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PRACTICE

IN PRE-UNIVERSITY CHEMISTRY

МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ

БЕЛОРУССКИЙ ГОСУДАРСТВЕННЫЙ МЕДИЦИНСКИЙ УНИВЕРСИТЕТ

КАФЕДРА ОБЩЕЙ ХИМИИ

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ПРАКТИКУМ ПО ДОУНИВЕРСИТЕТСКОМУ КУРСУ ХИМИИ

PRACTICE IN PRE-UNIVERSITY CHEMISTRY

Минск БГМУ 2016

Рекомендовано Научно-методическим советом университета в качестве
практикума 21.09.2016 г., протокол № 2

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Учебное издание

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ПРАКТИКУМ ПО ДОУНИВЕРСИТЕТСКОМУ КУРСУ ХИМИИ

PRACTICE IN PRE-UNIVERSITY CHEMISTRY

На английском языке

PREFACE

This book contains exercises for classwork and homework on 51 lessons from the course of pre-university chemistry. Multiple choice questions may have from 1 to 3 correct answers. The answers to multiple choice questions and the ways to solve problems and chains of chemical reactions can be found: 1) in the text of the book written by the same authors («Pre-University Chemistry»); 2) in any other relevant source of knowledge; 3) most answers are hidden in other questions from this book. Finally, all those questions must be answered during corresponding lessons. The main purpose of this book is to make foreign attendees familiar with the style of questions from the entrance exam. The authors are looking forward to receive any feedback regarding this book from both attendees and colleagues.

Please, be aware that some chemical terms have different meanings in English and Russian. For example, «chemical element» is defined in the IUPAC Gold Book as both: 1) all atoms with the same number of protons in the atomic nucleus; 2) a pure chemical substance composed of atoms with the same number of protons in the atomic nucleus. In Russian just the first meaning of the term «chemical element» is used, while the second meaning has its own expression which can be translated as «simple substance». Moreover, the term «compound» is used in English to refer to substances composed of atoms from different chemical elements, while in Russian it refers to any substance. In this book we use English terminology and not literal translation from Russian. Such trivial English names of substances as «lime water», «sodium bicarbonate», «carbon dioxide», etc. are also used in this book.

LESSON 1. INTRODUCTION TO THE GENERAL CHEMISTRY

TEST FOR CLASSWORK

1. Choose physical processes:
   a. the melting of the ice
   b. the boiling of water
   c. the burning of wood
   d. the oxidation of sulfur

2. Choose chemical processes:
   a. production of ammonia from nitrogen and hydrogen
   b. the dissolving of glucose in water
   c. the dissolving of calcium carbide in water
   d. the dissolving of sodium bicarbonate in acetic acid

3. Choose pure chemical elements:
   a. chlorine gas
   b. iron
   c. steel
   d. sodium chloride

4. Choose compounds:
   a. sulfur dioxide
   b. white phosphorus
   c. methane
   d. oxygen

5. Choose allotropic modifications of carbon:
   a. graphite
   b. diamond
   c. propane
   d. carbon dioxide

6. Choose oxygen containing compounds:
   a. CaO
   b. O_2
   c. O_3
   d. H_2SO_4

7. Choose chemical elements which have absolutely different names in English and Latin:
   a. Ag
   b. Ni
   c. K
   d. Fe

8. Choose chemical elements which have similar names in English and Latin:
   a. B
   b. W
   c. N
   d. Pb

9. Which compounds are composed of three atoms?
   a. NO_2
   b. HCN
   c. HNO_3
   d. N_2O_5

10. Which compounds are made from atoms of two chemical elements?
    a. SO_3
    b. N_2
    c. P_2O_5
    d. H_2SiO_3

TEST FOR HOMEWORK

1. Choose physical processes:
   a. the mixing of flour with sugar
   b. condensation of water
   c. the burning of magnesium in CO_2
   d. the rusting of iron

2. Choose chemical processes:
   a. production of the distilled water
   b. the dissolving of sodium chloride in water
   c. the dissolving of sodium sulfide in water
   d. the dissolving of aluminum chloride in water

3. Choose pure chemical elements:
   a. lime water
   b. marble
   c. nitrogen
   d. mercury

4. Choose compounds:
   a. pyrite
   b. gold
   c. silver
   d. bronze

5. Choose allotropic modifications of oxygen:
   a. oxide
   b. ozone
   c. oxygen
   d. ozonide

6. Choose phosphorus containing compounds:
   a. F_2 b. NaF   c. P_4 d. H_3PO_4

7. Choose chemical elements which have absolutely different names in English and Latin:
   a. Au   b. Pt   c. Na   d. F

8. Choose chemical elements which have similar names in English and Latin:
   a. Br   b. I   c. Sn   d. Sb

9. Which compounds are composed of four atoms?
   a. H_2O_2 b. SO_3 c. H_3O^+ d. P_4

10. Which compounds are made from atoms of three chemical elements?
    a. CCl_4 b. O_2 c. H_3PO_4 d. KCN

1. Write the formula of sodium sulfide: _____

2. Write the formula of zinc sulfide: _____

3. Write the formula of aluminum sulfide: _____

4. Write the formula of lithium sulfite: _____

5. Write the formula of calcium sulfate: _____

6. Write the formula of sodium nitrite: _____

7. Write the formula of potassium nitrate: _____

8. Write the formula of aluminum nitrite: _____

9. Write the formula of strontium phosphate: _____

10. Write the formula of calcium carbonate: _____

11. Write the formula of barium silicate: _____

12. Write the formula of strontium oxide: _____

13. Write the formula of calcium hydroxide: _____

14. Write the formula of sulfuric acid: _____

15. Write the formula of nitric acid: _____

EXERCISES FOR HOMEWORK

1. Write the name of NaOH: _____

2. Write the name of H_2SO_4: _____

3. Write the name of FeO: _____

4. Write the name of KCl: _____

5. Write the name of HBr: _____

6. Write the name of $NaNO_2$: _____

7. Write the name of NH_4NO_3: _____

8. Write the name of CO_2: _____

9. Write the name of H_3PO_4: _____

10. Write the name of K_2SiO_3: _____

LESSON 2. MOLAR MASS

EXERCISES FOR CLASSWORK

1. **Calculate the number of moles in 40 g of sodium hydroxide (NaOH)?**

   _____
   _____
   _____

2. **What is the mass of 3.6 moles of sulfuric acid (H_2SO_4)?**

   _____
   _____
   _____

3. **Find the molar mass of a substance if 5.5 moles of it has a mass of 435 g?**

   _____
   _____
   _____

4. **How many molecules are there in 3 L of liquid water (density is equal to 1 g/ml)?**

   _____
   _____
   _____

5. **Find the number of moles in a sample of a substance if there are $3.7 \cdot 10^{26}$ molecules in that sample.**

   _____
   _____
   _____

6. **How many molecules are there in 128 g of oxygen?**

   _____
   _____
   _____

7. **Calculate the mass of $4.9 \cdot 10^{25}$ molecules of carbon dioxide (CO_2).**

   _____
   _____
   _____

8. Find the molar mass of a substance if $3.01 \cdot 10^{23}$ molecules of it have a mass of 49 g.

_____

_____

_____

9. How many moles of oxygen atoms are there in 100 g of barium sulfate ($BaSO_4$)?

_____

_____

_____

10. Find the mass of a sample of ammonium nitrate if you know that there are 0.47 moles of nitrogen atoms in that sample.

_____

_____

_____

EXERCISES FOR HOMEWORK

1. Calculate the number of moles in 50 g of potassium hydroxide (KOH)?

_____

_____

_____

2. What is the mass of 0.67 moles of nitric acid (HNO_3)?

_____

_____

_____

3. Find the molar mass of a substance if 2.5 moles of it has a mass of 150 g?

_____

_____

_____

4. How many molecules are there in 4 L of liquid ethanol (the density of C_2H_5OH is equal to 0.8 g/ml)?

_____

_____

_____

5. **Find the number of moles in a sample of a substance if there are $8.9 \cdot 10^{22}$ molecules in that sample.**

_____
_____
_____
_____

6. **How many units are there in 523 g of $ZnCl_2$?**

_____
_____
_____
_____

7. **Calculate the mass of $2.6 \cdot 10^{23}$ molecules of hydrogen peroxide (H_2O_2).**

_____
_____
_____
_____

8. **Find the molar mass of a substance if $1.2 \cdot 10^{24}$ molecules of it have a mass of 126 g.**

_____
_____
_____
_____

9. **How many moles of sodium ions are there in 200 g of sodium carbonate (Na_2CO_3)?**

_____
_____
_____
_____

10. **Find the mass of a sample of zinc hydroxide if you know that there are 0.27 moles of oxygen atoms in that sample.**

_____
_____
_____
_____

LESSON 3. VALENCE

TEST FOR CLASSWORK

1. What is the valence of carbon in carbon dioxide?
   a. II   b. III   c. IV   d. V

2. In which compounds the valence of phosphorus is equal to V?
   a. P_2O_5 b. P_2O_3 c. H_3PO_4 d. PCl_5

3. Calculate the sum of all coefficients in the following chemical reaction:
   $Zn + HCl \rightarrow ZnCl_2 + H_2$
   a. 4   b. 5   c. 6   d. 7

4. Calculate the sum of coefficients before reactants in the following chemical reaction:
   $NaOH + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$
   a. 2   b. 3   c. 4   d. 5

5. Calculate the sum of coefficients before products in the following chemical reaction:
   $Al + HCl \rightarrow AlCl_3 + H_2$
   a. 3   b. 4   c. 5   d. 6

6. In which molecules there are three single or a single triple covalent bond?
   a. O_2 b. H_2O c. CO   d. H_2O_2

7. Calculate the sum of all coefficients in the following chemical reaction:
   $Ca + H_2O \rightarrow Ca(OH)_2 + ?$
   a. 3   b. 4   c. 5   d. 6

8. Calculate the sum of coefficients before reactants in the following chemical reaction:
   $AgNO_3 + ? \rightarrow AgCl + KNO_3$
   a. 2   b. 3   c. 4   d. 5

9. Calculate the sum of coefficients before products in the following chemical reaction:
   $Ca(OH)_2 + H_3PO_4 \rightarrow Ca_3(PO_4)_2 + ?$
   a. 1   b. 3   c. 5   d. 7

10. How many atoms are connected to the nitrogen atom in HNO_2 molecule?
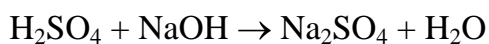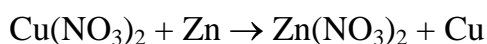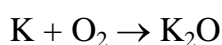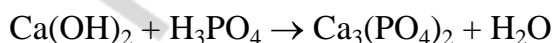   a. 0   b. 1   c. 2   d. 3

TEST FOR HOMEWORK

1. What is the valence of sulfur in sulfur trioxide?
   a. II   b. III   c. IV   d. VI

2. In which compounds the valence of silicon is equal to IV?

   a. SiO_2 b. H_2SiO_3 c. K_2SiO_3 d. SiO

3. Calculate the sum of all coefficients in the following chemical reaction: $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

   a. 4   b. 5   c. 6   d. 7

4. Calculate the sum of coefficients before reactants in the following chemical reaction: $Al(OH)_3 + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2O$

   a. 2   b. 3   c. 4   d. 5

5. Calculate the sum of coefficients before products in the following chemical reaction: $Fe_2O_3 + HNO_3 \rightarrow Fe(NO_3)_3 + H_2O$

   a. 3   b. 4   c. 5   d. 6

6. In which molecules there are four single or two double covalent bonds?

   a. C_2H_2 b. NH_3 c. SO_2 d. CH_4

7. Calculate the sum of all coefficients in the following chemical reaction: $K + H_2O \rightarrow ? + H_2$

   a. 4   b. 5   c. 6   d. 7

8. Calculate the sum of coefficients before reactants in the following chemical reaction: $CaCO_3 + ? \rightarrow CaSO_4 + CO_2 + H_2O$

   a. 2   b. 3   c. 4   d. 5

9. Calculate the sum of coefficients before products in the following chemical reaction: $Ca(OH)_2 + HNO_3 \rightarrow ? + H_2O$

   a. 1   b. 3   c. 5   d. 7

10. How many atoms are connected to the chlorine atom in $HClO_4$ molecule?

    a. 2   b. 3   c. 4   d. 5

EXERCISES FOR CLASSWORK

1. Balance the following chemical equations:

$Cr + O_2 \rightarrow Cr_2O_3$

$Zn(NO_3)_2 + Al \rightarrow Al(NO_3)_3 + Zn$
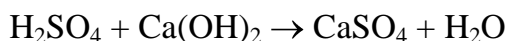
$H_3PO_4 + NaOH \rightarrow Na_3PO_4 + H_2O$

$Ca(OH)_2 + H_3PO_4 \rightarrow Ca_3(PO_4)_2 + H_2O$

$K + O_2 \rightarrow K_2O$

$Cu(NO_3)_2 + Zn \rightarrow Zn(NO_3)_2 + Cu$

$H_2SO_4 + NaOH \rightarrow Na_2SO_4 + H_2O$

$Ca(OH)_2 + HNO_3 \rightarrow Ca(NO_3)_2 + H_2O$

$Na + O_2 \rightarrow Na_2O$

$Cu(NO_3)_2 + Cr \rightarrow Cr(NO_3)_3 + Cu$

$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + H_2O$

$Sr(OH)_2 + HNO_3 \rightarrow Sr(NO_3)_2 + H_2O$
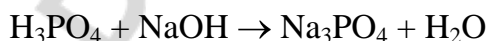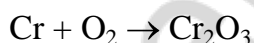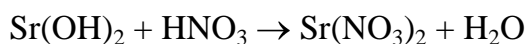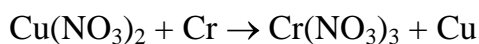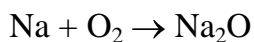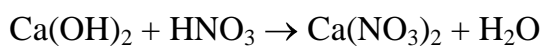
2. What are the products of the reaction between iron (II) oxide and hydrochloric acid?

   _____

3. What are the products of the reaction between iron (III) oxide and nitric acid?

   _____

4. To produce zinc sulfate we need to put _____ in sulfuric acid.

5. To produce potassium hydroxide we should put _____ in water

EXERCISES FOR HOMEWORK

1. Balance the following chemical equations

   $Pb(NO_3)_2 + Al \rightarrow Pb + Al(NO_3)_3$

   $Al(OH)_3 + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2O$

   $NH_3 + O_2 \rightarrow NO + H_2O$

   $P + O_2 \rightarrow P_2O_5$

   $PbCl_2 + Al \rightarrow Pb + AlCl_3$

   $Cr(OH)_3 + H_2SO_4 \rightarrow Cr_2(SO_4)_3 + H_2O$

   $NH_3 + O_2 \rightarrow N_2 + H_2O$

   $P + O_2 \rightarrow P_2O_3$

   $Al + KOH + H_2O \rightarrow K[Al(OH)_4] + H_2$

   $Fe_2O_3 + HCl \rightarrow FeCl_3 + H_2O$

   $AgNO_3 + AlCl_3 \rightarrow AgCl + Al(NO_3)_3$

   $N_2 + H_2 \rightarrow NH_3$
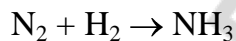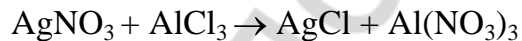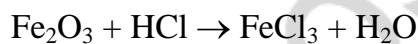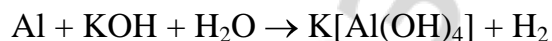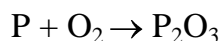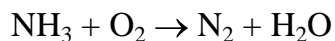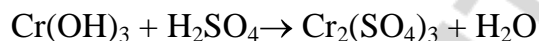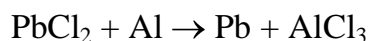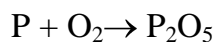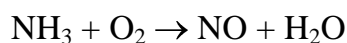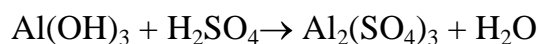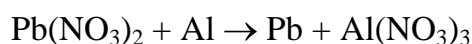
2. The products of the reaction between aluminum and hydrochloric acid are:

   _____

3. Copper forms _____ in the reaction with sulfur.

4. To produce zinc phosphate we need to put zinc in _____ acid.

5. To produce iron (III) oxide we should burn _____.

13

LESSON 4. STOICHIOMETRIC CALCULATIONS

EXERCISES FOR CLASSWORK

1. **What is the mass of sulfur reacted with oxygen and produced 3.6 g of sulfur dioxide:**

   balance the equation: $S + O_2 \rightarrow SO_2$

   _____

   _____

   _____

2. **Calculate the mass of phosphorus (V) oxide produced from 6.2 g of phosphorus and oxygen?**

   balance the equation: $P + O_2 \rightarrow P_2O_5$

   _____

   _____

   _____

3. **What is the mass of zinc chloride produced in the reaction between 9 g of zinc and hydrochloric acid?**

   balance the equation: $Zn + HCl \rightarrow ZnCl_2 + H_2$

   _____

   _____

   _____

4. **What is the mass of silver chloride produced in the reaction between 10 g of silver nitrate and barium chloride?**

   balance the equation: $AgNO_3 + BaCl_2 \rightarrow AgCl + BaNO_3$

   _____

   _____

   _____

5. **Calculate the mass of water needed to produce 20 g of lithium hydroxide from lithium.**

   balance the equation: $Li + H_2O \rightarrow LiOH + H_2$

   _____

   _____

   _____

6. **Find the mass of zinc oxide formed in the reaction of zinc hydroxide decomposition. The mass of zinc hydroxide was equal to 75 g, the mass of water produced is equal to 10 g.**

balance the equation: $Zn(OH)_2 \rightarrow ZnO + H_2O$

_____

_____

_____

_____

7. **What is the mass of iron (III) chloride formed in the reaction between iron and chlorine gas? The mass of iron is equal to 18.2 g, the mass of chlorine gas is equal to 16.4 g.**

balance the equation: $Fe + Cl_2 \rightarrow FeCl_3$

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **What is the mass of carbon reacted with oxygen and produced 5.2 g of carbon dioxide:**

balance the equation: $C + O_2 \rightarrow CO_2$

_____

_____

_____

_____

2. **Calculate the mass of orthophosphoric acid produced from 9.1 g of phosphorus (V) oxide and water?**

balance the equation: $P_2O_5 + H_2O \rightarrow H_3PO_4$

_____

_____

_____

_____

3. **What is the mass of sodium iodide produced in the reaction between 9 g of sodium and iodine?**

   balance the equation: $Na + I_2 \rightarrow NaI$

   _____

   _____

   _____

4. **What is the mass of barium sulfate produced in the reaction between 6 g of barium hydroxide and potassium sulfate?**

   balance the equation: $Ba(OH)_2 + K_2SO_4 \rightarrow BaSO_4 + KOH$

   _____

   _____

   _____

5. **Calculate the mass of strontium needed to produce 30 g of strontium hydroxide in the reaction with water.**

   balance the equation: $Sr + H_2O \rightarrow Sr(OH)_2 + H_2$

   _____

   _____

   _____

6. **Find the mass of aluminum oxide formed in the reaction of aluminum hydroxide decomposition. The mass of aluminum hydroxide was equal to 110 g, the mass of water produced is equal to 15 g.**

   balance the equation: $Al(OH)_3 \rightarrow Al_2O_3 + H_2O$

   _____

   _____

   _____

   _____

7. **What is the mass of calcium carbonate formed in the reaction between calcium oxide and carbon dioxide? The mass of calcium oxide is equal to 33.3 g, the mass of carbon dioxide is equal to 12.2 g.**

   balance the equation: $CaO + CO_2 \rightarrow CaCO_3$

   _____

   _____

   _____

   _____

LESSON 5. MOLAR VOLUME OF GASES

EXERCISES FOR CLASSWORK

1. **How many moles are there in 11.7 L of nitrogen (in normal conditions)?**

    _____
    _____
    _____

2. **What volume is occupied by 4.5 moles of oxygen (in normal conditions)?**

    _____
    _____
    _____

3. **How many molecules are there in 2 L of hydrogen (in normal conditions)?**

    _____
    _____
    _____

4. **Find the molar mass of a gas if 10 g of it occupy a volume of 5.1 L (in normal conditions)?**

    _____
    _____
    _____

5. **Calculate the mass of ammonia which has a volume of 133.6 L (in normal conditions)?**

    _____
    _____
    _____

6. **Calculate the volume of oxygen required to burn down 14.2 L of methane.**

    _____
    _____
    _____

7. **What is the volume of carbon monoxide produced from 37 L of carbon dioxide in its reaction with coal (in normal conditions)?**

    _____
    _____
    _____

8. **Calculate the volume of an unknown gas which has a mass equal to 7 g and the relative density per oxygen which is equal to 0.625?**

_____
_____
_____

9. **What is the density of unknown gas per nitrogen if its density per hydrogen is equal to 17?**

_____
_____
_____

10. **Find the volume of carbon dioxide (in normal conditions) produced in the reaction between 10 g of calcium carbonate and 8 g of hydrochloric acid.**

_____
_____
_____

EXERCISES FOR HOMEWORK

1. **How many moles are there in 1.8 L of ozone (in normal conditions)?**

_____
_____
_____

2. **What volume is occupied by 3.2 moles of hydrogen (in normal conditions)?**

_____
_____
_____

3. **How many molecules are there in 7.7 L of ammonia (in normal conditions)?**

_____
_____
_____

4. **Find the molar mass of a gas if 5 g of it occupy a volume of 2.2 L (in normal conditions)?**

_____
_____
_____

5. **Calculate the mass of sulfur (VI) oxide which has a volume of 43.7 L (in normal conditions)?**

_____
_____
_____
_____

6. **Calculate the volume of oxygen required to burn down 5.2 L of acetylene.**

_____
_____
_____
_____

7. **What is the volume of sulfur (IV) oxide produced from 4.5 g of hydrogen sulfide in its reaction with the excess of oxygen (in normal conditions)?**

_____
_____
_____
_____

8. **Calculate the volume of an unknown gas which has a mass equal to 5 g and the relative density per dry air which is equal to 1.25?**

_____
_____
_____
_____

9. **What is the density of unknown gas per dry air if its density per ozone is equal to 1.5?**

_____
_____
_____
_____

10. **Find the volume of ammonia (in normal conditions) produced in the reaction between 7 g of ammonium nitrate and 9 g of potassium hydroxide.**

_____
_____
_____
_____

LESSON 6. THE SAMPLE OF CONTROL TASK #1

1. **How many molecules are there in 128 g of oxygen?**

   _____

   _____

   _____

2. **Balance the following chemical equations:**

   $(NH_4)_2SO_4 + BaCl_2 \rightarrow BaSO_4 + NH_4Cl$

   $Al(OH)_3 + HCl \rightarrow AlCl_3 + H_2O$

   $CuS + O_2 \rightarrow CuO + SO_2$

   $Mg(NO_3)_2 + NaOH \rightarrow Mg(OH)_2 + NaNO_3$
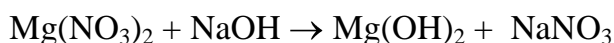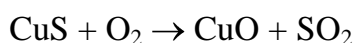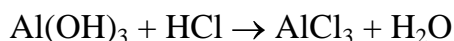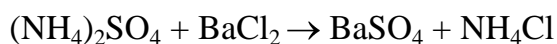
3. **How many moles of oxygen react with 36 g of carbon?**

   _____

   _____

   _____

4. **Calculate the molar mass of unknown gas if the mass of 3 L of that gas is equal to 9.51 g**

