## Part I

1. Which chemical process does the following diagram correspond to?



- A. Melting of ice.
- B. Combustion of natural gas.
- C. Evaporation of water.
- D. Dissolving of ammonium chloride in water.
- 2. In which group can all oxides react with potassium hydroxide solution?
- A. Li<sub>2</sub>O, CO<sub>2</sub>, CO
- B. Na<sub>2</sub>O, FeO, Ag<sub>2</sub>O
- C. CO, NO, N<sub>2</sub>O
- D. ZnO, N<sub>2</sub>O<sub>5</sub>, SO<sub>3</sub>
- 3. Which of the following simple substances, when reacted with an acid, will form hydrogen gas as a product:

#### A. calcium and magnesium

- B. gold and platinum
- C. neon and argon
- D. silver and copper
- 4. Arrange the formulae of the following compounds according to the number of electrons exchanged during the formation of ionic bonds, considering one formula unit:

I. NiO II.  $MnS_2$  III. NaCl IV. FeCl<sub>3</sub> V. CrO<sub>3</sub>

A. II < IV < I < V < IIIB. I < III < IV < II < VC. V > II > IV > I > IIID. V > IV > II > III > I

- 5. The sum of the valences of magnesium, iron, lead, and aluminum in their oxides is 11. How many oxygen atoms, altogether, will be in a set containing one formula unit of each oxide?
- <mark>A. 7</mark> B. 8
- C. 9
- D. 10
- 6. If the equation is balanced with the smallest possible integer stoichiometric coefficients, the sum of all coefficients is:

 $PCl_5 + H_2O \rightarrow H_3PO_4 + HCl$ A. 9
B. 10
C. 11
D. 12

7. A chemist has three test tubes in a test-tube rack containing: dilute HCl 1 : 10, dilute  $H_2SO_4$  1 : 1 and deionized water, but he forgot to label the tubes. He added a small piece of magnesium to each of the tubes. Based on the results shown in the figure, determine which liquid is in each of the tubes.



A. $X - HCl$ , $Y - H_2SO_4$ , $Z - water$
B. $X - water$ , $Y - H_2SO_4$ , $Z - HCl$
<mark>C. X – water, Y – HCl, Z - H<sub>2</sub>SO</mark> 4
D. $X - H_2SO_4$ , $Y - HCl$ , $Z - water$

**Тест за IX категорија**, Државен натпревар по хемија, 17 мај 2025



2. The following products are formed in the reaction between sodium carbonate and nitric acid:

- A. NaNO<sub>2</sub>, H<sub>2</sub>O and CO<sub>2</sub>
- B. Na, H<sub>2</sub>CO<sub>3</sub> and NO<sub>2</sub>
- C. NaNO<sub>3</sub>, H<sub>2</sub>O and CO<sub>2</sub>
- D. NaNO<sub>3</sub>,  $H_2$  and  $CO_2$
- 9. Chromium is a metal that is less reactive than zinc, but more reactive than iron. Using this information, encircle the equation that represents a reaction that cannot occur.
- A.  $3Pb + Cr_2O_3 \rightarrow 3PbO + 2Cr$
- B.  $3Zn + Fe_2O_3 \rightarrow 3ZnO + 2Fe$
- $C. \ 3Ca + Cr_2O_3 \rightarrow 3CaO + 2Cr$
- D.  $2Cr + Fe_2O_3 \rightarrow Cr_2O_3 + 2Fe$

10. X is a red-brown liquid that evaporates quickly at room temperature. The liquid is made up of an element from the fourth period, whose atoms have 7 electrons in the last electron shell. Encircle the correct statement about liquid X..

A. Liquid X is a good conductor of electric current.

B. Liquid X acts as an insulator.

C. Liquid X is iodine.

D. Liquid X is a salt solution.



# Part II

1. Represent the following descriptions of chemical reactions via chemical equations, and then balance the equations. Write down what visible change can be observed..

A. A piece of magnesium is added to a beaker of hydrochloric acid.

 $Mg + 2HCl \rightarrow MgCl_2 + H_2$ 

change: release of bubbles

B. A few drops of vinegar are added to baking soda.

 $NaHCO_3 + CH_3COOH \rightarrow CH_3COONa + CO_2 + H_2O$ 

change: release of bubbles

C. An iron nail is immersed in a solution of copper(II) sulfate..

 $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$ 

change: the iron turns brown, and the solution gradually loses its blue color

Correct equation is worth 1 point, correct change is worth 0.5 points (total 4.5 p.)

