (number of bonds of the same type might be different)?

24. How many structural isomers are possible for **A**₃ (assuming the same number of bonds of the same type)?

Questions 25-27 should be solved together.

The diagram below shows the transformations of substances **A-H**; substances **A-D** and **F-H** contain stable structural fragments **X** or **Y**.



25. Write the chemical formula of the compound **D**.

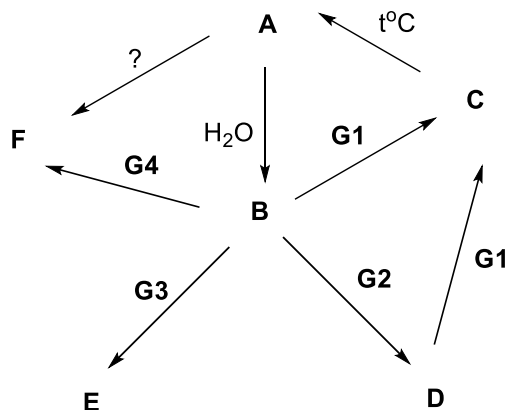
26. Write the chemical formula of the compound **F**.

27. Write the chemical formula of the compound **H**.

Questions 28-30 should be solved together.

Substance **A**, the main component of a common building material, reacts vigorously with water to form a solution of substance **B**. This solution reacts with four gases under various conditions. The reaction with gas **G**₁ results in the formation of precipitate **C**, which is used in industry to obtain substance **A**. The reaction with gas **G**₂, after careful evaporation, yields substance **D**, which has disinfectant properties. The reaction with gas **G**₃ (above 45°C) is very vigorous, forming substance **E**, which has found

application as a craft, construction, and finishing material; it is used in the pulp and paper industry, and in the chemical industry for producing paints. The reaction with gas **G4** at 5 atm and 120°C results in the formation of substance **A**, which is used as a preservative in the food industry. Substance **A** can be obtained in the reaction of **A** with the secretion product of certain insects or plants.



28. Write the chemical formula of the gas **G2**.
29. Write the chemical formula of the compound **E**.
30. Write the chemical formula of the compound **F**.