   _____

   _____

   _____

5. **What is the mass of AgCl which is produced in the reaction between 1.34 g of AgNO₃ and 1.34 g of ZnCl₂?**

   _____

   _____

   _____

6. **Calculate the volume of hydrogen gas required for the reaction with 3.3 L of oxygen at 35 °C and at the pressure of 1.2 atmospheres. Water is the product of that reaction.**

   _____

   _____

   _____

LESSON 7. THE PERIODIC TABLE

TEST FOR CLASSWORK

1. Metallic properties of chemical elements from A subgroups increase from:
    a. left to right   c. top to bottom
    b. right to left   d. bottom to top

2. Nonmetallic properties of chemical elements from A subgroups increase from:
    a. left to right   c. top to bottom
    b. right to left   d. bottom to top

3. Atomic radii of chemical elements from A subgroups increase from:
    a. left to right   c. top to bottom
    b. right to left   d. bottom to top

4. Electronegativity of chemical elements from A subgroups increases from:
    a. left to right   c. top to bottom
    b. right to left   d. bottom to top

5. Ionization energy of chemical elements from A subgroups increases from:
    a. left to right   c. top to bottom
    b. right to left   d. bottom to top

6. Choose s-elements:
    a. Na   b. Sr   c. Al   d. Sc

7. Choose p-elements:
    a. Cu   b. Sb   c. Cl   d. He

8. Choose d-elements:
    a. Ba   b. Fe   c. Si   d. Mn

9. Which properties are usually identical for elements from the same subgroup?
    a. number of protons
    b. highest valence
    c. number of electrons on the outer layer
    d. electronegativity

10. Which properties are identical for elements from the same period?
    a. atomic radius
    b. ionization energy
    c. the number of electron layers
    d. chemical properties

TEST FOR HOMEWORK

1. Metallic properties of chemical elements from A subgroups decrease from:
   a. left to right   c. top to bottom
   b. right to left   d. bottom to top

2. Nonmetallic properties of chemical elements from A subgroups decrease from:
   a. left to right   c. top to bottom
   b. right to left   d. bottom to top

3. Atomic radii of chemical elements from A subgroups decrease from:
   a. left to right   c. top to bottom
   b. right to left   d. bottom to top

4. Electronegativity of chemical elements from A subgroups decreases from:
   a. left to right   c. top to bottom
   b. right to left   d. bottom to top

5. Ionization energy of chemical elements from A subgroups decreases from:
   a. left to right   c. top to bottom
   b. right to left   d. bottom to top

6. Choose s-elements:
   a. He   b. Cl   c. H   d. Ar

7. Choose p-elements:
   a. Al   b. S   c. Hg   d. C

8. Choose d-elements:
   a. Be   b. Co   c. Ni   d. Mg

9. Which properties are usually identical for elements from the same subgroup?
   a. the formula of the highest oxide
   b. atomic radius
   c. the formula of the pure chemical element
   d. the formula of the binary compound with hydrogen

10. Which properties are identical for elements from the same period?
    a. electronegativity
    b. molecular mass
    c. the line in the Periodic table
    d. the column in the Periodic table

1. **Write the names of metals from the group IIIA of the periodic table:**

_____

2. **Write the names of metals from the group IVA of the periodic table:**

_____

3. **Write the names of nonmetals from the group VA of the periodic table:**

_____

4. **Write the names of nonmetals from the group VIA of the periodic table:**

_____

5. **Write the names of metals from the 3rd period of the periodic table:**

_____

6. **Arrange these elements in the order of the increase of their metallic properties (Al / Na / Mg / Si / Cs / C):** _____

7. **Arrange these elements in the order of the decrease of their nonmetallic properties (B / Br / Cl / F / Al / I):** _____

8. **Write the formula of the highest oxide of elements from the VIA group of the periodic table starting from the 3rd period:** _____

9. **Write the formula of the binary compound with hydrogen for elements from the IIIA group of the periodic table:** _____

10. **Which metalloids are classified as metals if we divide all the elements into metals and nonmetals?** _____

11. **Calculate the number of protons in 20 g of phosphoric acid.**

_____

12. **The percent of ^{35}Cl in the sample of HCl is 80 %, the percent of ^{37}Cl is 20 %. Find the volume of hydrogen produced in the reaction between 100 g of that HCl sample with sodium.**

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Write the names of nonmetals from the group IIIA of the periodic table:**

   _____

2. **Write the names of nonmetals from the group IVA of the periodic table:**

   _____

3. **Write the names of metals from the group VA of the periodic table:**

   _____

4. **Write the names of metals from the group VIA of the periodic table:**

   _____

5. **Write the names of metals from the 2nd period of the periodic table:**

   _____

6. **Arrange these elements in the order of the increase of their metallic properties (Ca / Sr / Al / Mg / Ba / B):** _____

7. **Arrange these elements in the order of the decrease of their nonmetallic properties (F / O / S / C / Si / Be):** _____

8. **Write the formula of the highest oxide of elements from the VA group of the periodic table starting from the 3rd period:** _____

9. **Write the formula of the binary compound with hydrogen for elements from the VIIA group of the periodic table:** _____

10. **Which metalloids are classified as nonmetals if we divide all the elements into metals and nonmetals?** _____

11. **Calculate the number of protons in 60 g of calcium phosphate.**

    _____

12. **The percent of ^{2}H in the sample of H_2O is 2 %, the percent of ^{1}H is 98 %. Find the volume of hydrogen produced in the reaction between 10 g of that H_2O sample with potassium.**

    _____
    _____
    _____

LESSON 8. ELECTRON CONFIGURATIONS

TEST FOR CLASSWORK

1. How many energetic sublevels are there on the 4th energetic level?
   a. 1   b. 2   c. 3   d. 4

2. How many electron orbitals are there on the p-sublevel?
   a. 1   b. 2   c.3   d. 4

3. What is the maximal number of electrons which can occupy all orbitals of the same d-sublevel?
   a. 2   b. 6   c. 10   d. 14

4. How many unpaired electrons are there in the nitrogen atom (in its normal state)?
   a. 1   b. 2   c. 3   d. 4

5. What is the number of electrons on the outer shell (level) of the chlorine atom:
   a. 17   b. 8   c. 18   d. 7

6. What is the maximal number of electrons on the same orbital?
   a. 1   b. 2   c. 6   d. 10

7. Choose the correct order of electron orbitals fulfillment:
   a. 1s/2s/2p/3s/3d   c. 1s/2s/3s/2p/3d
   b.1s/2s/3p/3s/3d   d. 1s/2s/2p/3s/3p

8. Choose the electron configuration of the nitrogen atom (in its normal state):
   a. $1s^2 2s^2 2p^3$ c. $1s^2 2s^3 2p^2$
   b. $1s^2 2s^1 2p^4$ d. $1s^1 2s^2 2p^4$

9. What element has the following electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^1$
   a. Na   b. Mg   c. Al   d. Si

10. Choose possible electron configurations (in both normal and excited states) for the carbon atom:
   a. $1s^2 2s^2 2p^2$ c. $1s^3 2s^2 2p^1$
   b. $1s^2 2s^1 2p^3$ d. $1s^2 2s^2 2p^1$

TEST FOR HOMEWORK

1. How many energetic sublevels are there on the 3rd energetic level?
   a. 1   b. 2   c. 3   d. 4

2. How many electron orbitals are there on the d-sublevel?
   a. 1   b. 3   c.5   d. 7

3. What is the maximal number of electrons which can occupy all orbitals of the same f-sublevel?
   a. 2   b. 6   c. 10   d. 14

4. How many unpaired electrons are there in the oxygen atom (in its normal state)?
   a. 1   b. 2   c. 3   d. 4

5. What is the number of electrons on the outer shell (level) of the copper atom:
   a. 1   b. 2   c. 8   d. 18

6. How many electrons are there on the 3rd sublevel of the chrome atom (in its normal state)?
   a. 1   b. 3   c. 4   d. 5

7. Choose the correct order of electron orbitals fulfillment:
   a. …3s/3p/4s/3d   c. …3s/3d/3p/4s
   b. …3s/3d/3p/4s   d. …3p/3d/3s/4s

8. Choose the electron configuration of the zinc atom (in its normal state):
   a. $[Ar]4s^24p^6$ c. $[Ar]4s^14d^{10}$
   b. $[Ar]4s^24d^{10}$ d. $[Kr]5s^25d^{10}$

9. What element has the following electron configuration: $[Ne]3s^23p^4$
   a. S   b. P   c. Cl   d. Ar

10. Choose possible electron configurations (in both normal and excited states) for the nitrogen atom:
    a. $1s^22s^22p^3$ c. $1s^32s^22p^2$
    b. $1s^22s^12p^4$ d. $1s^22s^32p^2$

EXERCISES FOR CLASSWORK

1. **Write the complete electron configuration for beryllium:**

   _____

2. **Write the complete electron configuration for bromine:**

   _____

3. **Write the complete electron configuration for scandium:**

   _____

4. **Write the short electron configuration for magnesium:** _____

5. **Write the short electron configuration for germanium:** _____

6. **Write the short electron configuration for titanium:** _____

7. **Draw the diagram with cells and arrows for the outer shell of carbon:**

   _____

8. **Draw the diagram with cells and arrows for the outer shell of sulfur:**

   _____

9. **Draw the diagram with cells and arrows for the outer shell of copper:**

   _____

10. **Find the mass of the product of the reaction between two pure chemical elements. The first one has an electronic configuration $1s^2 2s^2 2p5$ and the volume of 5 L (in normal conditions). The second one has an electronic configuration $1s^2 2s^2 2p^6 3s^2$ and the mass of 0.5 g.**

    _____
    _____

11. **Which particles from this line (Na^+ / Mg^{2+} / F^- / Cl^- / Al^{3+} / Ne / Ar) have the same electronic configuration (if we ignore empty orbitals). Write this configuration.**

    _____
    _____

12. **Arrange the atoms (in their ground state) from this line (Ne / Cr / C / N / K / Mn) in the order of the increase of the number of unpaired electrons.**

    _____
    _____

EXERCISES FOR HOMEWORK

1. **Write the complete electron configuration for calcium:**

    _____

2. **Write the complete electron configuration for phosphorus:**

    _____

3. **Write the complete electron configuration for vanadium:**

    _____

4. **Write the short electron configuration for lithium:** _____

5. **Write the short electron configuration for arsenic:** _____

6. **Write the short electron configuration for cobalt:** _____

7. **Draw the diagram with cells and arrows for the outer shell of chrome:**

    _____

8. **Draw the diagram with cells and arrows for the outer shell of fluorine:**

    _____

9. **Draw the diagram with cells and arrows for the outer shell of nickel:**

    _____

10. **Find the mass of the product of the reaction between two pure chemical elements. The first one has an electronic configuration $1s^2 2s^2 2p^4$ and the volume of 7 L (in normal conditions). The second one has an electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^4$ and the mass of 1.5 g.**

    _____
    _____

11. **Which particles from this line (K^+ / Ca^{2+} / I^- / Cl^- / S^{2-} / Xe / Ar) have the same electronic configuration (if we ignore empty orbitals). Write this configuration.**

    _____
    _____

12. **Arrange atoms and ions (in their ground state) from this line (He / Fe / Cu / P / Si / Mn^{2+}) in the order of the increase of the number of unpaired electrons.**

    _____
    _____

LESSON 9. CHEMICAL BONDS

TEST FOR CLASSWORK

1. Choose binary compounds with ionic bonds:
    a. CCl_4 b. KCl   c. ZnO   d. SiO

2. Choose compounds with ionic and covalent polar bonds:
    a. NaCl   b. KNO_3 c. NO_2 d. KOH

3. Choose binary compounds with covalent polar bonds:
    a. PCl_3 b. Na_3N c. K_2O d. KH

4. In which compounds one can find at least one covalent nonpolar bond?
    a. H_2 b. C_2H_6 c. H_2O_2 d. H_2O

5. Choose substances with the metallic bonding:
    a. AgCl   b. $KAlO_2$ c. AgAu   d. Cu_9Zn

6. In which compounds there are just sigma covalent bonds?
    a. CH_4 b. C_2H_2 c. C_2H_4 d. C_5H_{12}

7. Which compounds contain a double bond?
    a. O_2 b. N_2 c. H_2 d. C_2H_4

8. Which compounds contain a triple bond?
    a. C_2H_2 b. CO   c. N_2 d. O_3

9. Choose a compound with the most polar covalent bond:
    a. NaF   b. HF   c. H_2O d. H_2S

10. Indicate the possible schemes of hydrogen bond formation:
    a. N-H……O   b. O-H……N   c. F-H……F   d. N-H……C

TEST FOR HOMEWORK

1. Choose compounds with ionic bonds:
    a. $Ba(OH)_2$ b. H_2SO_4 c. KNO_3 d. SiO_2

2. Choose compounds with covalent polar bonds:
    a. Cl_2 b. $ZnSO_4$ c. NH_3 d. ZnO

3. Choose diatomic molecules with covalent nonpolar bonds:
    a. P_4 b. N_2 c. O_2 d. S_8

4. In which compounds one can find at least one covalent polar bond?
    a. Br_2 b. CH_3Cl c. N_2O d. LiCl

5. Choose substances with metallic bonding:
    a. NaH   b. $SnCu_4$ c. K_2ZnO_2 d. KNa

6. In which compounds there are pi-bonds?

   a. C_3H_8 b. C_3H_4 c. C_2H_4 d. O_2

7. Which compounds contain a double bond?

   a. I_2 b. P_4 c. SO_2 d. SO_3

8. Which compounds contain a triple bond?

   a. CaC_2 b. CO_2 c. KCN d. S_8

9. Choose a compound with the most polar bond:

   a. KCl   b. LiF   c. HF   d. BF_3

10. Indicate the possible schemes of hydrogen bond formation:

    a. N-H……F   b. P-H……P   c. O-H……O   d. N-H……N

EXERCISES FOR CLASSWORK

1. **Write 5 samples of substances with just covalent nonpolar bonds:**

   _____

2. **Write 5 samples of substances with just ionic bonds:**

   _____

3. **Write 5 samples of substances with just covalent polar bonds:**

   _____

4. **Write 5 samples of substances with metallic bonding:**

   _____

5. **Arrange substances in this line (HF / H_2O / BH_3 / CH_4 / H_2S) in the order of the increase of the polarity of a bond between atoms of different elements:**

   _____

EXERCISES FOR HOMEWORK

1. **Write 5 samples of substances with both covalent polar and ionic bonds:**

   _____

2. **Write 5 samples of substances with both covalent nonpolar and ionic bonds:**

   _____

3. **Write 5 samples of substances with both covalent polar and nonpolar bonds:**

   _____

4. **Write 5 samples of substances which can make intermolecular hydrogen bonds:**

   _____

5. **Write 5 samples of substances with a triple bond:**

   _____

LESSON 10. OXIDATION STATE

TEST FOR CLASSWORK

1. Determine the oxidation state of phosphorus in H_3PO_4:
    a. +5   b. +3   c. +1   d. –3

2. Choose compounds in which the oxidation state of nitrogen is equal to +3:
    a. NH_3 b. $NaNO_3$ c. N_2O_3 d. HNO_2

3. Choose anions in which the oxidation state of phosphorus is equal to +5:
    a. PO_4^{3-} b. HPO_4^{2-} c. $H_2PO_4^{-}$ d. $H_2PO_3^{-}$

4. Calculate the charge of the anion made from three oxygen atoms and one silicon atom in its maximal oxidation state:
    a. –2   b. +2   c. –3   d. +3

5. Choose oxidation states possible for hydrogen atoms:
    a. +1   b. –1   c. +2   d. 0

6. For which compounds the term «oxidation state» is more applicable than the term «valence»?
    a. K_2O b. NaCl   c. PH_3 d. SiH_4

7. For which compounds the term «valence» is more applicable than the term «oxidation state»?
    a. PCl_3 b. N_2 c. LiF   d. C_3H_8

8. Choose the minimal oxidation state for sulfur:
    a. 0   b. +6   c. +4   d. -2

9. Choose the maximal oxidation state for chlorine:
    a. -1   b. +1   c. +3   d. +7

10. Which chemical elements demonstrate a single possible oxidation state in compounds?
    a. H   b. K   c. F   d. O

TEST FOR HOMEWORK

1. Determine the oxidation state of sulfur in H_2SO_4:
   a. +4   b. +6   c. 0   d. –2

2. Choose compounds in which the oxidation state of oxygen is equal to –2:
   a. NO   b. K_2O c. K_2O_2 d. KO_2

3. Choose anions in which the oxidation state of carbon is equal to +4:
   a. CO_3^{2-} b. $HCOO^-$ c. HCO_3^- d. $C_2O_4^{2-}$

4. Calculate the charge of the anion made from four oxygen atoms and one phosphorus atom in its maximal oxidation state:
   a. –2   b. +2   c. –3   d. +3

5. Choose oxidation states possible for nitrogen atoms:
   a. +1   b. +3   c. +5   d. +7

6. For which compounds the term «oxidation state» is more applicable than the term «valence»?
   a. NaBr   b. Cl_2 c. CH_4 d. CaO

7. For which compounds the term «valence» is more applicable than the term «oxidation state»?
   a. NH_3 b. BaO   c. NaF   d. H_2S

8. Choose the minimal oxidation state for carbon:
   a. 0   b. –6   c. –4   d. –2

9. Choose the maximal oxidation state for manganese:
   a. –1   b. +1   c. +3   d. +7

10. Which chemical elements demonstrate a single possible oxidation state in compounds?
    a. Ca   b. Zn   c. Cr   d. Mn

EXERCISES FOR CLASSWORK

1. **Write oxidation states upon all the elements in the following compounds:**
   P_4 PCl_3 PCl_5 P_2O_3 H_3PO_4 $H_4P_2O_7$

2. **Write oxidation states upon all the elements in the following compounds:**
   S_8 SO_3 SO_2 H_2SO_3 H_2SO_4 $Al_2(SO_4)_3$

3. **Write oxidation states upon all the elements in the following compounds:**
   CO CO_2 H_2CO_3 CH_4 C_2H_2 HCOH

4. **Arrange compound in this line (CsCl / MgO / CrO_3 / Al_2O_3 / Mn_2O_7) in the order of the increase of the oxidation state of a metal:**

   _____

5. **Write 5 samples of substances in which oxygen demonstrates oxidation state different from –2:**

   _____

EXERCISES FOR HOMEWORK

1. **Write oxidation states upon all the elements in the following compounds:**
   N_2 NO N_2O_3 NH_4NO_2 N_2O_5 N_2O

2. **Write oxidation states upon all the elements in the following compounds:**
   Cr $K_2Cr_2O_7$ CrO $BaCrO_4$ $NaCrO_2$ Cr_2O_3

3. **Write oxidation states upon all the elements in the following compounds:**
   HI I_2 HIO_3 $NaIO_4$ KIO $Ca(IO_2)_2$

4. **Arrange compound in this line (SO_3 / OF_2 / SiO_2 / P_2O_5 / As_2O_3) in the order of the increase of the oxidation state of a nonmetal (which is not oxygen):**

   _____

5. **Write 5 samples of substances in which hydrogen demonstrates oxidation state different from +1:**

   _____

LESSON 11. CLASSIFICATION OF CHEMICAL REACTIONS

TEST FOR CLASSWORK

1. Choose composition reactions:
   a. $2H_2 + O_2 \rightarrow 2H_2O$
   b. $2Na + 2H_2O \rightarrow 2NaOH + H_2$
   c. $CaCO_3 \rightarrow CaO + CO_2$
   d. $Zn + S \rightarrow ZnS$

2. Choose decomposition reactions:
   a. $NH_3 + HCl \rightarrow NH_4Cl$
   b. $2KNO_3 \rightarrow 2KNO_2 + O_2$
   c. $N_2O_4 \rightarrow 2NO_2$
   d. $2Ag_2O \rightarrow 4Ag + O_2$

3. Choose single replacement reactions:
   a. $2K + 2H_2O \rightarrow 2KOH + H_2$
   b. $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$
   c. $KCl + AgNO_3 \rightarrow AgCl + KNO_3$
   d. $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

4. Choose double replacement reactions:
   a. $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$
   b. $CaO + 2HCl \rightarrow CaCl_2 + H_2O$
   c. $N_2 + 3H_2 \rightarrow 2NH_3$
   d. $ZnCl_2 + 2AgNO_3 \rightarrow 2AgCl + Zn(NO_3)_2$

5. Choose combustion reactions:
   a. $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$
   b. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
   c. $Mg + S \rightarrow MgS$
   d. $2Fe + O_2 \rightarrow 2FeO$

6. Which of the equations written above represent reduction-oxidation (redox) reactions?
   a. $2HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + 2H_2O$
   b. $2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$
   c. $Cl_2 + H_2O \rightarrow HCl + HClO$
   d. $3CaO + P_2O_5 \rightarrow Ca_3(PO_4)_2$