2. Jovana performed several chemical experiments: dissolving NaOH in water, dissolving  $NH_4NO_3$  in water, oxidation of methane and oxidation of propane. Using a thermometer, she measured the temperature at a precisely determined time and recorded the results in the table below. In doing so, she had equal amounts of all substances. In the appropriate place in the table, answer the following questions:

A. If the process releases heat to the surroundings, write YES, otherwise write NO (column A).

B. In column B, write what each process is called according to the temperature/energy change.

	Time	0	60	120	180	210	Α	В	С
	/s								
NaOH in H <sub>2</sub> O	<i>T/</i> °C	20	26	32	35	35	<b>YES</b>	exothermic	I
NH <sub>4</sub> NO <sub>3</sub> in H <sub>2</sub> O	<i>T/</i> °C	32	24	20	18	15	<mark>NO</mark>	endothermic	II
$CH_4 + O_2$	<i>T/</i> °C	126	537	1326	1700	1700	<b>YES</b>	exothermic	I
$C_{3}H_{8} + O_{2}$	<i>T/</i> °C	470	743	1066	1940	2580	YES	exothermic	I

 $12 \ge 0.5 = 6 p.$ 

C. In column C, write the number (I or II) on the energy diagram that corresponds to each process, respectively.





D. Which process can be used in cold compresses for athletes? Why?

The dissolution of NH<sub>4</sub>NO<sub>3</sub> in H<sub>2</sub>O due to it receiving heat from the surroundings.

1 p

E. Which substance is best to use as fuel? Why? It is best to use propane, because the temperature change is the greatest for the same period of time. 1 p

(total 8 p.)

3. A chemist has pieces of 3 different metals: X, Y, and Z, as well as test tubes with deionized water, HCl solution, and CuSO<sub>4</sub> solution. When the metals are added to each of the test tubes (at room temperature), the following is observed:

Metal	Deionized water	Solution of HCl	Solution of CuSO <sub>4</sub>
Х	no change	slow release of bubbles	discoloration of the
			solution
Y	the piece of metal moves	rapid bubble release	discoloration of the
	across the surface of the		solution
	liquid, bubbles are released		
Ζ	no change	moderately rapid	discoloration of the
		bubble release	solution

A. The chemist suspects that the metals may be: Zn, Au, Cu, Pb, Na and Mg. Identify the metals.



## 3 x 0.5 = 1.5 points

B. Write and balance the chemical reaction equations (where you think a reaction is occurring, and where you think a chemical reaction is not occurring, write **no reaction**).

 $X + HCl: Pb + 2HCl = PbCl_2 + H_2$   $X + CuSO_4: Pb + CuSO_4 = PbSO_4 + Cu$   $Y + H_2O: 2Na + 2H_2O = 2NaOH + H_2$ 

- $Y + CuSO_4: \frac{2Na + CuSO_4 = Na_2SO_4 + Cu}{2Na + CuSO_4 = Na_2SO_4 + Cu}$
- Z + H<sub>2</sub>O: no reaction
- $Z + HCl: \frac{Zn + 2HCl}{Zn + 2HCl} = \frac{ZnCl_2 + H_2}{2}$

 $6 \ge 1 = 6$  points

(Total 7.5 points)



### **III Imaginary experiment**

A chemist who lives near a factory that emits thick smoke every day wanted to investigate whether the smoke has a negative impact on the environment. After a quick search on the internet, he learned that many factories use fuel that contains nitrogen or sulfur. The next day it rained, so the chemist collected about 300 mL of rainwater and divided it into several beakers to perform various analyses.

A. He added a few drops of litmus indicator to the first glass. The solution turned red. What can he conclude from this result? What types of compounds are present in rainwater?

It can be concluded that the environment is acidic, which means that acid(s) are present in the water.

 $2 \ge 0.5 = 1 p$ 

B. Through further research, he learned that compounds in which the valence of nitrogen is five and the valence of sulfur is six may be present in the water. Write the chemical formulas and names of these compounds.

H2SO4 (sulfuric acid) и HNO3 (nitric acid)

1 point for each formula= 2 p. 0.5 points for each name = 1 p, total 3 p.

C. To determine what substance was present in the rainwater, he added a few drops of barium nitrate solution to the sample in a new beaker. He noticed that a white precipitate formed. According to this test, what substance was in question?

 $H_2SO_4$ 

1 p

D. Write and balance the chemical equation for the reaction in C.

 $\underline{\text{Ba}(\text{NO}_3)_2 + \text{H}_2\text{SO}_4 \rightarrow \text{Ba}\text{SO}_4 + 2\text{HNO}_3}$ 

1 p, if not balanced 0.5 p.

E. Using chemical equations, represent the transformations of the element from the fuel used by the factory to the compound detected in the rainwater. Finally, balance the chemical equations.

Help: The smoke released from the factory in the clouds comes into contact with water in the form of water vapor.

 $S + O_2 = SO_2$   $2SO_2 + O_2 = 2SO_3$   $SO_3 + H_2O = H_2SO_4$ (Also accepted 2S + 3O\_2 = 2SO\_3)  $SO_3 + H_2O = H_2SO_4$ )

1 point for each equation = total 3 p.

F. What procedure can be used to determine/measure the exact amount of pollutant in rainwater?

<u>Titration</u>

1 p