7. In which reactions hydrogen atoms act as reducers?

   a. $2H_2 + O_2 \rightarrow 2H_2O$

   b. $H_2 + 2K \rightarrow 2KH$

   c. $2HCl + Zn \rightarrow ZnCl_2 + H_2$

   d. $HCl + NH_3 \rightarrow NH_4Cl$

8. In which reactions sulfur atoms act as oxidizers:

   a. $H_2 + S \rightarrow H_2S$

   b. $Ca + S \rightarrow CaS$

   c. $H_2SO_{4\ (dilute)} + Zn \rightarrow ZnSO_4 + H_2$

   d. $2H_2SO_{4\ (concentrated)} + Zn \rightarrow ZnSO_4 + SO_2 + 2H_2O$

9. Choose appropriate characteristics of the following reaction: $3S + 2H_2O \rightarrow 2H_2S + SO_2$

   a. redox reaction

   b. single displacement reaction

   c. double displacement reaction

   d. disproportioning reaction for sulfur atoms

10. Choose appropriate characteristics of the following reaction: $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

   a. redox reaction

   b. single displacement reaction

   c. double displacement reaction

   d. composition reaction

TEST FOR HOMEWORK

1. Choose composition reactions:

   a. $2Ca + O_2 \rightarrow 2CaO$

   b. $2CaS + 3O_2 \rightarrow 2CaO + 2SO_2$

   c. $CO_2 + H_2O + CaCO_3 \rightarrow Ca(HCO_3)_2$

   d. $Zn + H_2S \rightarrow ZnS + H_2$

2. Choose decomposition reactions:

   a. $NH_4OH \rightarrow NH_3 + H_2O$

   b. $Ba(OH)_2 \rightarrow BaO + H_2O$

   c. $2CH_4 \rightarrow C_2H_2 + 3H_2$

   d. $2CO + O_2 \rightarrow 2CO_2$

3. Choose single replacement reactions:

   a. $SiO_2 + CaCO_3 \rightarrow CaSiO_3 + CO_2$

b. $Cl_2 + 2KI \rightarrow I_2 + 2KCl$

c. $Mg + H_2O$ (t°) $\rightarrow MgO + H_2$

d. $Al(OH)_3 + KOH$ (t°) $\rightarrow KAlO_2 + 2H_2O$

4. Choose double replacement reactions:

   a. $NaCl_{(solid)} + H_2SO_{4\ (concentrated)}$ $_{/(t°)}$ $\rightarrow NaHSO_4 + HCl$

   b. $NaOH + HCl \rightarrow NaCl + H_2O$

   c. $I_2 + H_2 \rightarrow 2HI$

   d. $Zn(OH)_2 + HCl \rightarrow ZnOHCl + H_2O$

5. Choose combustion reactions:

   a. $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

   b. $2Mg + CO_2 \rightarrow 2MgO + C$

   c. $CaO + H_2O \rightarrow Ca(OH)_2$

   d. $2NO + O_2 \rightarrow 2NO_2$

6. Which of the equations written above represent reduction-oxidation (redox) reactions?

   a. $H_2SO_3 \rightarrow SO_2 + H_2O$

   b. $4HNO_3 \rightarrow 4NO_2 + O_2 + 2H_2O$

   c. $K_2O + H_2O \rightarrow 2KOH$

   d. $2NO_2 + 2KOH \rightarrow KNO_2 + KNO_3 + H_2O$

7. In which reactions nitrogen atoms act as reducers?

   a. $3H_2 + N_2 \rightarrow 2NH_3$

   b. $4NH_3 + 5O_{2\ (catalyst)} \rightarrow 4NO + 6H_2O$

   c. $NH_3 + HNO_3 \rightarrow NH_4NO_3$

   d. $(NH_4)_2Cr_2O_7$ (t°) $\rightarrow N_2 + 4H_2O + Cr_2O_3$

8. In which reactions oxygen atoms act as oxidizers:

   a. $2H_2 + O_2 \rightarrow 2H_2O$

   b. $3O_2 \rightarrow 2O_3$

   c. $K_2Cr_2O_7 + 2KOH \rightarrow 2K_2CrO_4 + H_2O$

   d. $2H_2O_2 + S \rightarrow SO_2 + 2H_2O$

9. Choose appropriate characteristics of the following reaction: $NH_4NO_2 \rightarrow N_2 + 2H_2O$

   a. redox reaction

   b. composition reaction

   c. decomposition reaction

   d. conproportioning reaction for nitrogen atoms

10. Choose appropriate characteristics of the following reaction:

$Ca(HCO_3)_2 \rightarrow CaO + 2CO_2 + H_2O$

    a. redox reaction

    b. single displacement reaction

    c. double displacement reaction

    d. decomposition reaction

EXERCISES FOR CLASSWORK

1. **Write 3 samples of combination (composition) reaction for chlorides:**

_____
_____
_____

2. **Write 3 samples of decomposition reaction for salts:**

_____
_____
_____

3. **Write 3 samples of single displacement reaction with HCl:**

_____
_____
_____

4. **Write 3 samples of double displacement reaction with AgNO₃:**

_____
_____
_____

5. **Write 3 samples of neutralization reaction with KOH:**

_____
_____
_____

6. **Write 3 samples of combustion reaction in which CO₂ is a product:**

_____
_____
_____

7. **Write 2 samples of redox reaction in which hydrogen atoms are oxidizers:**

_____
_____

1. **Write 3 samples of combination (composition) reaction for sulfides:**

    _____
    _____
    _____

2. **Write 3 samples of decomposition reaction for acids:**

    _____
    _____
    _____

3. **Write 3 samples of single displacement reaction with H_2SO_4:**

    _____
    _____
    _____

4. **Write 3 samples of double displacement reaction with $BaCl_2$:**

    _____
    _____
    _____

5. **Write 3 samples of neutralization reaction with $Ba(OH)_2$:**

    _____
    _____
    _____

6. **Write 3 samples of combustion reaction in which SO_2 is a product:**

    _____
    _____
    _____

7. **Write 2 samples of redox reaction in which hydrogen atoms are reducers:**

    _____
    _____
    _____

LESSON 12. REDOX REACTIONS

EXERCISES FOR CLASSWORK

1. **Balance the following redox reactions using electron balancing, provide half-reactions of oxidation and reduction:**

$KBr + K_2Cr_2O_7 + H_2SO_4 \rightarrow Br_2 + Cr_2(SO_4)_3 + K_2SO_4 + H_2O$

_____

_____

$KMnO_4 + HCl \rightarrow MnCl_2 + Cl_2 + KCl + H_2O$

_____

_____

$NaBr + NaBrO_3 + H_2SO_4 \rightarrow Br_2 + Na_2SO_4 + H_2O$

_____

_____

$KMnO_4 + KNO_2 + KOH \rightarrow K_2MnO_4 + KNO_3 + H_2O$

_____

_____

$KMnO_4 + N_2O + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + Mn(NO_3)_2 + H_2O$

_____

_____
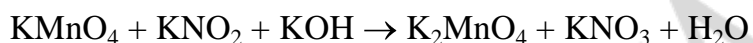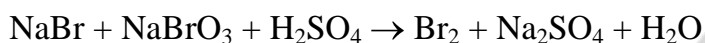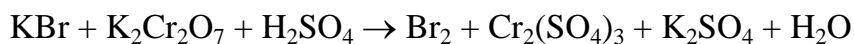
2. **What is the coefficient before $KMnO_4$ in the following reaction?**

$KMnO_4 + H_2S + H_2SO_4 \rightarrow MnSO_4 + S + K_2SO_4 + H_2O$

_____

_____

_____
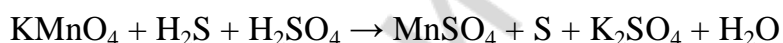
3. **What part of the total H_2SO_4 amount participated in the following reaction really acted as an oxidizer?**

$Cu + H_2SO_4 \rightarrow CuSO_4 + SO_2 + H_2O$

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Balance the following redox reactions using electron balancing, provide half-reactions of oxidation and reduction:**

$Na + HNO_3 \rightarrow NH_4NO_3 + NaNO_3 + H_2O$

_____

_____

$KBr + K_2Cr_2O_7 + H_2SO_4 \rightarrow Br_2 + Cr_2(SO_4)_3 + K_2SO_4 + H_2O$

_____

_____

$HI + H_2SO_4 \rightarrow I_2 + H_2S + H_2O$

_____

_____

$K_2Cr_2O_7 + Zn + H_2SO_4 \rightarrow ZnSO_4 + Cr_2(SO_4)_3 + K_2SO_4 + H_2O$

_____

_____

$Ca_3(PO_4)_2 + C + SiO_2 \rightarrow CaSiO_3 + P + CO$

_____

_____
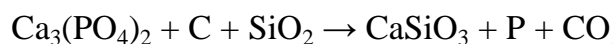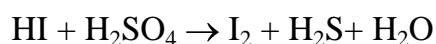
2. **What is the coefficient before $K_2Cr_2O_7$ in the following reaction?**

$K_2Cr_2O_7 + H_2S + H_2SO_4 \rightarrow Cr_2(SO_4)_3 + S + K_2SO_4 + H_2O$

_____

_____

_____

3. **What part of the total HNO_3 participated in the following reaction really acted as an oxidizer?**

$Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO_2 + H_2O$

_____

_____

_____

LESSON 13. CHEMICAL EQUILIBRIUM

EXERCISES FOR CLASSWORK

1. Write how different stresses will affect the equilibrium of the given system.

$2NOCl_{(g)} \leftrightarrow 2NO_{(g)} + Cl_{2(g)} + Q$

NOCl concentration increase: _____

NOCl concentration decrease: _____

NO concentration increase: _____

NO concentration decrease: _____

Cl_2 concentration increase: _____

Cl_2 concentration decrease: _____

Increase in pressure: _____

Decrease in pressure: _____

Increase in volume: _____

Decrease in volume: _____

Increase in temperature: _____

Decrease in temperature: _____

2. Write the expression of the constant of chemical equilibrium for the following processes.

$H_{2(g)} + F_{2(g)} \leftrightarrow 2HF_{(g)}$

_____

$CO_{2(g)} + C_{(s)} \leftrightarrow 2CO_{(g)}$

_____

$2NO_{(g)} + O_{2(g)} \leftrightarrow 2NO_{2(g)}$

_____

$N_2O_{(g)} + NO_{2(g)} \leftrightarrow 3NO_{(g)}$

_____
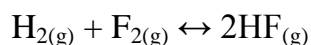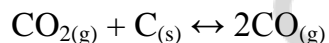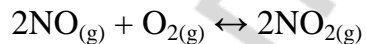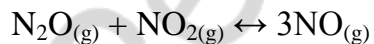
1. **Write how different stresses will affect the equilibrium of the given system.**

   $CO_{(g)} + 2H_{2(g)} \leftrightarrow CH_3OH_{(g)} + Q$
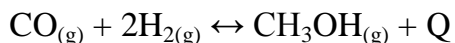
   CO concentration increase: _____

   CO concentration decrease: _____

   H_2 concentration increase: _____

   H_2 concentration decrease: _____

   CH_3OH concentration increase: _____

   CH_3OH concentration decrease: _____

   Increase in pressure: _____

   Decrease in pressure: _____

   Increase in volume: _____

   Decrease in volume: _____

   Increase in temperature: _____

   Decrease in temperature: _____

2. **Write the expression of the constant of chemical equilibrium for the following processes.**

   $CH_{4(g)} + 2H_2S_{(g)} \leftrightarrow CS_{2(g)} + 4H_{2(g)}$

   _____

   $SO_{2(g)} + NO_{2(s)} \leftrightarrow NO_{(g)} + SO_{3(g)}$

   _____

   $(NH_4)_2CO_{3(s)} \leftrightarrow 2NH_{3(g)} + CO_{2(g)} + H_2O_{(l)}$

   _____

   $2CO_{(g)} + O_{2(g)} \leftrightarrow 2CO_{2(g)}$

   _____
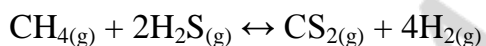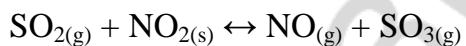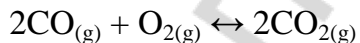
LESSON 14. CHEMICAL KINETICS

TEST FOR CLASSWORK

1. Which actions can shift the equilibrium of the following process towards reactants?
$2H_2S_{(g)} + 3O_{2(g)} \leftrightarrow 2SO_{2(g)} + 2H_2O_{(g)}$
   a. pressure increase
   c. addition of SO_2
   b. addition of O_2
   d. volume decrease

2. The increase of pressure will shift the equilibrium of $N_{2(g)} + O_{2(g)} \leftrightarrow 2NO_{(g)}$ reaction:
   a. towards reactants
   b. towards products
   c. it will not affect the equilibrium

3. The decrease of the volume of the gas container will shift the equilibrium of $2NO_{(g)} + O_{2(g)} \leftrightarrow 2NO_2$ process:
   a. towards reactants
   b. towards products
   c. it will not affect the equilibrium

4. How many times the velocity of $CO_{2(g)} + CaO_{(s)} \leftrightarrow CaCO_{3(s)}$ will grow in case of 3 times increase in CO_2 concentration?
   a. 2   b. 3   c. 4   d. 9

5. Indicate the change of the velocity of $2CO_{(g)} + O_{2(g)} \leftrightarrow 2CO_{2(g)}$ reaction in case of 3 times increase in CO concentration:
   a. 3 times increase
   c. 3 times decrease
   b. 9 times increase
   d. 9 times decrease

6. The velocity of endothermic reaction increases in case of:
   a. increase in temperature
   c. decrease in temperature
   b. increase in pressure
   d. decrease in pressure

7. The velocity of the reaction has become 4 times higher due to the growth of temperature from 30 to 50 °C. Find out the Q_{10} coefficient.
   a. 2   b. 3   c. 4   d. 5

8. How the velocity of the forward reaction $C_2H_{2(g)} + 2H_{2(g)} \rightarrow C_2H_{6(g)}$ will change in case of 2 times decrease in reactants concentration:
   a. decrease 2 times
   c. increase 16 times
   b. increase 4 times
   d. decrease 8 times

9. How the velocity of the forward reaction $N_{2\ (g)} + 6Li_{(s)} \rightarrow 2Li_3N_{(s)}$ will change in case of 3 times increase in pressure:
   a. increase 3 times   c. increase 2187 times
   b. decrease 3 times   d. decrease 2187 times

10. How the velocity of the forward reaction $2P_{(s)} + 3Cl_{2\ (g)} \rightarrow 2PCl_{3\ (g)}$ will change in case of 3 times increase of the volume of the gas container?
   a. increase 3 times   c. increase 27 times
   b. decrease 3 times   d. decrease 27 times

TEST FOR HOMEWORK

1. Which actions can shift the equilibrium of the following process towards products?
   $2H_2S_{(g)} + O_{2\ (g)} \leftrightarrow 2S_{(s)} + 2H_2O_{(g)}$
   a. pressure decrease   c. addition of H_2S
   b. addition of O_2 d. volume decrease

2. The decrease of pressure will shift the equilibrium of $2N_2O_{(g)} + O_{2\ (g)} \leftrightarrow 4NO_{(g)}$ reaction:
   a. towards reactants
   b. towards products
   c. it will not affect the equilibrium

3. The decrease of the volume of the gas container will shift the equilibrium of $P_{4\ (l)} + 6Cl_{2\ (g)} \leftrightarrow 4PCl_{3\ (l)}$ process:
   a. towards reactants
   b. towards products
   c. it will not affect the equilibrium

4. How many times the velocity of $PCl_{3\ (g)} + Cl_{2\ (g)} \leftrightarrow PCl_{5\ (g)}$ will grow in case of 3 times increase in Cl_2 concentration?
   a. 2   b. 3   c. 4   d. 9

5. Indicate the change of the velocity of $2P_{(s)} + 5O_{2\ (g)} \leftrightarrow 2P_2O_{5\ (s)}$ reaction in case of 2 times decrease in O_2 concentration:
   a. 4 times increase   c. 32 times increase
   b. 4 times decrease   d. 32 times decrease

6. The velocity of exothermic reaction increases in case of:
   a. increase in temperature   c. decrease in temperature
   b. increase in pressure   d. decrease in pressure

7. The velocity of the reaction has become 9 times higher due to the growth of temperature from 37 to 57 °C. Find out the Q_{10} coefficient.

   a. 2   b. 3   c. 4   d. 5

8. How the velocity of the forward reaction $2SO_{2\,(g)} + O_{2\,(g)} \rightarrow 2SO_{3\,(g)}$ will change in case of 3 times increase in reactants concentration:

   a. decrease 8 times   c. increase 27 times
   b. increase 9 times   d. decrease 4 times

9. How the velocity of the forward reaction $F_{2\,(g)} + H_{2\,(g)} \rightarrow 2HF_{(g)}$ will change in case of 2 times increase in pressure:

   a. increase 2 times   c. increase 4 times
   b. decrease 2 times   d. decrease 4 times

10. How the velocity of the forward reaction $CO_{(g)} + Cl_{2\,(g)} \rightarrow COCl_{2\,(g)}$ will change in case of 2 times increase of the volume of the gas container?

   a. increase 4 times   c. increase 2 times
   b. decrease 4 times   d. decrease 2 times

LESSON 15. THE SAMPLE OF CONTROL TASK #2

1. **Determine the oxidation state for each atom in the following compounds:**

   F_2O $Zn(NO_3)_2$ $MgSiO_3$ $NaCrO_2$ K_2HPO_4
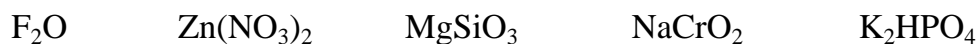
2. **Write down complete and short electron configurations for:**

   Na: _____

   S:_____

   P:_____

   Cu: _____

3. **Balance chemical reactions using electron balance method:**

   $FeSO_4 + KMnO_4 + H_2SO_4 \rightarrow MnSO_4 + K_2SO_4 + Fe_2(SO_4)_3 + H_2O$

   _____

   _____

   $HClO_3 + H_2SO_3 \rightarrow HCl + H_2SO_4$

   _____

   _____

   $NaOH + NO_2 \rightarrow NaNO_2 + NaNO_3 + H_2O$

   _____

   _____
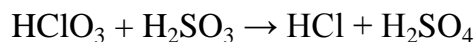
4. **Q10 coefficient for a given chemical reaction is equal to 3. How will the rates of this reaction change in case of 40 °C temperature increase?**

   _____

   _____

5. **Given this equilibrium, predict the direction of shift for each stress.**

   $4NH_{3(g)} + 5O_{2(g)} \leftrightarrow 4NO_{(g)} + 6H_2O_{(g)}$

   removal of NO: _____

   decrease of the volume of a gas container: _____

   the increase of the pressure: _____

LESSON 16. OXIDES

EXERCISES FOR CLASSWORK

1. **Write 5 samples of absolutely basic oxides:**

    _____

2. **Write 5 samples of absolutely acidic oxides:**

    _____

3. **Write 5 samples of amphoteric oxides:**

    _____

4. **Arrange these oxides (MnO / Mn_2O_7 / MnO_2 / MnO_3 / Mn_2O_3) in the order of the increase of their acidic properties:**

    _____

5. **Finish chemical reactions and balance them:**
    $CaO + SO_2 \rightarrow$ _____
    $Na_2O + SO_3 \rightarrow$ _____
    $Al_2O_3 + P_2O_5 \rightarrow$_____
    $CaO + H_2SO_4 \rightarrow$ _____
    $KOH + N_2O_5 \rightarrow$_____
    $SrO + H_2O \rightarrow$ _____
    $SO_3 + H_2O \rightarrow$ _____

6. **Calculate the mass of a salt produced in the reaction between 10 g of calcium oxide and 4 L of carbon dioxide (in normal conditions).**

    _____
    _____
    _____

7. **Find the mass of a salt formed in the reaction between 5 L of sulfur IV oxide (in normal conditions) and 2.3 g of barium oxide.**

    _____
    _____
    _____

EXERCISES FOR HOMEWORK

1. **Write 5 samples of basic anhydrides:**

   _____

2. **Write 5 samples of acidic anhydrides:**

   _____

3. **Write 5 samples of neutral oxides:**

   _____

4. **Arrange these oxides (CrO / CrO_6 / Cr_2O_3) in the order of the increase of their basic properties:**

   _____

5. **Finish chemical reactions and balance them:**
   $BaO + CO_2 \rightarrow$ _____
   $K_2O + SiO_2 \rightarrow$ _____
   $MgO + P_2O_5 \rightarrow$ _____
   $Na_2O + HNO_3 \rightarrow$ _____
   $LiOH + N_2O_3 \rightarrow$ _____
   $CaO + H_2O \rightarrow$ _____
   $SO_2 + H_2O \rightarrow$ _____
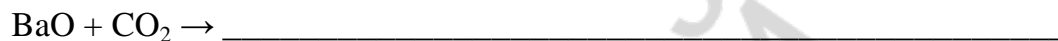
6. **Calculate the mass of a salt produced in the reaction between 8 g of strontium oxide and 9 g of silicon IV oxide.**

   _____
   _____
   _____

7. **Find the mass of a salt formed in the reaction between 3 L of sulfur VI oxide (in normal conditions) and 1.4 g of lithium oxide.**

   _____
   _____
   _____

LESSON 17. BASES

EXERCISES FOR CLASSWORK

1. **Write 5 samples of absolutely basic hydroxides:**

    _____

2. **Write 5 samples of alkalis:**

    _____

3. **Write 5 samples of amphoteric hydroxides:**

    _____

4. **Finish chemical reactions and balance them:**

    $NaOH + CO_2 \rightarrow$_____

    $KOH + SO_2 \rightarrow$_____

    $Na + H_2O \rightarrow$ _____

    $K_2O + H_2O \rightarrow$ _____

    $Ba(OH)_2 + N_2O_5 \rightarrow$ _____

    $Sr(OH)_2 + HNO_3 \rightarrow$_____

    $NaOH + Al(OH)_3 \rightarrow$ _____
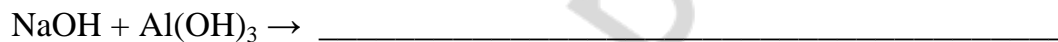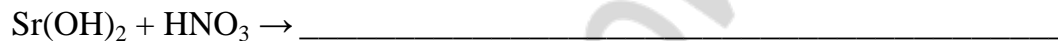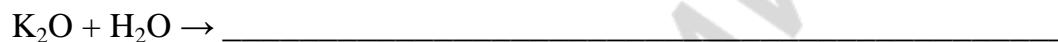
5. **Calculate the mass of an alkali produced in the reaction between 4 g of sodium and 50 g of water.**

    _____
    _____
    _____

6. **Find the maximal mass of oxide that can be produced due to thermal decomposition of 200 g of magnesium hydroxide.**

    _____
    _____
    _____

7. **What is the mass of a salt formed in the reaction between 5 g of solid potassium hydroxide and 8 g of aluminum oxide at high temperature?**

    _____
    _____
    _____

EXERCISES FOR HOMEWORK

1. **Write 5 samples of soluble metal hydroxides:**

   _____

2. **Write 5 samples of metal hydroxides which can be thermally decomposed:**

   _____

3. **Write 5 samples of diacidic metal hydroxides:**

   _____

4. **Finish chemical reactions and balance them:**

   $LiOH + SiO_2 \rightarrow$ _____

   $NaOH + P_2O_5 \rightarrow$ _____

   $Ca + H_2O \rightarrow$ _____

   $BaO + H_2O \rightarrow$ _____

   $Al(OH)_3 + SO_3 \rightarrow$ _____

   $Ca(OH)_2 + HNO_2 \rightarrow$ _____

   $KOH + Zn(OH)_2 \rightarrow$ _____
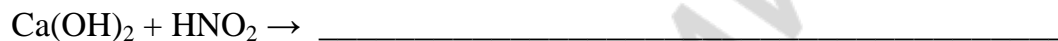
5. **Calculate the mass of an alkali produced in the reaction between 7 g of calcium oxide and 20 ml of water (density of water is 1 g/ml).**

   _____

   _____

   _____

6. **Find the maximal mass of water that can be produced due to thermal decomposition of 300 g of lithium hydroxide.**

   _____

   _____

   _____

7. **What is the mass of a salt formed in the reaction between 4 g of solid sodium hydroxide and 7 g of zinc oxide at high temperature?**

   _____

   _____

   _____

LESSON 18. ACIDS

EXERCISES FOR CLASSWORK

1. **Write 7 strong acids:**

    _____

2. **Write 5 samples of monoprotic acids:**

    _____

3. **Finish chemical reactions and balance them:**

    $Zn + H_2SO_4 \rightarrow$ _____

    $KOH + HNO_3 \rightarrow$ _____

    $CaO + HCl \rightarrow$_____

    $Na_2CO_3 + CH_3COOH \rightarrow$ _____

    $K_2SiO_3 + HBr \rightarrow$ _____

4. **Calculate the volume of hydrogen (in normal conditions) released in the reaction between 6 g of zinc and 10 g of sulfuric acid.**

    _____

    _____

    _____

5. **Find the volume of carbon dioxide (in normal conditions) produced in the reaction between 5 g of sodium carbonate and 17 g of hydrochloric acid.**

    _____

    _____

    _____

6. **What is the mass of a salt formed in the reaction between 13 g of sodium hydroxide and 8 g of hydrobromic acid?**

    _____

    _____

    _____

7. **Find the mass of sulfuric acid produced from 8 L of sulfur VI oxide in its reaction with water (in normal conditions).**

    _____

    _____

    _____

EXERCISES FOR HOMEWORK

1. **Write 5 samples of weak acids:**

   _____

2. **Write 5 samples of diprotic acids:**

   _____

3. **Finish chemical reactions and balance them:**

   $Al + H_2SO_4 \rightarrow$ _____

   $LiOH + HNO_2 \rightarrow$ _____

   $BaO + HI \rightarrow$ _____

   $K_2CO_3 + H_2C_2O_4 \rightarrow$ _____

   $H_2SiO_3 + KOH \rightarrow$ _____

4. **Calculate the volume of hydrogen (in normal conditions) released in the reaction between 3 g of aluminum and 6 g of hydrochloric acid.**

   _____
   _____
   _____

5. **Find the mass of a salt produced in the reaction between 4 g of potassium carbonate and 10 g of sulfuric acid.**

   _____
   _____
   _____

6. **What is the mass of a salt formed in the reaction between 11 g of lithium hydroxide and 28 g of hydroiodic acid?**

   _____
   _____
   _____

7. **Find the mass of orthophosphoric acid produced from 6 g of phosphorus V oxide in its reaction with water.**

   _____
   _____
   _____

LESSON 19. SALTS

EXERCISES FOR CLASSWORK

1. **Write 5 samples of acidic salts:**

   _____

2. **Write 5 samples of basic salts:**

   _____

3. **Which metals from this line (Na / Fe / Zn / Ag / Ba / Ni) can substitute copper in $CuCl_2$ in water solution?** _____

4. **Finish chemical reactions and balance them, notice the coefficients:**

   $2NaOH + 1H_2SO_3 \rightarrow$ _____

   $1NaOH + 1H_2SO_3 \rightarrow$ _____

   $1Zn(OH)_2 + 2HCl \rightarrow$ _____

   $1Zn(OH)_2 + 1HCl \rightarrow$ _____

   $1KHSiO_3 + 1KOH \rightarrow$ _____

   $1KHSiO_3 + 1HCl \rightarrow$ _____

   $Al(OH)_3 + 1KOH \rightarrow$ _____

5. **Determine what kind of salt(s) is formed in the reaction between 2 g of sodium hydroxide and 25 g of phosphoric acid, find its mass.**

   _____
   _____
   _____
   _____

6. **Find what kind of salt(s) is formed in the reaction between 4 g of potassium hydroxide and 3.5 L (normal conditions) of carbon dioxide.**

   _____
   _____
   _____
   _____

1. **Write 5 samples of acids which can form acidic salts:**

   _____

2. **Write 5 samples of bases salts which can form basic salts:**

   _____

3. **Which metals from this line (K / Cr / Zn / Ag / Sn / Ni) can substitute cobalt in $CoCl_2$ in water solution?** _____

4. **Finish chemical reactions and balance them, notice the coefficients:**

   $2NaOH + 1CO_2 \rightarrow$ _____

   $1NaOH + 1CO_2 \rightarrow$ _____

   $1Mg(OH)_2 + 2HNO_3 \rightarrow$ _____

   $1Mg(OH)_2 + 1HNO_3 \rightarrow$ _____

   $ZnOHCl_2 + 1NaOH \rightarrow$ _____

   $ZnOHCl_2 + 1HCl \rightarrow$ _____

   $Al(OH)_3 + 3KOH \rightarrow$ _____
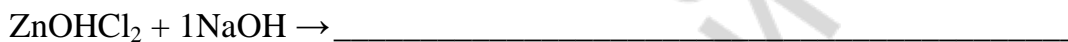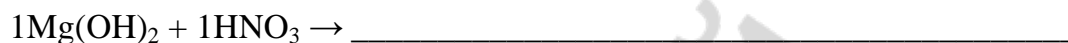
5. **Determine what kind of salt(s) is formed in the reaction between 3 g of potassium hydroxide and 4 g of phosphoric acid, find its mass.**

   _____

   _____

   _____

   _____

6. **Find what kind of salt(s) is formed in the reaction between 7 g of sodium hydroxide and 1.2 g of zinc hydroxide, find its mass.**

   _____

   _____

   _____

   _____

LESSON 20. INORGANIC COMPOUNDS

TEST FOR CLASSWORK

1. Choose basic oxides:
    a. SiO_2 b. K_2O c. ZnO d. SrO

2. Choose acidic oxides:
    a. CO b. CO_2 c. BaO d. SO_2

3. Choose amphoteric oxides:
    a. Al_2O_3 b. ZnO c. SiO d. Cr_2O_3

4. Choose neutral oxides (those which cannot form salts):
    a. NO b. SiO_2 c. MgO d. N_2O

5. Choose strong acids:
    a. HCl b. HBr c. HI d. HF

6. Choose strong bases:
    a. $Be(OH)_2$ b. $Sr(OH)_2$ c. KOH d. $LiOH$

7. Choose acidic salts:
    a. NH_4NO_3 b. $NH_4H_2PO_4$ c. $KHCO_3$ d. $(MgOH)_2CO_3$

8. Choose bases which cannot be formed in the reaction between corresponding oxide and water:
    a. $Al(OH)_3$ b. $NaOH$ c. KOH d. $Zn(OH)_2$

9. Choose salts which can react with the acid containing the same anion:
    a. KNO_3 b. Na_2SO_3 c. K_3PO_4 d. KH_2PO_4

10. Choose salts which can react with alkali:
    a. $NaCl$ b. KBr c. $MgCl_2$ d. $AlPO_4$

TEST FOR HOMEWORK

1. Choose basic oxides:
    a. CaO b. Mn_2O_7 c. CrO_3 d. Cs_2O

2. Choose acidic oxides:
    a. SO_2 b. BeO c. N_2O_5 d. H_2O_2

3. Choose amphoteric oxides:
    a. Fe_2O_3 b. MnO_2 c. P_2O_3 d. Na_2O

4. Choose neutral oxides (those which cannot form salts):
   a. CO   b. SiO   c. CaO   d. SrO

5. Choose weak acids:
   a. H_2SO_4 b. HNO_3 c. HNO_2 d. H_2SO_3

6. Choose weak bases:
   a. $Fe(OH)_2$ b. $Cu(OH)_2$ c. NaOH   d. NH_4OH

7. Choose basic salts:
   a. CaOHCl   b. $(MgOH)_2SO_4$ c. $K[Al(OH)_4]$ d. $FeCl_3$

8. Choose bases which cannot be formed in the reaction between corresponding oxide and water:
   a. $Fe(OH)_3$ b. LiOH   c. CsOH   d. $Fe(OH)_2$

9. Choose salts which can react with the acid containing the same anion:
   a. KCl   b. $NaHCO_3$ c. K_3PO_4 d. K_2HPO_4

10. Choose salts which can react with alkali:
    a. NH_4Cl b. $ZnBr_2$ c. NaCl   d. $BaCl_2$

EXERCISES FOR CLASSWORK

1. Write four reactions according to the following classic chains of chemical reactions and balance them:

$K \rightarrow KOH \rightarrow K_2SO_3 \rightarrow KOH \rightarrow K_2S$

1. _____
2. _____
3. _____
4. _____

$Al \rightarrow AlCl_3 \rightarrow Al(OH)_3 \rightarrow NaAlO_2 \rightarrow Al_2(SO_4)_3$

1. _____
2. _____
3. _____
4. _____

$Mg(OH)_2 \rightarrow MgO \rightarrow Mg(NO_3)_2 \rightarrow Mg(OH)_2 \rightarrow MgOHCl$

1. _____
2. _____
3. _____
4. _____

$Zn(OH)_2 \rightarrow K_2[Zn(OH)_4] \rightarrow ZnCl_2 \rightarrow Zn(OH)_2 \rightarrow ZnO$

1. _____

2. _____

3. _____

4. _____

2. **Write four reactions with _sodium_ containing compounds according to the chain of chemical reactions**

$Na \xrightarrow{+ H_2O} A \xrightarrow{+ HI} B \xrightarrow{+ Cl_2} C \xrightarrow{+ AgNO_3} D$

1. _____

2. _____

3. _____

4. _____
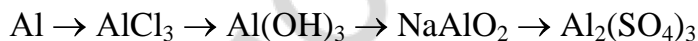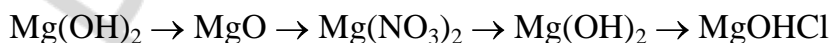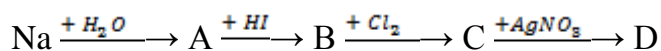
Calculate the sum of molar masses for substances B and D:

_____

_____

3. **Write four reactions with _silicon_ containing compounds according to the chain of chemical reactions**

$Si \xrightarrow{+ O_2} A \xrightarrow{+ 2NaOH} B \xrightarrow{+ H_2SO_4} C \xrightarrow{+2KOH} D$

1. _____

2. _____

3. _____

4. _____
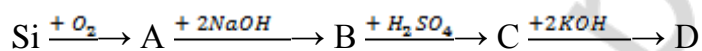
Calculate the sum of molar masses for substances B and D:

_____

_____

EXERCISES FOR HOMEWORK

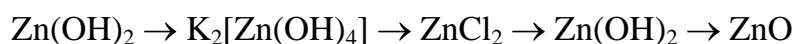1. **Write four reactions according to the following classic chains of chemical reactions and balance them:**

$Mg \rightarrow MgO \rightarrow Mg(NO_3)_2 \rightarrow Mg(OH)_2 \rightarrow MgSO_4$

1. _____

2. _____

3. _____

4. _____

$CaCO_3 \rightarrow Ca(HCO_3)_2 \rightarrow CaO \rightarrow CaSO_3 \rightarrow Ca(NO_3)_2$

1. _____

2. _____

3. _____

4. _____

$P \rightarrow P_2O_5 \rightarrow Na_3PO_4 \rightarrow Na_2HPO_4 \rightarrow Ba_3(PO_4)_2$

1. _____

2. _____

3. _____

4. _____

$K \rightarrow K_2O \rightarrow K_2S \rightarrow KCl \rightarrow KNO_3$

1. _____

2. _____

3. _____

4. _____
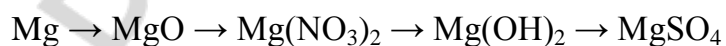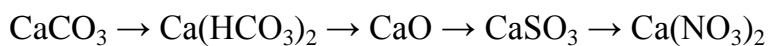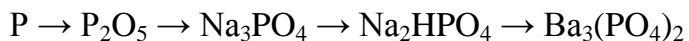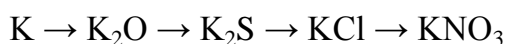
2. **Write four reactions with _zinc_ containing compounds according to the chain of chemical reactions**

$Zn \xrightarrow{+ O_2} A \xrightarrow{+ 2HCl} B \xrightarrow{+ 2NaOH} C \xrightarrow{+2NaOH \ (in \ water \ solution)} D$

1. _____

2. _____

3. _____

4. _____
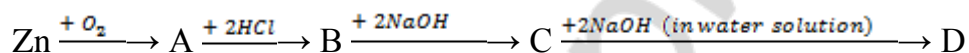
Calculate the sum of molar masses for substances C and D:

_____

_____

3. **Write four reactions with _magnesium_ containing compounds according to the chain of chemical reactions**

$Mg \xrightarrow{+HCl} A \xrightarrow{+ KOH \ (in \ excess)} B \xrightarrow{t} C \xrightarrow{P_2O_5} D$

1. _____

2. _____

3. _____

4. _____
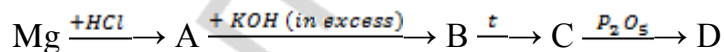
Calculate the sum of molar masses for substances C and D:

_____

_____

LESSON 21. THE SAMPLE OF CONTROL TASK #3

1. **Write down equations of chemical reactions between the following substances (in case if they are possible) and balance them:**
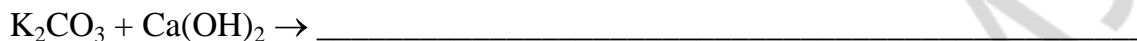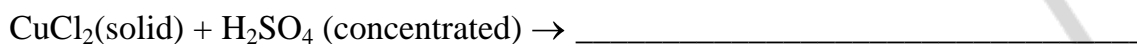
$CuCl_2$(solid) + H_2SO_4 (concentrated) $\rightarrow$ _____

$FeCl_3$ + $AgNO_3$ $\rightarrow$ _____

K_2CO_3 + $Ca(OH)_2$ $\rightarrow$ _____

K + H_2O $\rightarrow$ _____

Ag + H_2SO_4(diluted) $\rightarrow$ _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$C \rightarrow CO_2 \rightarrow NaHCO_3 \rightarrow Na_2CO_3 \rightarrow CaCO_3$
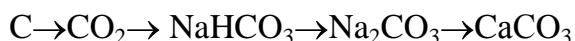
1. _____
2. _____
3. _____
4. _____

3. **Write four reactions with _chlorine_ containing compounds according to the chain of chemical reactions**

$Cl_2 \xrightarrow{+H_2} A \xrightarrow{+Al} B \xrightarrow{+3NaOH} C \xrightarrow{+AgNO_3} D$
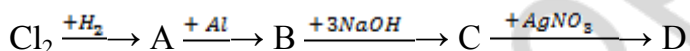
1. _____
2. _____
3. _____
4. _____

4. **What salt (potassium sulfite, potassium hydrogen sulfite, or the mixture of them) will be formed from 16.8 g of potassium hydroxide and 6.7 L of sulfurous acid anhydride? Calculate the mass of that salt.**

_____
_____
_____
_____

LESSON 22. SOLUBILITY

TEST FOR CLASSWORK

1. Choose insoluble (solubility < 0.1 g per 100 g of H_2O) salts:
    a. KCl   b. Na_2SO_4 c. $CaCO_3$ d. $BaSO_4$

2. Choose soluble (solubility > 1 g per 100 g of H_2O) salts:
    a. NaI   b. $Zn(NO_3)_2$ c. AgCl   d. $Zn_3(PO_4)_2$

3. Slightly soluble salt (with solubility between 0.1 and 1 g per 100 g of H_2O) is considered to be insoluble in the written form of chemical reaction:
    a. if it is a reactant
    b. if it is a product
    c. always
    d. never

4. Will there be a precipitate if we put 0.5 mg or 0.05 mg of $CaCO_3$ in 200 g of water ($CaCO_3$ solubility is 0.0006 g per 100 g of H_2O)?
    a. Yes / Yes   b. Yes / No   c. No / Yes   d. No / No

5. Which substances demonstrate good solubility in water?
    a. O_2 b. C_2H_5OH c. N_2 d. HCl

6. Which substances demonstrate good solubility in benzene?
    a. CH_4 b. C_7H_8 c. H_2O d. C_6H_{14}

7. How can we dissolve a precipitate in water solution?
    a. increase the temperature
    b. decrease the temperature
    c. add more water
    d. add a substance which reacts with that precipitate

8. Molarity is the ratio between:
    a. the mass of a solute and the mass of a solution
    b. the number of moles of a solute and the mass of a solvent
    c. the number of moles of a solute and the volume of a solution
    d. the volume of a solute and the volume of a solution

9. Mass percentage is the ratio between:
    a. the mass of a solute and the mass of a solvent
    b. the number of moles of a solute and the mass of a solution

c. the mass of a solute and the mass of a solution

d. the number of moles of a solute and the volume of a solution

10. Choose true statements about saturated solution:

a. saturated solution exists upon the precipitate of a solute

b. saturated solution cannot dissolve more solute

c. saturated solution is always considered as concentrated solution

d. saturated solution may have rather low concentration

TEST FOR HOMEWORK

1. Choose insoluble (solubility < 0.1 g per 100 g of H_2O) salts:
   a. $MgSO_4$ b. $(NH_4)_2SO_4$ c. $SrCO_3$ d. K_2SiO_3

2. Choose soluble (solubility > 1 g per 100 g of H_2O) salts:
   a. $BaCl_2$ b. HNO_3 c. $NiCl_2$ d. KOH

3. Slightly soluble salt (with solubility between 0.1 and 1 g per 100 g of H_2O) is considered to be soluble in the written form of chemical reaction:
   a. if it is a reactant
   b. if it is a product
   c. always
   d. never

4. Will there be a precipitate if we put 100 g or 10 g of KBr in 100 g of water (KBr solubility is 70.7 g per 100 g of H_2O)?
   a. Yes / Yes   b. Yes / No   c. No / Yes   d. No / No

5. Which substances demonstrate low solubility in water?
   a. H_2 b. CH_3COOH c. $HCOOH$ d. H_2SiO_3

6. Which substances demonstrate low solubility in benzene?
   a. C_2H_2 b. $NaOH$ c. $Mg(OH)_2$ d. C_4H_8

7. How can we produce a precipitate in water solution?

a. increase the temperature, dissolve high amount of solute, then cool down the solution

b. increase the temperature and wait until sufficient amount of water will be evaporated, then cool down the solution

c. add more water

d. add a substance which produces precipitate in reaction with a given solute

8. Molality is the ratio between:
   a. the mass of a solute and the mass of a solvent
   b. the number of moles of a solute and the mass of a solvent
   c. the number of moles of a solute and the mass of a solution
   d. the mass of a solute and the volume of a solution

9. Mole fraction is the ratio between:
   a. the mass of a solute and the mass of a solvent
   b. the number of moles of a solute and the number of moles of all components of a solution
   c. the volume of a solute and the mass of a solution
   d. the number of moles of a solute and the mass of a solution

10. Choose true statements about unsaturated solution:
    a. unsaturated solution always have rather low concentration
    b. unsaturated solution can dissolve more solute
    c. unsaturated solution can dissolve more solvent
    d. unsaturated solution may become saturated at lower temperature

LESSON 23. MASS PERCENTAGE AND MOLARITY

EXERCISES FOR CLASSWORK

1. Convert the molarity (0.001 mol/L) of the H_2SO_4 solution into the mass percentage. The density is approximately equal to 1 g/ml.

   _____

   _____

   _____

2. Calculate the molarity of $Ba(OH)_2$ in the final volume of 750 ml, if the initial mass of $Ba(OH)_2$ was equal to 17 g.

   _____

   _____

   _____

3. Calculate the mass percentage of KOH solution made from 30 g of KOH dissolved in water until the final volume of 300 ml. The density of the solution is equal to 0.92 g/ml.

   _____

   _____

   _____

4. Calculate the mass of KOH needed to make 400 ml of solution with mass percentage of 15 % and density equal to 0.85 g/ml.

   _____

   _____

   _____

5. Calculate the number of moles of $Ba(OH)_2$ present in 950 ml of solution with the molarity equal to 0.03 mol/L

   _____

   _____

   _____

6. Calculate the molarity of the water solution made from 40 g of Na_2SO_4, if the final volume is 1200 ml.

   _____

   _____

   _____

7. Calculate the mass percentage of sodium hydroxide in the water solution made from 12 g of NaOH and 68 ml of pure water.

_____

_____

_____

8. Find the mass of $CuSO_4 \cdot 5H_2O$ which is needed to prepare 1 L of $CuSO_4$ water solution with the molarity equal to 0.02 mol/L.

_____

_____

_____

9. Calculate the mass of a precipitate formed after the mixing of 20 ml of 0.02 M potassium chloride and 15 ml of 0.01 M silver nitrate solutions.

_____

_____

_____

10. Calculate the mass of a precipitate formed after the mixing of 40 ml of 0.01 M sodium sulfate and 35 ml of 0.02 M strontium chloride solutions.

_____

_____

_____

EXERCISES FOR HOMEWORK

1. Convert the mass percentage (0.85 %) of the NaCl water solution into the molarity. The density is approximately equal to 1 g/ml.

_____

_____

_____

2. Calculate the molarity of LiOH in the final volume of 300 ml, if the initial mass of LiOH was equal of 7 g.

_____

_____

_____

3. Calculate the mass percentage of NaOH solution made from 23 g of NaOH dissolved in water until the final volume of 200 ml. The density of the solution is equal to 0.91 g/ml.

_____

_____

4. **Calculate the mass of KCl needed to make 200 ml of solution with mass percentage of 5 % and density equal to 0.95 g/ml.**

_____

_____

_____

5. **Calculate the number of moles of $Sr(OH)_2$ present in 650 ml of solution with the molarity equal to 0.09 mol/L**

_____

_____

_____

6. **Calculate the molarity of the water solution made from 10 g of H_2SO_4, if the final volume is 2400 ml.**

_____

_____

_____

7. **Calculate the mass percentage of potassium hydroxide in the water solution made from 15 g of KOH and 135 ml of pure water.**

_____

_____

_____

8. **Find the mass of $Na_2SO_4 \cdot 10H_2O$ which is needed to prepare 1 L of Na_2SO_4 water solution with the mass percentage equal to 0.5 %. The density is 1 g/ml.**

_____

_____

_____

9. **Calculate the mass of a precipitate formed after the mixing of 30 ml of 0.03 M barium chloride and 20 ml of 0.02 M lithium sulfate solutions.**

_____

_____

_____

10. **Calculate the mass of a precipitate formed after the mixing of 70 ml of 0.02 M potassium silicate and 10 ml of 0.1 M hydrochloric acid solutions.**

_____

_____

_____

LESSON 24. ELECTROLYTIC DISSOCIATION

EXERCISES FOR CLASSWORK

1. **Write 5 samples of strong electrolytes:**

_____

2. **Write 5 samples of weak electrolytes:**

_____

3. **Write equations of electrolytic dissociation for the following substances:**

HCl: _____

H_2SO_4: _____

$LiOH$: _____

$Ca(OH)_2$:_____

4. **Write equations of _stepwise_ dissociation for the following substances:**

H_2SO_3: _____

_____

H_3PO_4: _____

_____

_____

$NaHCO_3$: _____

_____

$ZnOHCl$:_____

_____

5. **How many types of ions are formed in the process of electrolytic dissociation of the following substances:**

K_3PO_4: _____

K_2HPO_4: _____

KH_2PO_4: _____

$MgCl_2$: _____

$MgOHCl$: _____

6. **What is the number of moles of ions formed after the dissociation of 1 mole of the following substances:**

$NaCl$: _____

$MgCl_2$: _____

$AlCl_3$: _____

$Al_2(SO_4)_3$: _____

$Ba(OH)_2$:_____

7. **Calculate the molar concentration of chloride ions in the water solution prepared from 10 g of aluminum chloride. The final volume is 300 ml.**

_____
_____
_____

8. **Calculate the molar concentration of sulfate ions in the water solution prepared from 15 g of potassium sulfate. The final volume is 400 ml.**

_____
_____
_____

9. **Calculate the molar concentration of all ions in the water solution prepared from 20 g of barium chloride. The final volume is 2 L.**

_____
_____
_____

10. **Calculate the molar concentration of hydrogen ions in the water solution prepared from 5 L of hydrogen chloride (in normal conditions). The final volume is 500 ml.**

_____
_____
_____

<div align="center">

EXERCISES FOR HOMEWORK

</div>

1. **Write 5 samples of nonelectrolytes:**

_____

2. **Write 5 samples of substances which have two steps of dissociation:**

_____

3. **Write equations of electrolytic dissociation for the following substances:**
   NaOH: _____
   $Ba(OH)_2$:_____
   HI:_____
   $HClO_4$: _____

4. **Write equations of _stepwise_ dissociation for the following substances:**
   H_2S: _____

   _____

   $Al(OH)_3$:_____

   _____
   _____

KHSO₃:_____

_____

CuOHBr: _____

_____

5. **How many types of ions are formed in the process of electrolytic dissociation of the following substances:**

K_2SO_4: _____

$KHSO_4$:_____

$KHSiO_3$: _____

$AlCl_3$: _____

$Al(OH)_2Cl$: _____

6. **What is the number of moles of ions formed after the dissociation of 1 mole of the following substances:**

KI:_____

Na_2SO_4: _____

CaI_2: _____

CH_3COOK:_____

$Sr(OH)_2$: _____

7. **Calculate the molar concentration of sodium ions in the water solution prepared from 13 g of sodium sulfate. The final volume is 200 ml.**

_____

_____

8. **Calculate the molar concentration of potassium ions in the water solution prepared from 3 g of potassium. The final volume is 100 ml.**

_____

_____

9. **Calculate the molar concentration of hydrogen ions in the water solution prepared from 4 g of potassium hydrogen sulfate. The final volume is 200 ml.**

_____

_____

10. **Calculate the total molar concentration of all phosphate, hydrogen phosphate and dihydrogen phosphate anions in the water solution prepared from 14 g of sodium phosphate. The final volume is 400 ml.**

_____

_____

_____

LESSON 25. IONIC EQUATIONS

EXERCISES FOR CLASSWORK

1. **Continue equations of chemical reactions, balance and write complete and short ionic equations for them:**

    $H_2SO_4 + NaOH \rightarrow$ _____

    _____

    _____

    $H_2S + KOH \rightarrow$ _____

    _____

    _____

    $Zn(OH)_2 + H_2SO_4 \rightarrow$ _____

    _____

    _____

    $BaCl_2 + K_2SO_4 \rightarrow$_____

    _____

    _____

    $CaCl_2 + Na_2CO_3 \rightarrow$ _____

    _____

    _____

2. **Suggest a chemical reaction which can be expressed by the given short ionic equation and write it down:**

    $Ag^+ + I^- = AgI$

    _____

    $H^+ + OH^- = H_2O$

    _____

    $Al^{3+} + 3OH^- = Al(OH)_3$

    _____
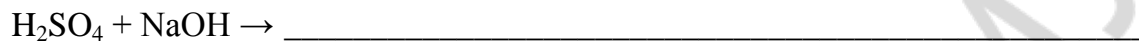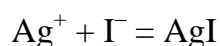
EXERCISES FOR HOMEWORK

1. **Continue equations of chemical reactions, balance and write complete and short ionic equations for them:**

    $H_3PO_4 + KOH \rightarrow$ _____

    _____

$K_2S + HCl \rightarrow$ _____

_____

_____

$Ba(NO_3)_2 + H_2SO_4 \rightarrow$ _____

_____

_____

$NH_4Cl + AgNO_3 \rightarrow$ _____

_____

_____

$CaCl_2 + Na_2SO_4 \rightarrow$ _____

_____

_____

2. **Suggest a chemical reaction which can be expressed by the given short ionic equation and write it down:**

$Ca^{2+} + 2F^- = CaF_2$ _____

_____

$CO_3^{2-} + 2H^+ = CO_2 + H_2O$ _____

_____

$Zn^{2+} + 4OH^- = [Zn(OH)_4]^{2-}$ _____

_____
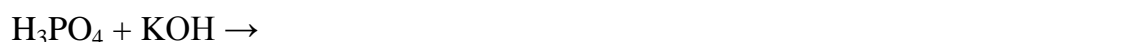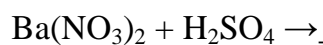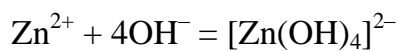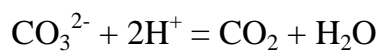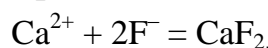
LESSON 26. HYDROLYSIS OF INORGANIC SALTS

TEST FOR CLASSWORK

1. Which ions are present in NaH_2PO_4 solution?
   a. Na^+ b. $H_2PO_4^-$ c. HPO_4^{2-} d. NaH_2^{3+}

2. Choose strong electrolytes:
   a. $NaCl$ b. KNO_2 c. $C_6H_{12}O_6$ d. HNO_2

3. Choose weak electrolytes:
   a. C_2H_5OH b. CH_3COOH c. $AgNO_3$ d. $Zn(OH)_2$

4. Which reactions can be expressed by the same ionic equation?
   a. $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$
   b. $Na_2O + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$
   c. $2Na_3PO_4 + 3Li_2SO_4 \rightarrow 3Na_2SO_4 + 2Li_3PO_4$
   d. $KOH + HNO_3 \rightarrow KNO_3 + H_2O$

5. Choose the correct ionic equation for the following reaction:
   $Na_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 + 2NaOH$
   a. $CO_3^{2-} + Ca(OH)_2 \rightarrow CaCO_3 + 2OH^-$
   b. $CO_3^{2-} + Ca^{2+} \rightarrow CaCO_3$
   c. $Na^+ + OH^- \rightarrow NaOH$
   d. $Na_2CO_3 + Ca^{2+} \rightarrow CaCO_3 + 2Na^+$

6. In water solutions of which substances there is acidic medium (pH < 7)?
   a. HCl b. H_2S c. $ZnCl_2$ d. KCl

7. In water solutions of which substances there is basic medium (pH > 7)?
   a. H_2SO_4 b. K_3PO_4 c. NH_3 d. NH_4Cl

8. What substances will be formed if we mix solutions of K_2S and $AlCl_3$ together?
   a. H_2S b. Cl_2 c. Al_2S_3 d. $Al(OH)_3$

9. Dissolving HCl in water includes such steps, as:
   a. ionization and dissociation   c. just ionization
   b. just dissociation   d. neither ionization, nor dissociation

10. Dissolving $ZnCl_2$ in water includes such steps, as:
    a. ionization and dissociation   c. just dissociation
    b. dissociation and partial hydrolysis   d. just complete hydrolysis

TEST FOR HOMEWORK

1. Which ions are present in NH_4Cl solution?
   a. N^{3+} b. NH_4^+ c. H^+ d. Cl^-

2. Choose strong electrolytes:
   a. $NaOH$ b. NO_2 c. $HClO_4$ d. H_2O_2

3. Choose weak electrolytes:
   a. C_3H_7OH b. CH_3NH_2 c. HI d. $Ca(OH)_2$

4. Which reactions can be expressed by the same ionic equation?
   a. $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$
   b. $Ba + H_2SO_4 \rightarrow BaSO_4 + H_2$
   c. $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$
   d. $Ba(NO_3)_2 + K_2SO_4 \rightarrow 2KNO_3 + BaSO_4$

5. Choose the correct ionic equation for the following reaction:
   $HCl + KOH \rightarrow KCl + H_2O$
   a. $HCl + OH^- \rightarrow Cl^- + H_2O$
   b. $K^+ + Cl^- \rightarrow KCl$
   c. $H^+ + OH^- \rightarrow H_2O$
   d. $KOH + H^+ \rightarrow K^+ + H_2O$

6. In water solutions of which substances there is acidic medium (pH < 7)?
   a. CO_2 b. $AlCl_3$ c. $FeBr_2$ d. K_2SO_3

7. In water solutions of which substances there is basic medium (pH > 7)?
   a. NO_2 b. KNO_2 c. Na_2SiO_3 d. $NaCl$

8. What substances will be formed if we mix solutions of Na_2SO_3 and $CrCl_3$ together?
   a. SO_2 b. Cr c. $Cr(OH)_3$ d. $NaCl$

9. Dissolving $NaCl$ in water includes such steps, as:
   a. ionization and dissociation   c. just ionization
   b. just dissociation   d. neither ionization, nor dissociation

10. Dissolving Na_3PO_4 in water includes such steps, as:
    a. ionization and dissociation   c. just dissociation
    b. dissociation and partial hydrolysis   d. just complete hydrolysis

EXERCISES FOR CLASSWORK

1. **Write the equation of hydrolysis for given substances, provide its complete and short ionic forms.**

   $KNO_2 + H_2O \leftrightarrow$ _____

   _____

   _____

   $NH_4NO_3 + H_2O \leftrightarrow$ _____

   _____

   _____

   $CH_3COONa + H_2O \leftrightarrow$ _____

   _____

   _____

2. **Write the equation of stepwise hydrolysis for given substances, provide its complete and short ionic forms.**

   $Na_2CO_3 + H_2O \leftrightarrow$ _____

   _____

   _____

   _____

   _____

   _____

   $FeCl_2 + H_2O \leftrightarrow$ _____

   _____

   _____

   _____

   _____

   _____

EXERCISES FOR HOMEWORK

1. **Write the equation of hydrolysis for given substances, provide its complete and short ionic forms.**

   $LiF + H_2O \leftrightarrow$ _____

   _____

   _____

$NH_4Cl + H_2O \leftrightarrow$ _____

_____

_____

$CH_3COOK + H_2O \leftrightarrow$ _____

_____

_____

2. **Write the equation of stepwise hydrolysis for given substances, provide its complete and short ionic forms.**

$K_2SO_3 + H_2O \leftrightarrow$ _____

_____

_____

_____

_____

_____

$MgCl_2 + H_2O \leftrightarrow$ _____

_____

_____

_____

_____

_____
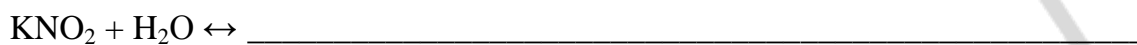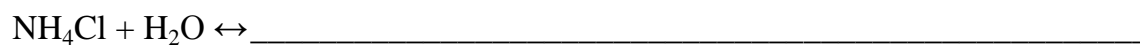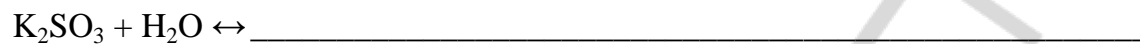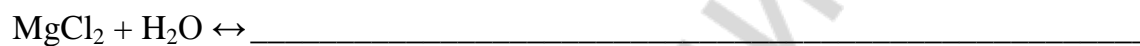
LESSON 27. THE SAMPLE OF CONTROL TASK #4

1. **Suggest a chemical reaction which can be expressed by the given short ionic equation and write it down:**

$3Ca^{2+} + 2PO_4^{3-} \rightarrow Ca_3(PO_4)_2$

_____
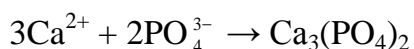
2. **Continue equations of chemical reactions, balance and write complete and short ionic equations for them:**

$Ca(OH)_2 + H_3PO_4 \rightarrow$ _____

_____

_____

_____

3. **Write the equation of stepwise hydrolysis for given substances, provide its complete and short ionic forms.**

$ZnSO_4 + H_2O \leftrightarrow$ _____

_____

_____

_____

_____

_____

4. **Indicate the pH level in water solutions of the following substances:**

$CaCl_2$ _____

$FeBr_3$_____

Li_3PO_4_____

NH_4NO_2 _____
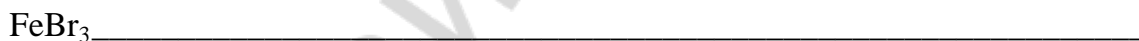
5. **Calculate the mass of sulfate ions formed after the addition of 3L of sulfur (VI) oxide into 2L of liquid water.**

_____

_____

_____

LESSON 28. HYDROGEN AND WATER

EXERCISES FOR CLASSWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$H_2 \rightarrow H_2O \rightarrow NaOH \rightarrow H_2O \rightarrow HCl$

1. _____

2. _____

3. _____

4. _____

Write the third reaction in the complete and short ionic forms:

_____

_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$H_2O \rightarrow H_2SO_4 \rightarrow H_2 \rightarrow NH_3 \rightarrow NH_4Cl$

1. _____

2. _____

3. _____

4. _____

Write the fourth reaction in the complete and short ionic forms:

_____

_____
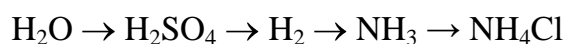
3. **Calculate the mass of water produced from 10 L of hydrogen and 20 g of copper (II) oxide.**

_____

_____

_____

4. **Calculate the mass of sulfuric acid produced in the reaction between 20 L of sulfur (VI) oxide and 30 g of water.**

_____

_____

_____

5. **Calculate the mass of nitric acid produced in the reaction between 3 g of nitrogen (V) oxide and 20 g of water.**

   _____

   _____

   _____

6. **Calculate the molarity of sodium hydroxide water solution formed after dissolving 2 g of sodium in 300 g of water. The density of the final solution is approximately equal to 1 g/ml.**

   _____

   _____

   _____

7. **The mass of an alloy made from sodium and potassium was equal to 5 g. The mass percentage of sodium in that alloy was equal to 40 %. Calculate the volume of hydrogen produced after that alloy had been put into water.**

   _____

   _____

   _____

EXERCISES FOR HOMEWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   $KH \rightarrow KOH \rightarrow H_2O \rightarrow H_2 \rightarrow H_2S$

   1. _____

   2. _____

   3. _____

   4. _____

   Write the second reaction in the complete and short ionic forms:

   _____

   _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   $H_2O \rightarrow NaOH \rightarrow NaHCO_3 \rightarrow H_2O \rightarrow HNO_3$

   1. _____

   2. _____

3. _____

4. _____

Write the second reaction in the complete and short ionic forms:

_____
_____
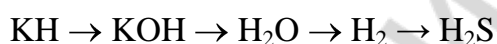
3. **Calculate the mass of water produced from 5 L of hydrogen and 10 g of tin (II) oxide.**

_____
_____
_____

4. **Calculate the mass of barium hydroxide produced in the reaction between 8 g of barium oxide and 20 g of water.**

_____
_____
_____

5. **Calculate the mass of calcium hydroxide produced in the reaction between 5 g of calcium and 30 g of water.**

_____
_____
_____

6. **Calculate the molarity of orthophosphoric acid water solution formed after dissolving 2 g of phosphorus (V) oxide in 200 g of water. The density of the final solution is approximately equal to 1 g/ml.**

_____
_____
_____
_____

7. **The mass of a mixture made from magnesium oxide and calcium oxide was equal to 7 g. The mass percentage of magnesium oxide in that mixture was equal to 65 %. Calculate the mass of water reacted with that mixture.**

_____
_____
_____
_____

LESSON 29. HALOGENS

TEST FOR CLASSWORK

1. In which reactions hydrogen atoms act as reducers?

    a. $H_2 + Cl_2 \rightarrow 2HCl$

    b. $2K + H_2 \rightarrow 2KH$

    c. $CuCl_2 + H_2 \rightarrow Cu + 2HCl$

    d. $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

2. In which reactions hydrogen atoms act as oxidizers?

    a. $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

    b. $2CH_4 + O_2 \rightarrow 2CO + 4H_2$

    c. $2Na + 2H_2O \rightarrow 2NaOH + H_2$

    d. $3H_2 + N_2 \rightarrow 2NH_3$

3. In which reactions hydrogen gas is released?

    a. $H_2O + K \rightarrow$ b. $HCl + Zn \rightarrow$ c. $H_2SO_4 + Cu \rightarrow$ d. $HNO_3 + Fe \rightarrow$

4. Choose ions represented as H^+ in ionic equations:

    a. H_3O^+ b. $H_3O_2^-$ c. $H_5O_2^+$ d. OH^-

5. Bromine (Br_2) in normal conditions is a:

    a. gas   b. liquid   c. solid substance   d. plasma

6. Which substance is used in qualitative analysis of solutions for the presence of halogens anions?

    a. $NaNO_3$ b. H_2SO_4 c. $AgNO_3$ d. KOH

7. Which reactions are possible?

    a. $KI + Cl_2 \rightarrow$ b. $KBr + I_2 \rightarrow$ c. $NaBr + Cl_2 \rightarrow$ d. $NaCl + I_2 \rightarrow$

8. Calculate the sum of all coefficients in the redox reaction:

    $LiOH + Cl_2 (t°) \rightarrow LiCl + LiClO_3 + H_2O$

    a. 9   b. 10   c. 17   d. 18

9. Which reactions can be expressed by the ionic equation: $Ca + 2H^+ \rightarrow Ca^{2+} + H_2$

    a. $Ca + 2HF \rightarrow CaF_2 + H_2$

    b. $Ca + 2HCl \rightarrow CaCl_2 + H_2$

    c. $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

    d. $Ca + H_2 \rightarrow CaH_2$

10. Choose formulas of hydrates:

    a. BaH_2 b. $NaOH$ c. $CuSO_4 \cdot 5H_2O$ d. $H_2C_2O_4 \cdot 2H_2O$

TEST FOR HOMEWORK

1. In which reactions chlorine atoms act as oxidizers?
   a. $KOH + HCl \rightarrow KCl + H_2O$ c. $KCl + AgNO_3 \rightarrow KNO_3 + AgCl$
   b. $3Cl_2 + 2P \rightarrow 2PCl_3$ d. $3Cl_2 + 2Fe \rightarrow 2FeCl_3$

2. In which reactions iodine atoms act as reducers?
   a. $2KI + Cl_2 \rightarrow 2KCl + I_2$ c. $2Na + I_2 \rightarrow 2NaI$
   b. $I_2 + H_2 \rightarrow 2HI$ d. $6KI + 2KMnO_4 + 4H_2O \rightarrow 3I_2 + 2MnO_2 + 8KOH$

3. In which reactions chlorine gas is released?
   a. $MnO_2 + HCl \rightarrow$ c. $BaCl_2 + H_2SO_4 \rightarrow$
   b. $KMnO_4 + HCl \rightarrow$ d. $FeCl_3 + H_2O \rightarrow$

4. Choose ions formed in water solution of I_2 in the presence of KI:
   a. I_3^- b. I_2^- c. I_3^{3-} d. I_2^{2-}

5. Iodine (I_2) in normal conditions is a:
   a. gas   b. liquid   c. solid substance   d. plasma

6. Indicate the colors of AgCl, AgBr and AgI:
   a. white / yellow / red
   b. white / pale yellow / yellow
   c. yellow / pale yellow / white
   d. red / yellow / white

7. Which reactions are possible?
   a. $NaBr + Cl_2 \rightarrow$ c. $HBr + Cl_2 \rightarrow$
   b. $NaBr + I_2 \rightarrow$ d. $NaCl + I_2 \rightarrow$

8. Calculate the sum of all coefficients in the redox reaction:
   $KI + CO_2 + O_2 \rightarrow K_2CO_3 + I_2$
   a. 11   b. 10   c. 9   d. 8

9. Which reactions can be expressed by the ionic equation:
   $2Br^- + Cl_2 \rightarrow 2Cl^- + Br_2$
   a. $2AgBr + CaCl_2 \rightarrow CaBr_2 + 2AgCl$
   b. $2HBr + Cl_2 \rightarrow 2HCl + Br_2$
   c. $2NaBr + CaCl_2 \rightarrow CaBr_2 + 2NaCl$
   d. $2KBr + Cl_2 \rightarrow 2KCl + Br_2$

10. Choose formulas of hydrides:
    a. CaH_2 b. LiH c. $FeSO_4 \cdot 5H_2O$ d. $H_2C_2O_4$

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   $NaCl \rightarrow Cl_2 \rightarrow FeCl_3 \rightarrow KCl \rightarrow AgCl$

   1. _____
   2. _____
   3. _____
   4. _____

   Write the third reaction in the complete and short ionic forms:

   _____

   _____

   Write the fourth reaction in the complete and short ionic forms:

   _____

   _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   $K \rightarrow KI \rightarrow KBr \rightarrow KCl \rightarrow KNO_3$

   1. _____
   2. _____
   3. _____
   4. _____

   Write the third reaction in the complete and short ionic forms:

   _____

   _____

   Write the fourth reaction in the complete and short ionic forms:

   _____

   _____

3. **Calculate the volume of hydrogen chloride that can be produced from 100 g of solid sodium chloride with the help of concentrated sulfuric acid.**

   _____

   _____

   _____

4. **Find the simplest formula of a compound. The mass percentages of elements in the compound are as follows: 44.83 % of potassium, 18.39 % of sulfur and 36.78 % of oxygen.**

_____
_____
_____

5. **Find out the simplest formula of a substance if in 200 g of it there are 80 g of calcium, 24 g of carbon and 96 g of oxygen.**

_____
_____
_____
_____

6. **The mass of the mixture made from iron and copper is 15 g. That mixture reacted with 7.75 L of chlorine gas. Find the mass percentage of copper in the initial mixture.**

_____
_____
_____
_____
_____

EXERCISES FOR HOMEWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$Br_2 \rightarrow ZnBr_2 \rightarrow NaBr \rightarrow Br_2 \rightarrow KBrO_3$

1. _____
2. _____
3. _____
4. _____

Write the first reaction in the complete and short ionic forms:

_____
_____

Write the second reaction in the complete and short ionic forms:

_____
_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$F_2 \rightarrow HF \rightarrow NiF_2 \rightarrow ZnF_2 \rightarrow CaF_2$

1. _____

2. _____

3. _____

4. _____

Write the second reaction in the complete and short ionic forms:

_____

_____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

3. **Calculate the mass of 5 % hydrochloric acid that can be produced from 100 g of solid potassium chloride with the help of concentrated sulfuric acid.**

_____

_____

_____

4. **Find the simplest formula of a compound. The mass percentages of elements in the compound are as follows: 18.78 % of sodium, 28.98 % of chlorine and 52.24 % of oxygen.**

_____

_____

_____

5. **Find out the simplest formula of a substance if in 699 g of it there are 411 g of barium, 96 g of sulfur and 192 g of oxygen.**

_____

_____

_____

6. **The mass of the mixture made from iron and copper is 30 g. That mixture reacted with hydrochloric acid and produced 0.5 L of hydrogen. Find the mass percentage of copper in the initial mixture.**

_____

_____

_____

LESSON 30. OXYGEN AND ITS COMPOUNDS

EXERCISES FOR CLASSWORK

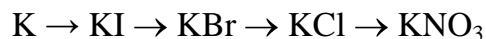1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   $O_2 \rightarrow Na_2O_2 \rightarrow Na_2O \rightarrow NaNO_3 \rightarrow O_2$

   1. _____
   2. _____
   3. _____
   4. _____

   Write the third reaction in the complete and short ionic forms:

   _____
   _____

   Write the fourth reaction in the complete and short ionic forms:

   _____
   _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   $O_3 \rightarrow O_2 \rightarrow Na_2O_2 \rightarrow H_2O_2 \rightarrow O_2$

   1. _____
   2. _____
   3. _____
   4. _____
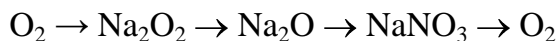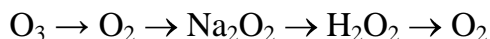
   Write the kinetic equation for the first reaction, and the equation for the constant of equilibrium for that process:

   _____
   _____

   Write the third reaction in the complete and short ionic forms:

   _____
   _____

3. **Calculate the volume of oxygen needed to burn 10 g of potassium. Consider potassium superoxide as the only one product of this reaction.**

   _____
   _____
   _____

4. **Find the volume percentage of methane in its mixture with carbon dioxide. 30 L of that mixture reacted with 30 L of oxygen (in normal conditions).**

_____

_____

_____

5. **The mass of oxygen atoms in the sample of barium sulfate is equal to 11.7 g. Find out the mass of the whole sample.**

_____

_____

_____

_____

6. **The mass of the mixture made from gold and zinc is 30 g. That mixture has been burnt. The mass of the resulting mixture is equal to 40 g. Find the mass percentage of gold in the initial mixture.**

_____

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$O_2 \rightarrow SO_2 \rightarrow Na_2SO_3 \rightarrow BaSO_3 \rightarrow SO_2$

1. _____

2. _____

3. _____

4. _____

Write the second reaction in the complete and short ionic forms:

_____

_____

Write the third reaction in the complete and short ionic forms:

_____

_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$O_2 \rightarrow KO_2 \rightarrow K_2O_2 \rightarrow KOH \rightarrow KBr$

1. _____

2. _____

3. _____

4. _____

Write the third reaction in the complete and short ionic forms:

_____

_____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

3. **Calculate the volume of oxygen needed to burn 3 g of sodium. Consider sodium peroxide as the only one product of this reaction.**

_____

_____

_____

4. **Find the volume percentage of acetylene in its mixture with nitrogen. 20 L of that mixture reacted with 7 L of oxygen (in normal conditions).**

_____

_____

_____

5. **The mass of oxygen atoms in the sample of copper sulfate pentahydrate is equal to 21.7 g. Find out the mass of the whole sample.**

_____

_____

_____

6. **The mass of the mixture made from platinum and aluminum is 25 g. That mixture has been burnt. The mass of the resulting mixture is equal to 30 g. Find the mass percentage of platinum in the initial mixture.**

_____

_____

_____

_____

LESSON 31. SULFUR AND ITS COMPOUNDS

TEST FOR CLASSWORK

1. Choose formulas of oxides:

   a. H_2O b. H_2O_2 c. BaO d. BaO_2

2. Choose formulas of peroxides:

   a. K_2O b. K_2O_2 c. KO_2 d. CaO_2

3. Choose formulas of superoxides:

   a. Na_2O b. NaO_2 c. PbO_2 d. KO_2

4. Oxygen will be released in reactions:

   a. $Na + H_2O \rightarrow$ c. $KClO_3 (t°) \rightarrow$

   b. $NaNO_3 (t°) \rightarrow$ d. $CaCO_3 (t°) \rightarrow$

5. In which reactions sulfur atoms act as reducers:

   a. $Na_2S + 2HCl \rightarrow 2NaCl + H_2S$ c. $2H_2S + O_2 \rightarrow 2S + 2H_2O$

   b. $2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$ d. $Cu + S \rightarrow CuS$

6. Choose substances which react with concentrated H_2SO_4:

   a. $NaCl_{(solid)}$ b. $KCl_{(water\ solution)}$ c. Ag d. Au

7. Which reactions are possible?

   a. $Fe + H_2SO_{4\ (dilute)} \rightarrow$

   b. $Fe + H_2SO_{4\ (concentrated\ /\ low\ temperature)} \rightarrow$

   c. $Al + H_2SO_{4\ (concentrated\ /\ high\ temperature)} \rightarrow$

   d. $Pt + H_2SO_4 \rightarrow$

8. Calculate the sum of all coefficients in the redox reaction:

   $C + H_2SO_{4\ (concentrated)} \rightarrow CO_2 + SO_2 + H_2O$

   a. 5   b. 6   c. 7   d. 8

9. Which reactions can be expressed by the following ionic equation:

   $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$

   a. $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$

   b. $Ba + H_2SO_4 \rightarrow BaSO_4 + H_2$

   c. $Ba(NO_3)_2 + K_2SO_4 \rightarrow BaSO_4 + 2KNO_3$

   d. $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$

10. Choose formulas of sulfites:

    a. BaS b. K_2S c. K_2SO_3 d. Na_2SO_3

TEST FOR HOMEWORK

1. Choose formula of iron sulfide used in industrial sulfuric acid production:
   a. FeS   b. Fe_2S_3 c. FeS_2 d. Fe_3S_4

2. Choose correct statements about hydrogen sulfide (H_2S):
   a. it has an odor of rotten eggs
   b. it is solid in normal conditions
   c. it is weak electrolyte
   d. its water solution is acidic

3. Choose substances which cannot react with dilute sulfuric acid (H_2SO_4):
   a. NaOH   b. NaCl $_{(solid)}$ c. Cu   d. CuO

4. Oxygen will be released in reactions:
   a. H_2O_2 (t°) →   c. NaOH (t°) →
   b. $AgNO_3$ (t°) →   d. $Ca(OH)_2$ (t°) →

5. In which reactions sulfur atoms act as oxidizers:
   a. $SO_2 + C → CO_2 + S$ c. $5SO_3 + 2P → 5SO_2 + P_2O_5$
   b. $2H_2SO_3 + O_2 → 2H_2SO_4$ d. $Mg + S → MgS$

6. Choose substances which react with concentrated H_2SO_4:
   a. $BaCl_2$ $_{(solid)}$ c. Pt
   b. $BaCl_2$ $_{(water\ solution)}$ d. P

7. Which reactions are possible?
   a. $FeSO_3 + H_2SO_4 →$ c. $C + H_2SO_4 →$
   b. $Al_2S_3 + H_2O →$ d. $Na_2SO_4 + K_2S →$

8. Calculate the sum of all coefficients in the redox reaction:
   $S + H_2SO_4$ $_{(concentrated)}$ $→ SO_2 + H_2O$
   a. 5   b. 6   c. 7   d. 8

9. Which reactions can be expressed by the following ionic equation:
   $2H^+ + S^{2-} → H_2S$
   a. $2HCl + K_2S → 2KCl + H_2S$
   b. $H_2SO_4 + BaS → BaSO_4 + H_2S$
   c. $2HNO_3 + Na_2S → 2NaNO_3 + H_2S$
   d. $H_2 + S → H_2S$

10. Choose formulas of sulfides:
    a. ZnS   b. Na_2S c. K_2S d. Na_2SO_3

EXERCISES FOR CLASSWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

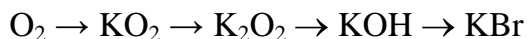$S \rightarrow SO_2 \rightarrow SO_3 \rightarrow ZnSO_4 \rightarrow K_2SO_4$

1. _____
2. _____
3. _____
4. _____

Write the third reaction in the complete and short ionic forms:

_____
_____

Write the fourth reaction in the complete and short ionic forms:

_____
_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$CuS \rightarrow SO_2 \rightarrow S \rightarrow H_2S \rightarrow CoS$
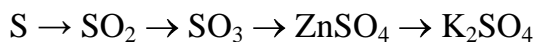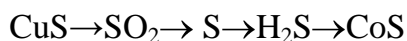
1. _____
2. _____
3. _____
4. _____

Write kinetic equation for the third reaction, and the equation for the constant of equilibrium for that process:

_____
_____

Write the fourth reaction in the complete and short ionic forms:

_____
_____

3. **Find the mass percentage of copper in its mixture with zinc. 20 g of that mixture reacted with the excess of dilute sulfuric acid and produced 1.1 L of a gas.**

_____
_____
_____

4. **The mixture of sulfur and phosphorus had a mass of 6 g. That mixture has been burnt completely in 4.4 L of oxygen. Find the mass percentage of sulfur in the initial mixture.**

_____
_____
_____

5. **The mass percentage of sulfur VI oxide in oleum is 20 %. What mass of that oleum is required to prepare 1 kg of pure sulfuric acid?**

_____
_____
_____

6. **The mass of the mixture made from copper and silver is 4 g. That mixture reacted with concentrated sulfuric acid and produced 0.9074 L of sulfur dioxide. Find the mass percentage of silver in the initial mixture.**

_____
_____
_____

<div align="center">EXERCISES FOR HOMEWORK</div>

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$H_2SO_4 \rightarrow H_2S \rightarrow KHS \rightarrow K_2S \rightarrow SO_2$

1. _____
2. _____
3. _____
4. _____

Write the second reaction in the complete and short ionic forms:

_____
_____

Write the third reaction in the complete and short ionic forms:

_____
_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$Li_2S \rightarrow H_2S \rightarrow S \rightarrow SrS \rightarrow ZnS$

1. _____

2. _____

3. _____

4. _____

Write the first reaction in the complete and short ionic forms:

_____

_____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

3. **25 g of zinc reacted with 70 g of concentrated sulfuric acid. Calculate the volume of sulfur (IV) oxide released in this process.**

_____

_____

_____

4. **The mixture of zinc and aluminum had a mass of 15 g. That mixture reacted with sulfuric acid and produced 68 g of salts. Find the mass percentage of zinc in the initial mixture.**

_____

_____

_____

5. **The mass percentage of sulfur (VI) oxide in oleum is 10 %. What mass of that oleum is required to prepare 1 kg of sulfuric acid with the mass percentage of 30 %?**

_____

_____

_____

_____

6. **The mass of the mixture made from potassium and sodium sulfides is 5 g. That mixture reacted with hydrochloric acid and produced 1.2688 L of hydrogen sulfide. Find the mass percentage of potassium sulfide in the initial mixture.**

_____

_____

_____

_____

_____

LESSON 32. NITROGEN AND ITS COMPOUNDS

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   $N_2 \rightarrow NH_3 \rightarrow NH_4NO_3 \rightarrow N_2O \rightarrow NO_2$

   1. _____
   2. _____
   3. _____
   4. _____

   Write the second reaction in the complete and short ionic forms:

   _____

   _____

   Write the kinetic equation for the fourth reaction, and the equation for the constant of equilibrium for that process:

   _____

   _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   $Cu(NO_3)_2 \rightarrow NO_2 \rightarrow HNO_3 \rightarrow KNO_3 \rightarrow KNO_2$

   1. _____
   2. _____
   3. _____
   4. _____

   Write the second reaction in the complete and short ionic forms:

   _____

   _____

   Write the third reaction in the complete and short ionic forms:

   _____

   _____

3. **Calculate the mass of nitric acid produced from 12 L of nitrogen (IV) oxide (in normal conditions) and 25 g of water in the presence of oxygen.**

   _____

   _____

   _____

4. **What is the mass of ammonium bromide formed in the reaction between 4 L of ammonia (in normal conditions) and 2 g of hydrogen bromide?**

_____

_____

_____

5. **What is the mass of sodium nitrate formed in the reaction between 100 g of 5 % sodium hydroxide solution and 200 g of 10 % nitric acid?**

_____

_____

_____

_____

6. **Find the mass percentage of potassium nitrate in its mixture with iron (III) nitrate. 15 g of that mixture has been heated up and produced 2 L of a brown gas.**

_____

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

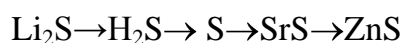$HNO_2 \rightarrow HNO_3 \rightarrow Zn(NO_3)_2 \rightarrow NO_2 \rightarrow NaNO_3$

1. _____

2. _____

3. _____

4. _____

Write the first reaction in the complete and short ionic forms:

_____

_____

Write the second reaction in the complete and short ionic forms:

_____

_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$Zn(NO_3)_2 \rightarrow Ba(NO_3)_2 \rightarrow HNO_3 \rightarrow AgNO_3 \rightarrow KNO_3$

1. _____

2. _____

3. _____

4. _____

Write the first reaction in the complete and short ionic forms:

_____

_____

Write the second reaction in the complete and short ionic forms:

_____

_____
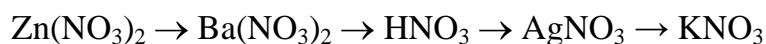
3. **Calculate the mass of nitric acid produced from 10 L of nitrogen (IV) oxide (in normal conditions) and 7 g of water in the absence of oxygen.**

_____

_____

_____

4. **What is the volume of nitrogen (in normal conditions) formed after the decomposition of 6 g of ammonium nitrite?**

_____

_____

_____

5. **Calculate the volume of nitrogen released in the reaction between 18 g of nitric acid and 3 g of zinc.**

_____

_____

_____

6. **Find the mass percentage of copper (II) nitrate decomposed during the heating. The initial mass was equal to 20 g. The final mass of the mixture of solid substances after the heating is equal to 18 g.**

_____

_____

_____

_____

LESSON 33. PHOSPHORUS AND ITS COMPOUNDS

TEST FOR CLASSWORK

1. Choose formulas of compounds in which nitrogen has negative oxidation state:

    a. Na_3N b. NaN_3 c. NH_4Br d. NO_2

2. During NH_4^+ cation formation nitrogen atom behaves as:

    a. electron pair donor   c. proton donor

    b. electron pair acceptor   d. proton acceptor

3. Choose redox reactions:

    a. $N_2O_3 + H_2O \rightarrow$ c. $N_2O_5 + H_2O \rightarrow$

    b. $NO_2 + H_2O \rightarrow$ d. $NH_3 + O_2 \rightarrow$

4. NO_2 will be released in reactions:

    a. KNO_3 (t°) $\rightarrow$ c. $AgNO_3$ (t°) $\rightarrow$

    b. $Zn(NO_3)_2$ (t°) $\rightarrow$ d. $Cu + HNO_{3 \text{ (concentrated)}} \rightarrow$

5. Which substances react with HNO_3:

    a. Hg   b. KOH   c. KCl   d. Au

6. Choose molecular compounds:

    a. white phosphorus   c. ammonia

    b. red phosphorus   d. ammonium chloride

7. Gas will be released in the reaction:

    a. $Fe + HNO_3 \rightarrow$ c. $FeO + HNO_3 \rightarrow$

    b. $NH_4Cl + H_2SO_4 \rightarrow$ d. NH_4NO_3 (t°) $\rightarrow$

8. Calculate the sum of all coefficients in the redox reaction:

    $Zn + HNO_3 \rightarrow Zn(NO_3)_2 + N_2O + H_2O$

    a. 10   b. 13   c. 24   d. 20

9. Which reactions can be expressed by the following ionic equation:

    $3Ca^{2+} + 2PO_4^{3-} \rightarrow Ca_3(PO_4)_2$

    a. $3CaCl_2 + 2H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6HCl$

    b. $3CaCl_2 + 2Na_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6NaCl$

    c. $3CaSO_4 + 2K_3PO_4 \rightarrow Ca_3(PO_4)_2 + 3K_2SO_4$

    d. $3Ca + 2H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 3H_2$

10. Dihydrogen phosphate will be produced in the reaction between:

   a. 2 mol NaOH and 1 mol H_3PO_4

   b. 1 mol NaOH and 1 mol H_3PO_4

   c. 3 mol NaOH and 1 mol H_3PO_4

   d. 1 mol NaOH and 3 mol H_3PO_4

TEST FOR HOMEWORK

1. Choose formulas of compounds in which nitrogen has positive oxidation state:

   a. $NaNO_3$ b. $NaNO_2$ c. NH_3 d. N_2

2. Describe pH level in the water solution of ammonia?

   a. slightly acidic   c. strongly acidic

   b. slightly basic   d. strongly basic

3. Choose redox reactions:

   a. $NH_3 + HCl \rightarrow$ c. $NO + O_2 \rightarrow$

   b. $N_2 + H_2 \rightarrow$ d. $AgNO_3 + KCl \rightarrow$

4. O_2 will be released in reactions:

   a. $NaNO_3$ (t°) $\rightarrow$ c. NH_4NO_3 (t°) $\rightarrow$

   b. $Cu(NO_3)_2$ (t°) $\rightarrow$ d. NH_4NO_2 (t°) $\rightarrow$

5. Which substances react with $AgNO_3$:

   a. KF   b. KCl   c. KBr   d. KI

6. Choose ionic compounds:

   a. phosphine   c. ammonium phosphate

   b. phosphorus (III) chloride   d. potassium dihydrogen phosphate

7. Water will be produced in the reaction:

   a. $Zn + HNO_3 \rightarrow$ c. $CuO + HNO_3 \rightarrow$

   b. $NH_4Cl + H_3PO_4 \rightarrow$ d. $NH_4Cl + KOH \rightarrow$

8. Calculate the sum of all coefficients in the redox reaction:

   $Ca + HNO_3 \rightarrow Ca(NO_3)_2 + N_2 + H_2O$

   a. 12   b. 17   c. 27   d. 29

9. Which reactions can be expressed by the ionic equation: $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$

   a. $NH_4NO_3 + LiOH \rightarrow LiNO_3 + NH_3 + H_2O$

   b. $(NH_4)_2SO_4 + Ba(OH)_2 \rightarrow BaSO_4 + 2NH_3 + 2H_2O$

   c. $NH_4Cl + NaOH \rightarrow NaCl + NH_3 + H_2O$

   d. $NH_4H_2PO_4 + 3KOH \rightarrow K_3PO_4 + NH_3 + 3H_2O$

10. Monohydrogen phosphate will be produced in the reaction between:

a. 2 mol NaOH and 1 mol H_3PO_4 c. 4 mol NaOH and 1 mol H_3PO_4

b. 1 mol NaOH and 2 mol H_3PO_4 d. 1 mol NaOH and 3 mol H_3PO_4

EXERCISES FOR CLASSWORK

**1. Write four reactions according to the following classic chain of chemical reactions and balance them:**

$P \rightarrow P_2O_3 \rightarrow P_2O_5 \rightarrow H_3PO_4 \rightarrow Ca_3(PO_4)_2$

1. _____

2. _____

3. _____

4. _____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

2. Write four reactions according to the following classic chain of chemical reactions and balance them:

$H_3PO_4 \rightarrow K_3PO_4 \rightarrow K_2HPO_4 \rightarrow KH_2PO_4 \rightarrow Na_3PO_4$

1. _____

2. _____

3. _____

4. _____

Write the second reaction in the complete and short ionic forms:

_____

_____
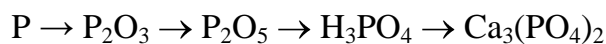
3. Calculate the mass of phosphorus (V) oxide that is needed to make 300 ml of orthophosphoric acid solution with the molarity of 0.1 mol/L.

_____

_____

_____

4. Calculate the mass of a product of the reaction between 3 g of calcium oxide and 9 g of phosphorus (V) oxide.

_____

_____

_____

5. **Calculate the mass of a salt(s) produced in the reaction between 5 g of barium oxide and 8 g of phosphoric acid.**

_____

_____

_____

_____

_____

6. **What salt will be formed in the reaction between 17 g of sodium hydroxide and 190 g of phosphoric acid? Calculate the mass of a salt(s).**

_____

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$H_3PO_4 \rightarrow Ca(H_2PO_4)_2 \rightarrow NaH_2PO_4 \rightarrow Na_3PO_4 \rightarrow Li_3PO_4$

1. _____

2. _____

3. _____

4. _____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$P \rightarrow P_2O_5 \rightarrow H_3PO_4 \rightarrow Na_3PO_4 \rightarrow Zn_3(PO_4)_2$

1. _____

2. _____

3. _____

4. _____

Write the fourth reaction in the complete and short ionic forms:

_____

_____
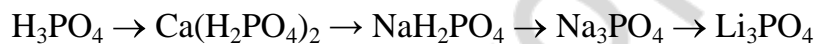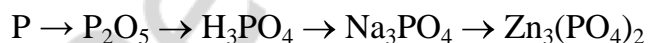
3. Calculate the mass of phosphorus that is needed to make 200 ml of orthophosphoric acid solution with the molarity of 0.05 mol/L.

_____

_____

_____

_____

4. Calculate the mass of a product of the reaction between 2 g of sodium oxide and 8 g of phosphorus (V) oxide.

_____

_____

_____

_____

5. Calculate the mass of a salt(s) produced in the reaction between 4 g of potassium hydroxide and 10 g of phosphoric acid.

_____

_____

_____

_____

_____

_____

6. What salt will be formed in the reaction between 11 g of calcium hydroxide and 3 g of phosphoric acid? Calculate the mass of a salt(s).

_____

_____

_____

_____

_____

_____

LESSON 34. CARBON AND ITS COMPOUNDS

EXERCISES FOR CLASSWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

    $C \rightarrow CO_2 \rightarrow Na_2CO_3 \rightarrow CaCO_3 \rightarrow CO_2$

    1. _____

    2. _____

    3. _____

    4. _____

    Write the third reaction in the complete and short ionic forms:

    _____
    _____

    Write the fourth reaction in the complete and short ionic forms:

    _____
    _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

    $Al_4C_3 \rightarrow CH_4 \rightarrow CO_2 \rightarrow CO \rightarrow CO_2$

    1. _____

    2. _____

    3. _____

    4. _____
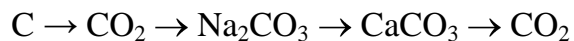
    Write the kinetic equation for the second reaction, and the equation for the constant of equilibrium for that process:

    _____
    _____

    Write the kinetic equation for the third reaction, and the equation for the constant of equilibrium for that process:

    _____
    _____

3. **Calculate the volume of carbon (IV) oxide produced after the addition of the excess of hydrochloric acid to 100 ml of 0.2M solution of sodium carbonate.**

    _____
    _____
    _____

4. **Calculate the mass of a product of the reaction between 2 g of calcium oxide and 3 L of carbon dioxide.**

_____

_____

_____

5. **Calculate the mass of a salt(s) produced in the reaction between 5 L of carbon dioxide and 30 g of potassium hydroxide solution with the mass percentage of 5 %.**

_____

_____

_____

_____

6. **The mass of the mixture of calcium carbonate and barium carbonate is 500 g. The mass of the mixture after the complete thermal decomposition is 345 g. Find the mass percentage of calcium carbonate in the initial mixture.**

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$K_2CO_3 \rightarrow CO_2 \rightarrow CaCO_3 \rightarrow Ca(HCO_3)_2 \rightarrow Na_2CO_3$

1. _____

2. _____

3. _____

4. _____

Write the third reaction in the complete and short ionic forms:

_____

_____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$CaC_2 \rightarrow C_2H_2 \rightarrow CO_2 \rightarrow (NH_4)_2CO_3 \rightarrow CO_2$

1. _____

2. _____

3. _____

4. _____

Write the third reaction in the complete and short ionic forms:

_____

_____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

3. **Calculate the volume of carbon (IV) oxide produced after the addition of the excess of sulfuric acid to 200 ml of 0.1M solution of potassium carbonate.**

_____

_____

_____

4. **Calculate the mass of a product of the reaction between 3 g of strontium oxide and 5 L of carbon dioxide.**

_____

_____

_____

5. **Calculate the mass of a salt(s) produced in the reaction between 6 L of carbon dioxide and 25 g of calcium hydroxide solution with the mass percentage of 3 %.**

_____

_____

_____

_____

6. **The mass of the mixture of sodium carbonate and potassium carbonate is 10 g. The volume of a gas produced after the reaction with the excess of hydrochloric acid is equal to 1.8686 L. Find the mass percentage of sodium carbonate in the initial mixture.**

_____

_____

_____

_____

LESSON 35. SILICON AND ITS COMPOUNDS

TEST FOR CLASSWORK

1. In which kind of hybridization electron orbitals of the outer shell of carbon atoms exist in diamond?

   a. sp   b. sp^2 c. sp^3 d. no hybridization

2. In which kind of hybridization electron orbitals of the outer shell of carbon atoms exist in graphite?

   a. sp   b. sp^2 c. sp^3 d. no hybridization

3. Which substances should we add to $CaCO_3$ precipitate in water solution to dissolve it?

   a. HCl   b. KOH   c. CO_2 d. HNO_3

4. What gas is produced in CaC_2 hydrolysis reaction?

   a. CO_2 b. O_2 c. C_2H_2 d. H_2

5. What gas is produced in Al_4C_3 hydrolysis reaction?

   a. H_2 b. CH_4 c. CO_2 d. H_2S

6. In which reactions precipitate is formed?

   a. $Ca(OH)_2 + HCl \rightarrow$ c. $Na_2SiO_3 + HCl \rightarrow$

   b. $CaCl_2 + Na_2CO_3 \rightarrow$ d. $KHCO_3 + HCl \rightarrow$

7. Which reactions are possible?

   a. $K_2SiO_3 + CO_2 \rightarrow$ c. $K_2CO_3 + SiO_2 \rightarrow$

   b. $Mg_2Si + HCl \rightarrow$ d. $Na_2SiO_3 + K_2CO_3 \rightarrow$

8. Calculate the sum of all coefficients in the redox reaction:

   $SiH_4 + NaOH + H_2O \rightarrow Na_2SiO_3 + H_2$

   a. 9   b. 10   c. 11   d. 12

9. In which reactions a gas is formed:

   a. $CaCO_3 + HCl \rightarrow$

   b. $CaCO_3 + CO_2 + H_2O \rightarrow$

   c. $Ca(HCO_3)_2 + H_2SO_4 \rightarrow$

   d. $Ca(HCO_3)_2 \ (t°) \rightarrow$

10. In which reactions carbon atoms behave as oxidizers?

   a. $C + CuO \rightarrow Cu + CO$

   b. $C + 4HNO_{3 \ (concentrated)} \rightarrow CO_2 + 4NO_2 + 2H_2O$

   c. $C_2H_2 + H_2 \rightarrow C_2H_4$

   d. $2C + Ca \rightarrow CaC_2$

TEST FOR CLASSWORK

1. What is the type of crystal structure for SiO_2 in normal conditions?

   a. molecular   b. ionic   c. atomic   d. metallic

2. With which chemical element hydrogen atoms form the most stable compounds?

   a. B   b. Si   c. C   d. P

3. Which substances should we add to $Ca(OH)_2$ water solution to cause precipitation?

   a. HNO_3 b. K_2CO_3 c. excess of CO_2 d. limited CO_2

4. Choose carbonates which cannot be decomposed at high temperature:

   a. Na_2CO_3 b. K_2CO_3 c. $CaCO_3$ d. $MgCO_3$

5. Choose formulas of bicarbonates:

   a. $NaHCO_3$ b. $KHCO_3$ c. $Ca(HCO_3)_2$ d. $(MgOH)_2CO_3$

6. In which reactions precipitate is formed?

   a. $Ca(HCO_3)_2 + HCl \rightarrow$

   b. $Ca(HCO_3)_2 + KOH \rightarrow$

   c. $KHSiO_3 + HCl \rightarrow$

   d. $KHSiO_3 + KOH \rightarrow$

7. Which reactions are possible?

   a. $SiO_2 + H_2O \rightarrow$

   b. $Si + NaOH + H_2O \rightarrow$

   c. $CaCO_3 + SiO_2 \rightarrow$

   d. $Na_2SO_4 + K_2CO_3 \rightarrow$

8. Calculate the sum of all coefficients in the redox reaction: $Ca_2Si + HCl \rightarrow CaCl_2 + SiH_4$

   a. 6   b. 7   c. 8   d. 9

9. In which reactions a gas is formed:

   a. $CaC_2 + HCl \rightarrow$

   b. $K_2SiO_3 + CO_2 \rightarrow$

   c. $Li_2CO_3 (t°) \rightarrow$

   d. $NaHCO_3 (t°) \rightarrow$

10. In which reactions carbon atoms behave as reducers?

    a. $2C + O_2 \rightarrow 2CO$

    b. $C + O_2 \rightarrow CO_2$

    c. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

    d. $3C + 4Al \rightarrow Al_4C_3$

<center>**EXERCISES FOR CLASSWORK**</center>

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$K_2SiO_3 \rightarrow H_2SiO_3 \rightarrow Na_2SiO_3 \rightarrow CaSiO_3 \rightarrow SiO_2$

1. _____
2. _____
3. _____
4. _____

Write the second reaction in the complete and short ionic forms:

_____
_____

Write the third reaction in the complete and short ionic forms:

_____
_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$SiH_4 \rightarrow SiO_2 \rightarrow Na_2SiO_3 \rightarrow H_2SiO_3 \rightarrow BaSiO_3$

1. _____
2. _____
3. _____
4. _____

Write the third reaction in the complete and short ionic forms:

_____
_____

Write the fourth reaction in the complete and short ionic forms:

_____
_____

3. **Calculate the volume of carbon (IV) oxide produced after the reaction between 20 g of sodium carbonate and the excess of silicon (IV) oxide.**

_____
_____
_____

<center>105</center>

4. **Calculate the mass of a product of the reaction between 3 g of barium oxide and 6 g of silicon (IV) oxide.**

_____

_____

_____

5. **Calculate the mass of a precipitate produced in the reaction between 4 g of sodium silicate and 50 g of hydrochloric acid solution with the mass percentage of 12 %.**

_____

_____

_____

_____

6. **The mass of the mixture of silicon (IV) oxide and solid potassium silicate was 20 g. The mixture has been put into the solution of hydrochloric acid. Find the mass percentage of sodium (IV) oxide in the initial mixture if the mass of a precipitate after the reaction was equal to 12.6 g.**

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   $SiO_2 \rightarrow Si \rightarrow Na_2SiO_3 \rightarrow H_2SiO_3 \rightarrow SiO_2$

   1. _____

   2. _____

   3. _____

   4. _____

   Write the second reaction in the complete and short ionic forms:

   _____

   _____

   Write the fourth reaction in the complete and short ionic forms:

   _____

   _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

$Ca_2Si \rightarrow SiH_4 \rightarrow SiO_2 \rightarrow CaSiO_3 \rightarrow SiO_2$

1. _____

2. _____

3. _____

4. _____

Write the third reaction in the complete and short ionic forms:

_____

_____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

3. **Calculate the volume of carbon (IV) oxide produced after the reaction between 30 g of calcium carbonate and the excess of silicon (IV) oxide.**

_____

_____

_____

4. **Calculate the mass of a product of the reaction between 2 g of potassium oxide and 4 g of silicon (IV) oxide.**

_____

_____

_____

5. **Calculate the mass of a precipitate produced in the reaction between 7 g of potassium silicate and 55 g of nitric acid solution with the mass percentage of 22 %.**

_____

_____

_____

6. **The mass of the mixture of silicon (IV) oxide and silicic acid was 40 g. The mixture has been heated until the constant mass of 36 g. Find the mass percentage of sodium (IV) oxide in the initial mixture.**

_____

_____

_____

_____

LESSON 36. ALKALI METALS

EXERCISES FOR CLASSWORK

1. **Write four reactions with _potassium_ containing compounds according to the chain of chemical reactions**

   $K \xrightarrow{+S} A \xrightarrow{+HCl} B \xrightarrow{+AgNO_3} C \xrightarrow{t°} D$

   1. _____
   2. _____
   3. _____
   4. _____

   Write the second reaction in the complete and short ionic forms:

   _____
   _____

   Write the third reaction in the complete and short ionic forms:

   _____
   _____

2. **Write four reactions with _sodium_ containing compounds according to the chain of chemical reactions**

   $Na \xrightarrow{+H_2O} A \xrightarrow{+HI} B \xrightarrow{+Cl_2} C \xrightarrow{+AgNO_3} D$

   1. _____
   2. _____
   3. _____
   4. _____

   Write the second reaction in the complete and short ionic forms:

   _____
   _____

   Write the third reaction in the complete and short ionic forms:

   _____
   _____

3. **10 g of sodium has been dissolved in 400 g of water. Find the minimal mass of sulfuric acid solution with the mass percentage of 15 % needed to neutralize that sodium hydroxide solution.**

   _____
   _____
   _____

4. **Find the difference between mass percentages of potassium in its oxide and superoxide.**

_____

_____

_____

5. **Which substance can you add to the solution containing lithium and sodium hydroxides to remove lithium cations from it (in form of precipitate)? Write the reaction and its complete and short ionic forms:**

_____

_____

_____

_____

6. **How can you confirm the presence of iodide ions in the solution of sodium iodide? Write the reaction and its complete and short ionic forms:**

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Write four reactions with _lithium_ containing compounds according to the chain of chemical reactions**
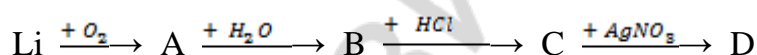
$Li \xrightarrow{+ O_2} A \xrightarrow{+ H_2O} B \xrightarrow{+ HCl} C \xrightarrow{+ AgNO_3} D$
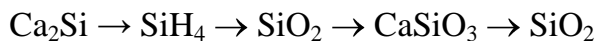
1. _____

2. _____

3. _____

4. _____

Write the third reaction in the complete and short ionic forms:

_____

_____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

2. **Write four reactions with _potassium_ containing compounds according to the chain of chemical reactions**

$1KOH \xrightarrow{+ H_3PO_4} A \xrightarrow{+ 1 KOH} B \xrightarrow{+ 1KOH} C \xrightarrow{+ LiCl} D$

1. _____
2. _____
3. _____
4. _____

Write the first reaction in the complete and short ionic forms:

_____
_____
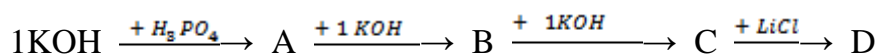
Write the second reaction in the complete and short ionic forms:

_____
_____

3. **12 g of lithium has been dissolved in 300 g of water. Find the minimal mass of sulfuric acid solution with the mass percentage of 8 % needed to neutralize that lithium hydroxide solution.**

_____
_____
_____
_____

4. **Find the difference between mass percentages of sodium in its oxide and peroxide.**

_____
_____
_____

5. **Which substance can you add to the solution containing sodium chloride and sodium fluoride to remove fluoride anions from it (in form of precipitate)? Write the reaction and its complete and short ionic forms:**

_____
_____
_____

6. **How can you confirm the presence of sulfate ions in the solution of sodium sulfate? Write the reaction and its complete and short ionic forms:**

_____
_____
_____

LESSON 37. ALKALINE-EARTH METALS

EXERCISES FOR CLASSWORK

1. **Write four reactions with _calcium_ containing compounds according to the chain of chemical reactions**
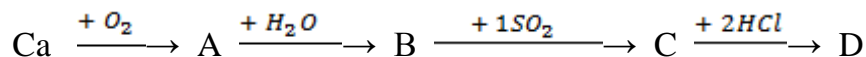
$$Ca \xrightarrow{+ O_2} A \xrightarrow{+ H_2O} B \xrightarrow{+ 1SO_2} C \xrightarrow{+ 2HCl} D$$

1. _____
2. _____
3. _____
4. _____

Write the third reaction in the complete and short ionic forms:

_____
_____

Write the fourth reaction in the complete and short ionic forms:

_____
_____

2. **Write four reactions with _magnesium_ containing compounds according to the chain of chemical reactions**

$$Mg \xrightarrow{+HCl \ (in \ excess)} A \xrightarrow{+ KOH \ (in \ excess)} B \xrightarrow{t} C \xrightarrow{P_2O_5} D$$

1. _____
2. _____
3. _____
4. _____

Write the first reaction in the complete and short ionic forms:

_____
_____

Write the second reaction in the complete and short ionic forms:

_____
_____

3. **Calculate the volume of carbon dioxide which will be enough to make the maximal amount of precipitate in 1 L of the solution of calcium hydroxide with the molarity equal to 0.05 mol/L.**

_____
_____
_____

4. **Find the difference between mass percentages of calcium in its oxide and phosphate.**

_____

_____

_____

5. **You have two tubes: one contains magnesium chloride, another contains strontium chloride. Which substance can you add to both of them to find out which one contains magnesium chloride. Write the reaction and its complete and short ionic forms:**

_____

_____

_____

_____

6. **How can you confirm the presence of barium ions in the solution of barium chloride? Write the reaction and its complete and short ionic forms:**

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Write four reactions with _barium_ containing compounds according to the chain of chemical reactions**
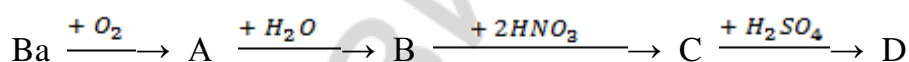
$$Ba \xrightarrow{+ O_2} A \xrightarrow{+ H_2O} B \xrightarrow{+ 2HNO_3} C \xrightarrow{+ H_2SO_4} D$$

1. _____

2. _____

3. _____

4. _____

Write the third reaction in the complete and short ionic forms:

_____

_____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

2. **Write four reactions with *strontium* containing compounds according to the chain of chemical reactions**
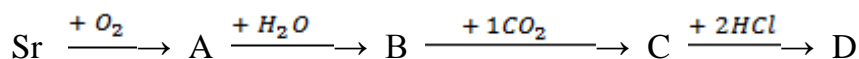
$$Sr \xrightarrow{+\ O_2} A \xrightarrow{+\ H_2O} B \xrightarrow{+\ 1CO_2} C \xrightarrow{+\ 2HCl} D$$
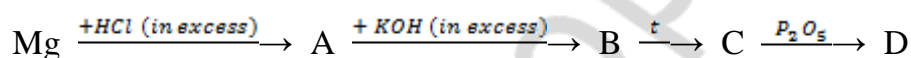
1. _____

2. _____

3. _____

4. _____

Write the third reaction in the complete and short ionic forms:

_____

_____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

3. **Calculate the mass of solid substances left after the heating of 200 g of magnesium hydroxide if the yield of the decomposition was 70 %.**

_____

_____

_____

4. **Find the difference between mass percentages of barium in its oxide and peroxide.**

_____

_____

_____

5. **You have two tubes: one contains potassium hydroxide, another contains barium hydroxide. Which substance can you add to both of them to find out which one contains barium hydroxide. Write the reaction and its complete and short ionic forms:**

_____

_____

_____

6. **How can you test the amphoteric properties of beryllium hydroxide? Write the reaction and its complete and short ionic forms:**

_____

_____

_____

LESSON 38. ALUMINUM AND IRON

TEST FOR CLASSWORK

1. Choose metals which react with water at normal temperature and produce alkali:
    a. Li   b. Na   c. Zn   d. Al

2. Choose hydroxides which can be decomposed at high temperature:
    a. $Ca(OH)_2$ b. KOH   c. LiOH   d. NaOH

3. Which cations are responsible of water hardness?
    a. Mg^{2+} b. Ca^{2+} c. Na^{+} d. K^{+}

4. Choose compound that will be formed in the reaction between $AlCl_3$ and the excess of KOH water solution?
    a. $Al(OH)_3$ c. $K_3[Al(OH)_6]$
    b. $K[Al(OH)_4]$ d. $KAlO_2$

5. In which reactions iron is oxidized to Fe^{3+}?
    a. $Fe + HCl$ c. $Fe + H_2SO_4$ (dilute)
    b. $Fe + Cl_2$ d. $Fe + H_2O + O_2 \rightarrow$

6. Which reactions are possible?
    a. $CuCl_2 + Zn \rightarrow$ c. $Al_2O_3 + H_2O \rightarrow$
    b. $ZnCl_2 + Cu \rightarrow$ d. $Al_2O_3 + NaOH + H_2O \rightarrow$

7. Which reactions can be described by the following ionic equation?
    $Al^{3+} + 4OH^- \rightarrow [Al(OH)_4]^-$
    a. $Al(OH)_3 + KOH \rightarrow K[Al(OH)_4]$
    b. $AlCl_3 + 4KOH \rightarrow K[Al(OH)_4] + 3KCl$
    c. $AlCl_3 + 6KOH \rightarrow K_3[Al(OH)_6] + 3KCl$
    d. $Al(NO_3)_3 + 4NaOH \rightarrow Na[Al(OH)_4] + 3NaNO_3$

8. Calculate the sum of all coefficients in the redox reaction: $K + KNO_3 \rightarrow K_2O + N_2$
    a. 12   b. 18   c. 19   d. 20

9. Which metals have a color different from gray?
    a. gold   b. copper   c. silver   d. cesium

10. In which reactions aluminum atoms behave as reducers?
    a. $4Al + 3O_2 \rightarrow 2Al_2O_3$
    b. $2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$
    c. $AlCl_3 + 3NaOH \rightarrow Al(OH)_3 + 3NaCl$
    d. $2Al(OH)_3 (t°) \rightarrow Al_2O_3 + 3H_2O$

TEST FOR HOMEWORK

1. Choose metals which react with water at high temperature and produce an oxide:

   a. Mg   b. Na   c. Fe   d. K

2. Choose reactions in which metal melts before the completion:

   a. $Li + H_2O \rightarrow$ c. $K + H_2O \rightarrow$

   b. $Na + H_2O \rightarrow$ d. $Cs + H_2O \rightarrow$

3. Which salts are associated with temporary water hardness?

   a. $MgCl_2$ b. $Ca(HCO_3)_2$ c. $Mg(HCO_3)_2$ d. K_2SO_4

4. Choose compound that will be formed in the reaction between solid $AlCl_3$ and solid NaOH at high temperature:

   a. $Al(OH)_3$ b. $Na[Al(OH)_4]$ c. $Na_3[Al(OH)_6]$ d. $NaAlO_2$

5. In which conditions iron turns to rust?

   a. in the presence of water

   b. in the presence of oxygen

   c. in the presence of water and oxygen

   d. in the presence of water and nitrogen

6. Which reactions are possible?

   a. $NaCl + KOH \rightarrow$ c. $KOH + HCl \rightarrow$

   b. $NaCl + AgNO_3 \rightarrow$ d. $FeCl_2 + Cl_2 \rightarrow$

7. Which reactions can be described by the following ionic equation?

   $Al^{3+} + 6OH^- \rightarrow [Al(OH)_6]^{3-}$

   a. $Al(OH)_3 + NaOH \rightarrow Na[Al(OH)_4]$

   b. $AlCl_3 + 4NaOH \rightarrow Na[Al(OH)_4] + 3KCl$

   c. $AlCl_3 + 6LiOH \rightarrow Li_3[Al(OH)_6] + 3LiCl$

   d. $Al_2(SO_4)_3 + 12NaOH \rightarrow 2Na_3[Al(OH)_6] + 3Na_2SO_4$

8. Calculate the sum of all coefficients in the redox reaction: $CaSO_4 (t°) \rightarrow CaO + SO_2 + O_2$

   a. 5   b. 6   c. 7   d. 8

9. What particles can be found in metallic solids?

   a. neutral atoms   c. anions

   b. cations   d. free electrons

10. In which reactions iron atoms behave as reducers?

    a. $4Fe + 3O_2 \rightarrow 2Fe_2O_3$ c. $2Fe + 3Cl_2 \rightarrow 2FeCl_3$

    b. $2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$ d. $Fe(OH)_3 + 3HCl \rightarrow FeCl_3 + 3H_2O$

1. **Write four reactions with *aluminum* containing compounds according to the chain of chemical reactions**

Al $\xrightarrow{+\ O_2}$ A $\xrightarrow{+\ HCl}$ B $\xrightarrow{+\ 3NaOH}$ C $\xrightarrow{+\ 3NaOH}$ D

1. _____

2. _____

3. _____

4. _____

Write the third reaction in the complete and short ionic forms:

_____

_____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

2. **Write four reactions with *iron* containing compounds according to the chain of chemical reactions**

FeO $\xrightarrow{+\ 2HNO_3}$ A $\xrightarrow{+\ 1KOH}$ B $\xrightarrow{+\ 1KOH}$ C $\xrightarrow{+\ H_2SO_4}$ D

1. _____

2. _____

3. _____

4. _____

Write the second reaction in the complete and short ionic forms:

_____

_____

Write the third reaction in the complete and short ionic forms:

_____

_____

3. **Calculate the mass of a salt produced after the heating together 5 g of solid sodium hydroxide and 2 g of aluminum hydroxide.**

_____

_____

_____

_____

4. **What is the mass percentage of iron turned to rust if the initial mass of iron was equal to 84 g, and the mass of iron hydroxide now is equal to 12 g.**

_____
_____
_____

5. **Calculate the volume of nitrogen released in the reaction between 18 g of nitric acid and 3 g of aluminum at high temperature.**

_____
_____
_____

6. **Calculate the volume of sulfur (IV) oxide released in the reaction between 5 g of concentrated sulfuric acid and 4 g of iron at high temperature.**

_____
_____
_____

EXERCISES FOR HOMEWORK

1. **Write four reactions with _iron_ containing compounds according to the chain of chemical reactions**

   $$Fe(OH)_3 \xrightarrow{+2HCl} A \xrightarrow{+1HCl} B \xrightarrow{+AgNO_3} C \xrightarrow{+H_3PO_4} D$$

   1. _____
   2. _____
   3. _____
   4. _____

   Write the second reaction in the complete and short ionic forms:

   _____
   _____

   Write the fourth reaction in the complete and short ionic forms:

   _____
   _____

2. **Write four reactions with _aluminum_ containing compounds according to the chain of chemical reactions**

   $$Al \xrightarrow{+HNO_3} A \xrightarrow{+4NaOH} B \xrightarrow{+1HCl} C \xrightarrow{+3HCl} D$$

   1. _____

2. _____

3. _____

4. _____

Write the second reaction in the complete and short ionic forms:

_____

_____

Write the fourth reaction in the complete and short ionic forms:

_____

_____

3. **Calculate the mass of a complex salt produced after putting 6 g of aluminum chloride in 200 g of the solution with the mass percentage of sodium hydroxide equal to 25 %.**

_____

_____

_____

_____

4. **What is the mass percentage of aluminum oxide on the surface of aluminum plate? That plate had a mass of 10 g. Complete dissolving in hydrochloric acid produced 12.32 L of hydrogen (in normal conditions).**

_____

_____

_____

_____

5. **Calculate the mass of ammonium nitrate formed in the reaction between 12 g of nitric acid and 2 g of aluminum at high temperature.**

_____

_____

_____

_____

6. **Calculate the volume of sulfur (IV) oxide released in the reaction between 5 g of concentrated sulfuric acid and 4 g of iron at high temperature.**

_____

_____

_____

_____

LESSON 39. THE SAMPLE OF CONTROL TASK #5

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   $C \rightarrow CO_2 \rightarrow KHCO_3 \rightarrow K_2CO_3 \rightarrow BaCO_3$

   1. _____
   2. _____
   3. _____
   4. _____

   Write the third reaction in the complete and short ionic forms:

   _____
   _____

   Write the fourth reaction in the complete and short ionic forms:

   _____
   _____
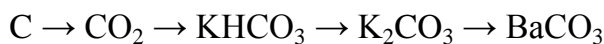
2. **Write four reactions with _sulfur_ containing compounds according to the chain of chemical reactions**

   $S \xrightarrow{+ O_2} A \xrightarrow{+ NaOH \ (in \ excess)} B \xrightarrow{+ HCl \ (in \ excess)} C \xrightarrow{+ CaO} D$
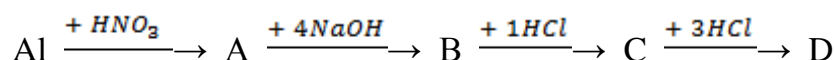
   1. _____
   2. _____
   3. _____
   4. _____

   Write the second reaction in the complete and short ionic forms:

   _____
   _____

   Write the third reaction in the complete and short ionic forms:

   _____
   _____

3. **Find the volume percentage of ammonia in its mixture with nitrogen. 5 L of that mixture reacted with 2 g of hydrogen chloride.**

   _____
   _____
   _____
   _____

4. **Find the simplest formula of a compound. The mass percentages of elements in the compound are as follows: 62.22 % of iron, 35.56% of oxygen and 2.22 % of hydrogen.**

_____
_____
_____
_____

5. **The mass of the mixture made from zinc nitrate and cobalt (II) nitrate is 12 g. That mixture has been thermally decomposed and produced 2.914 L of nitrogen dioxide. Find the mass percentage of zinc nitrate in the initial mixture.**

_____
_____
_____
_____

LESSON 40. SATURATED HYDROCARBONS

TEST FOR CLASSWORK

1. What is the valence of carbon in all organic compounds?
   a. I   b. II   c. III   d. IV

2. Choose the common formula for alkanes:
   a. C_nH_{2n-2} b. C_nH_{2n} c. C_nH_{2n+2} d. C_nH_{2n-6}

3. How many isomers can you suggest for butane molecule?
   a. 1   b. 2   c. 3   d. 4

4. Choose isomers which can be described by the same C_5H_{12} formula:
   a. 2-methyl-butane
   b. 3-methyl-pentane
   c. 2,2-dimethyl-propane
   d. 2,2-dimethyl-pentane

5. Choose alkanes existing in gaseous state in normal conditions:
   a. C_2H_6 b. CH_4 c. C_6H_{12} d. C_3H_8

6. Describe the type of chemical reaction between C_2H_6 and Cl_2:
   a. addition
   b. substitution
   c. decomposition
   d. composition

7. Which reactants can be used to synthesize $C_{10}H_{22}$ from $C_5H_{11}Cl$?
   a. potassium
   b. potassium chloride
   c. sodium
   d. sodium hydroxide

8. Calculate the sum of all coefficients in the redox reaction: $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$
   a. 6   b. 10   c. 7   d. 13

9. Choose the final products of C_4H_{10} combustion in the excess of oxygen:
   a. CO_2 and H_2O c. C_2H_6 and C_2H_4
   b. CO and H_2O d. C_4H_9OH

10. Which substances can be produced in the reaction between three substances: C_2H_5Cl, C_3H_7Cl and Na?
    a. C_4H_{10} b. C_6H_{14} c. C_5H_{12} d. C_7H_{16}

TEST FOR HOMEWORK

1. Choose the type of hybridization state for outer shell electron orbitals of each carbon atom in saturated hydrocarbons?

    a. sp   b. sp^2 c. sp^3 d. no hybridization

2. Cracking of alkanes results in formation of:

    a. shorter alkanes   c. longer alkanes

    b. shorter alkenes   d. longer alkenes

3. How many isomers can you suggest for pentane molecule?

    a. 1   b. 2   c. 3   d. 4

4. Choose isomers which can be described by the same C_6H_{14} formula:

    a. 2-methyl-butane

    b. 2-methyl-pentane

    c. 3-methyl-pentane

    d. 2,3-dimethyl-pentane

5. Choose alkanes existing in solid state in normal conditions

    a. C_5H_{12} b. C_6H_{14} c. $C_{16}H_{34}$ d. $C_{23}H_{48}$

6. Describe the type of the following chemical reaction: $2CH_4\,(t°) \rightarrow C_2H_2 + 3H_2$

    a. composition   c. decomposition

    b. dehydration   d. dehydrogenation

7. Which reactants can be used to synthesize $C_{12}H_{24}$ from $C_6H_{13}Br$?

    a. potassium   c. lithium

    b. potassium carbonate   d. potassium permanganate

8. Calculate the sum of all coefficients in the redox reaction:

    $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$

    a. 15   b. 18   c. 25   d. 33

9. Choose the products of the reaction between HNO_3 and C_4H_{10}:

    a. $C_4H_9NO_2$ and H_2O

    b. $C_4H_9NH_3$ and H_2O

    c. $C_3H_9NO_2$ and H_2O

    d. $C_4H_{11}NO_3$

10. Which substances can be produced in the reaction between tree substances: C_3H_7Br, C_4H_9Br and K?

    a. C_8H_{18} b. C_6H_{14} c. C_5H_{12} d. C_7H_{16}

1. **Draw structural formulas of the following compounds:**

    3-ethyl-3-methyl-hexane

    2,2-dimethylbutane

    3-ethyl-4-propylheptane

    1,2-dimethylcyclopentane

2. **Find the formula of a hydrocarbon. Combustion of that hydrocarbon resulted in the formation of 2 L of carbon dioxide and 1.205 g of water. The relative density of the hydrocarbon per helium is 13.5.**

    _____

    _____

    _____

    _____

3. **The mixture made from ethane and butane has a volume of 4 L. That mixture has been completely burnt. The volume of carbon dioxide was equal to 12 L. Find the volume percentage of ethane in the initial mixture of gases.**

    _____

    _____

    _____

    _____

4. **The mixture made from methane and propane has a volume of 6 L. That mixture has been completely burnt. The volume of oxygen used in this process was equal to 24 L. Find the volume percentage of propane in the initial mixture of gases.**

    _____

    _____

    _____

    _____

EXERCISES FOR HOMEWORK

1. **Draw structural formulas of the following compounds:**

    2-methyl-4-propyl-octane

    3,3-diethylhexane

    2,3,4-trimethylpentane

    2,4-dimethylhexane

2. **The products of the complete combustion of a hydrocarbon are: 40 L of carbon dioxide and 32.143 g of water. The relative density of this compound per oxygen is 1.75. Find the formula of a hydrocarbon.**

_____
_____
_____
_____

3. **The mixture made from methane and butane has a volume of 5 L. That mixture has been completely burnt. The volume of oxygen used in this process was equal to 28 L. Find the volume percentage of methane in the initial mixture of gases.**

_____
_____
_____
_____

4. **The mixture made from propane and butane has a volume of 6 L. That mixture has been completely burnt. The volume of carbon dioxide produced in this process was equal to 19 L. Find the volume percentage of butane in the initial mixture of gases.**

_____
_____
_____
_____

LESSON 41. NOMENCLATURE OF UNSATURATED HYDROCARBONS

1. **Draw structures of all the isomers (including interclass ones) of hexene:**

2. **Draw structures of the following compounds:**

    5-methyl-trans-2-hexene

    3-methyl-1-pentyne

    3,4-dimethyl-cis-3-hexene

    1,3-hexadiene

3. **Name the following compounds:**

1. **Draw structures of all the isomers (including interclass ones) of heptyne:**

2. **Draw structures of the following compounds:**

   2-methyl-2-pentene
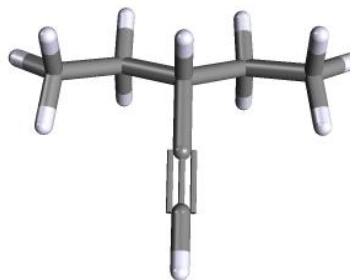
   3-ethyl-4-octyne

   4,4-dimethyl-cis-2-pentene

   2-methyl-1,3-butadiene

3. **Name the following compounds:**
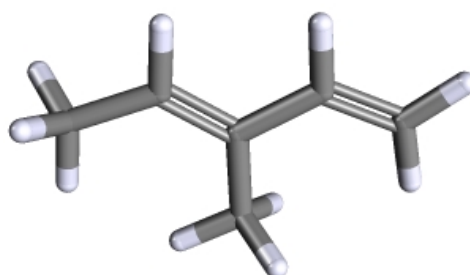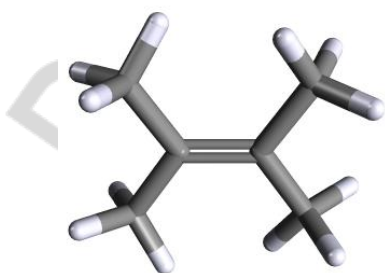
LESSON 42. CHEMICAL PROPERTIES OF UNSATURATED HYDROCARBONS

1. **What volume is occupied by 33 g of ethylene in normal conditions?**

   _____
   _____
   _____
   _____
   _____

2. **Determine the volume of acetylene which can be produced from 1 kg of calcium carbide containing 30 % of impurities.**

   _____
   _____
   _____
   _____
   _____

3. **The mixture of methane and acetylene had a volume of 6 L. That mixture has been passed through the bromine water solution. The mass of the solution increased by 5 g. Find the volume percentage of methane in the initial mixture.**

   _____
   _____
   _____
   _____
   _____

4. **The mixture of propane and propyne had a volume of 6 L (in normal conditions). The mixture reacted with 1.2 L of hydrogen. Calculate the volume percentage of propane in the initial mixture.**

   _____
   _____
   _____
   _____
   _____

5. **9.375 g of a hydrocarbon reacted with 5 L of hydrogen up to the complete saturation and produced 5 L of an alkane. Find the formula of that compound.**

_____

_____

_____

_____

_____

_____

6. **There is a mixture of ethene, propyne and propadiene. 2 L of that mixture reacted with 3.5 L of hydrogen until the complete saturation. Find the volume percentage of ethene in the mixture.**

_____

_____

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **How many molecules are there in 13 L of propylene in normal conditions?**

_____

_____

_____

_____

_____

_____

2. **Determine the volume of methane which can be produced from 1 kg of aluminum carbide containing 12 % of impurities.**

_____

_____

_____

_____

_____

_____

3. **The mixture of propane and propene had a volume of 8 L. That mixture has been passed through the bromine water solution. The mass of the solution increased by 3 g. Find the volume percentage of methane in the initial mixture.**

_____
_____
_____
_____
_____

4. **The mixture of butane and ethene had a volume of 3 L (in normal conditions). The mixture reacted with 1.4 g of hydrogen chloride. Calculate the volume percentage of butane in the initial mixture.**

_____
_____
_____
_____
_____

5. **2 L of an alkene added 7.2321 g of hydrogen bromide and produced 10.9821 g of an alkyl bromide. Find the formula of that alkene.**

_____
_____
_____
_____
_____
_____

6. **There is a mixture of propene, butyne and 1,3-butadiene. 2 L of that mixture reacted with 21.429 g of bromine until the complete saturation. Find the volume percentage of propene in the mixture.**

_____
_____
_____
_____
_____
_____

LESSON 43. POLYMERS OF UNSATURATED HYDROCARBONS

EXERCISES FOR CLASSWORK

1. **Write four reactions with _organic_ compounds according to the chain of chemical reactions**

   $Al_4C_3 \xrightarrow{H_2O} A \xrightarrow{+1Cl_2} B \xrightarrow{+2K} C \xrightarrow{+1Br_2} D$

   1. _____
   2. _____
   3. _____
   4. _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   octane → 1-butene → 2-chlorobutane → 2-butene → 2,3-dichlorobutane
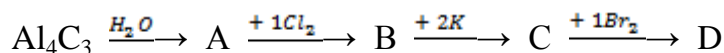
   1. _____
   2. _____
   3. _____
   4. _____

   Draw structures of stereoisomers for 2-butene:

3. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   methane → methylchloride → ethane → ethylbromide → hexane

   1. _____
   2. _____
   3. _____
   4. _____

4. **Calculate the volume of 1,3-butadiene that is needed to make 200 g of polybutadiene.**

   _____
   _____
   _____
   _____

5. **Calculate the number of monomers in 100 g of polyethylene.**

_____

_____

_____

_____

6. **Find the mass of chlorine in 500 g of polyvinylchloride.**

_____

_____

_____

_____

<div align="center">

EXERCISES FOR HOMEWORK

</div>

1. **Write four reactions with _organic_ compounds according to the chain of chemical reactions**

    $CaC_2 \xrightarrow{+ H_2O} A \xrightarrow{+ 1H_2} B \xrightarrow{+ HCl} C \xrightarrow{+ Na} D$

    1. _____

    2. _____

    3. _____

    4. _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

    decane → pentane → 1-pentene → 2-chloropentane → 4,5-dimethyloctane

    1. _____

    2. _____

    3. _____

    4. _____
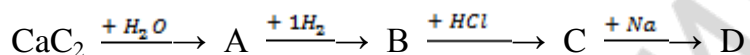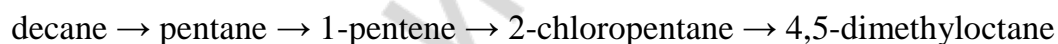
    Draw the structure of the last compound:

3. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   ethane → ethylchloride → ethene → polyethylene → carbon dioxide

   1. _____

   2. _____

   3. _____

   4. _____

4. **Calculate the volume of ethylene that is needed to make 300 g of polyethylene.**

   _____

   _____

   _____

   _____

5. **Calculate the number of monomers in 150 g of natural rubber.**

   _____

   _____

   _____

   _____

6. **Find the mass of chlorine in 400 g of polychloroprene.**

   _____

   _____

   _____

   _____

LESSON 44. BENZENE AND ITS HOMOLOGS

TEST FOR CLASSWORK

1. Which reactant can be used to distinguish unsaturated hydrocarbons from saturated ones?
   a. Tollen's reagent
   c. bromine water
   b. Fehling's solution
   d. silver nitrate

2. Choose the common formula for alkenes and cyclic alkanes:
   a. C_nH_{2n-2}
   b. C_nH_{2n}
   c. C_nH_{2n+2}
   d. C_nH_{2n-6}

3. Are there cis- and trans- isomers for 1-butene and 2-butene, respectively?
   a. yes / no
   b. no / yes
   c. yes / yes
   d. no / no

4. Choose the product of acetylene trimerization:
   a. vinyl acetylene
   c. methane
   b. benzene
   d. toluene

5. Choose the most abundant product of 1-propene reaction with HCl:
   a. 1-chloropropane
   c. propyne
   b. 2-chloropropane
   d. propane

6. Describe the type of chemical reaction between C_2H_4 and Br_2:
   a. addition
   c. decomposition
   b. substitution
   d. composition

7. Choose the formula of polyvinylchloride:
   a. $[-CHCl=CH_2-]_n$
   c. $[-CHCl-CH_2-]_n$
   b. $[-CH_2-CH_2-]_n$
   d. $[-CHCl=CHCl-]_n$

8. Calculate the sum of all coefficients in the redox reaction:
   $C_5H_{10} + O_2 \rightarrow CO_2 + H_2O$
   a. 17
   b. 20
   c. 37
   d. 48

9. Choose the hybridization state of outer shell electron orbitals in carbon atoms from benzene:
   a. sp
   b. sp^2
   c. sp^3
   d. no hybridization

10. What type of compound is produced in alkene hydration reaction?
    a. alkane
    c. aldehyde
    b. diene
    d. alcohol

TEST FOR HOMEWORK

1. Choose formulas of benzene homologues (arenes)?
   a. C_6H_6 b. C_8H_{10} c. C_8H_{18} d. C_2H_2

2. Choose the common formula for alkynes and dienes:
   a. C_nH_{2n-2} b. C_nH_{2n} c. C_nH_{2n+2} d. C_nH_{2n-6}

3. Are there cis- and trans- isomers for 2-pentene and 2-pentyne, respectively?
   a. yes / no   b. no / yes   c. yes / yes   d. no / no

4. Choose the product of acetylene dimerization:
   a. toluene   c. methane
   b. benzene   d. vinyl acetylene

5. Choose the most abundant product of 2-propanol dehydration at temperature higher than 170 °C in the presence of H_2SO_4:
   a. propene   c. 2-propyne
   b. 1-butene   d. propane

6. Describe the type of chemical reaction between C_2H_2 and H_2O:
   a. addition   c. composition
   b. redox reaction   d. one step reaction

7. Choose the formula of polyethylene:
   a. $[-CHCl=CH_2-]_n$ c. $[-CHCl-CH_2-]_n$
   b. $[-CH_2-CH_2-]_n$ d. $[-CHCl=CHCl-]_n$

8. Calculate the sum of all coefficients in the redox reaction:
   $C_4H_6 + O_2 \rightarrow CO_2 + H_2O$
   a. 13   b. 14   c. 27   d. 30

9. Choose correct statements about benzene molecule:
   a. it is prone to substitution reactions more than to addition reactions
   b. it is prone to addition reactions more than to substitution reactions
   c. three bonds between carbon atoms in the molecule are shorter than three other bonds
   d. lengths of all six bonds between carbon atoms are equal to each other

10. Choose the most abundant product of $CH_2=CH-CH=CH_2 + H_2$ reaction? The molar ration between reactants is 1:1.
    a. 1-butene   c. butane
    b. 2-butene   d. 1,2-butadiene

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

    methane → acetylene → benzene → cyclohexane → cyclohexene

    1. _____

    2. _____

    3. _____

    4. _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

    propane → 1-bromopropane → hexane → benzene → styrene

    1. _____

    2. _____

    3. _____

    4. _____

    Draw the structural formula for the last compound:

3. **Draw structures of all isomers for trimethylbenzene and name them:**

4. **Find the volume of hydrogen needed for complete saturation of 7 g of benzene.**

    _____

    _____

    _____

    _____

5. Determine the mass of the organic product of the reaction between 15 g of toluene and the excess of bromine water.

_____

_____

_____

_____

6. Calculate the volume of oxygen which is required to burn down 34 L of benzene. The density of benzene is 0.89 g/ml.

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. Write four reactions according to the following classic chain of chemical reactions and balance them:

methane → acetylene → benzene → bromobenzene → ethylbenzene

1. _____

2. _____

3. _____

4. _____

2. Write four reactions according to the following classic chain of chemical reactions and balance them:

hexane → benzene → chlorobenzene → toluene → trinitrotoluene

1. _____

2. _____

3. _____

4. _____

Draw the structural formula of the last compound:

3. **Draw structures of all isomers for dichlorobenzene and name them:**

4. **Find the volume of chlorine gas (in normal conditions) needed for complete saturation of 9 g of benzene (up to hexachlorocyclohexane).**

_____

_____

_____

_____

5. **Calculate the mass of calcium carbide needed to make 100 g of benzene. The yield of the first step is 60 %, the yield of the second step is 75 %.**

_____

_____

_____

_____

6. **Calculate the volume of air which is required to burn down 15 g of benzene.**

_____

_____

_____

_____

LESSON 45. ALCOHOLS

EXERCISES FOR CLASSWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   glucose → ethanol → 1,3-butadiene → 2-butene → 2,3-dibromobutane

   1. _____
   2. _____
   3. _____
   4. _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   ethane → 1-chloroethane → ethanol → diethyl ether → carbon dioxide

   1. _____
   2. _____
   3. _____
   4. _____

   Draw the structural formula of the third compound:

3. **Draw structures of all isomers for butanol and name them:**

4. **Calculate the mass of methanol which has been burned down. The volume of carbon dioxide produced is equal to 56 L.**

   _____
   _____
   _____
   _____

5. **What is the mass of carbon dioxide formed in the reaction between 15 ml of ethanol (density is 0.8 g/ml) and the excess of oxygen?**

_____

_____

_____

_____

_____

6. **What is the mass of diethyl ether formed from 12 g of ethanol?**

_____

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   methane → chloromethane → ethane → bromoethane → ethanol

   1. _____

   2. _____

   3. _____

   4. _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   chloroethane → ethene → ethanol → 1,3-butadiene → 2-butene

   1. _____

   2. _____

   3. _____

   4. _____

   Draw the structural formula of the fourth compound:

3. **Draw structures of all isomers for pentanol and name them:**

4. **Calculate the mass of 1,2-ethanediol (ethylene glycol) which has been burned down. The volume of carbon dioxide produced is equal to 26 L.**

_____
_____
_____
_____

5. **What is the mass of carbon dioxide formed in the reaction between 15 ml of glycerol (density is 1.3 g/ml) and the excess of oxygen?**

_____
_____
_____
_____
_____

6. **What is the mass of polybutadiene that can be produced from 1 L of ethanol (density is 0.8 g/ml). The yield of the process is 40 %.**

_____
_____
_____
_____

LESSON 46. ALDEHYDES AND KETONES

EXERCISES FOR CLASSWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   calcium carbide → acetylene → acetaldehyde → ethanol → ethene

   1. _____

   2. _____

   3. _____

   4. _____

   Draw the structural formula of the intermediate product of the second reaction:

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   propane → 1-chloropropane → propanol → propanal → propionic acid

   1. _____

   2. _____

   3. _____

   4. _____

3. **Draw structures of all isomers for pentanal and name them:**

4. **Calculate the mass of silver produced in the silver mirror test with 4 ml of 0.02 M solution of propanal.**

   _____

   _____

   _____

   _____

5. **The mass of an alcohol formed by the way of hydrogenation of a corresponding aldehyde is 3.45 % higher than the mass of that aldehyde. Find the formula of an aldehyde.**

_____
_____
_____
_____

6. **What is the mass of acetaldehyde that can be produced from 5 L of acetylene (in normal conditions) if the yield of the process is 66 %?**

_____
_____
_____
_____

EXERCISES FOR HOMEWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

methane → chloromethane → methanol → methanal → formic acid

1. _____
2. _____
3. _____
4. _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

butanone → 2-butanol → 2-butene → butane → ethane

1. _____
2. _____
3. _____
4. _____

Draw structural formulas of the most abundant and the less abundant products of the second reaction:

3. **Draw structures of all isomers for hexanone and name them:**

4. **Calculate the mass of silver produced in the silver mirror test with 200 g of a solution containing 4 % of ethanal and 3 % of butanal by mass.**

_____

_____

_____

_____

5. **The mass of an alcohol formed by the way of hydrogenation of a corresponding aldehyde is 4.45 % higher than the mass of that aldehyde. Find the formula of an aldehyde.**

_____

_____

_____

_____

_____

6. **200 g of the solution of propanal and propanone produced 3 g of silver in the silver mirror test. The total mass percentage of organic substances (propanal and propanone) in the initial solution was equal to 15 %. Find the mass percentage of propanone in the initial solution.**

_____

_____

_____

_____

LESSON 47. CARBOXYLIC ACIDS

EXERCISES FOR CLASSWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   chloromethane → methanol → methanal → formic acid → methyl formiate

   1. _____

   2. _____

   3. _____

   4. _____

   Write the same reaction as the first one but in the alcoholic solution:

   _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   propionic acid → ethyl propionate → sodium propionate → ethane → ethene

   1. _____

   2. _____

   3. _____

   4. _____

   Write the same reaction as the second one in acidic medium:

   _____

3. **Draw the structural formula of oxalic acid:**

4. **Calculate the volume of carbon dioxide produced in the reaction between 20 g of 9 % acetic acid solution and 5 g of sodium bicarbonate.**

   _____

   _____

   _____

   _____

5. **Find the mass of acetic acid anhydride needed to prepare 300 g of acetic acid solution with the mass percentage of 5 %.**

_____

_____

_____

_____

_____

6. **The volume of hydrogen released in the reaction between 10 g of a saturated monoprotic carboxylic acid and potassium is equal to 1.273 L. Find the formula of that acid.**

_____

_____

_____

_____

<div align="center">

EXERCISES FOR HOMEWORK

</div>

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

ethanal → ethanol → acetaldehyde → acetic acid → acetic acid anhydrate

1. _____

2. _____

3. _____

4. _____

Write the third reaction with another oxidizer:

_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

butane → 1-butyne → butanone → 2-butanol → 2-bromobutane

1. _____

2. _____

3. _____

4. _____

Write the second reaction in which its minor product is formed:

_____

3. **Draw the structural formula of butanoic acid:**

4. **Calculate the volume of carbon dioxide produced in the reaction between 30 g of 9 % acetic acid solution and 15 g of potassium carbonate.**

    _____
    _____
    _____
    _____

5. **Find the mass of acetic acid anhydride needed to prepare 250 g of acetic acid solution with the mass percentage of 15 %.**

    _____
    _____
    _____
    _____
    _____

6. **The volume of hydrogen released in the reaction between 8 g of a saturated monoprotic carboxylic acid and sodium is equal to 1.211 L. Find the formula of that acid.**

    _____
    _____
    _____
    _____

LESSON 48. ESTERS AND FATS

TEST FOR CLASSWORK

1. Esters may be described as products of the reaction between:

   a. alcohols and aldehydes

   b. carboxylic acids and aldehydes

   c. carboxylic acids and alcohols

   d. alcohols and alkanes

2. Choose the common formula for monoatomic saturated alcohols:

   a. $C_nH_{2n-1}OH$ c. $C_nH_{2n+2}OH$

   b. $C_nH_{2n}OH$ d. $C_nH_{2n+1}OH$

3. Ethers are isomers of:

   a. esters   c. alcohols

   b. aldehydes   d. carboxylic acids

4. Choose the product of 1-propanol dehydration reaction at the temperature lower than 140 °C in the presence of H_2SO_4:

   a. propanal   c. dipropyl ether

   b. propene   d. ethyl acetate

5. Acetic acid reacts with:

   a. K   b. KOH   c. KCl   d. Cl_2

6. Fat can be described as:

   a. ether   c. aldehyde

   b. ester   d. carboxylic acid

7. Silver mirror test (reaction with Ag_2O) can be used to approve the presence of:

   a. aldehyde   c. glucose

   b. ketone   d. fructose

8. Calculate the sum of all coefficients in the reaction between formic acid aldehyde (H_2CO) and the excess of Tollen's reactant (Ag_2O):

   a. 9   b. 5   c. 10   d. 4

9. How many isomers can you suggest for butanol molecule?

   a. 2   b. 4   c. 5   d. 7

10. Which products may be formed in the process of ethanol oxidation (consider different oxidizers and conditions)?

    a. CO_2 b. CH_3CHO c. CH_3COOH d. C_2H_6

TEST FOR HOMEWORK

1. Ethers may be described as products of the reaction between:

    a. alcohols

    b. carboxylic acids and alcohols

    c. carboxylic acids

    d. alkenes

2. Choose the common formula for monoprotic saturated carboxylic acids:

    a. $C_nH_{2n+1}COOH$ c. $C_nH_{2n+2}COOH$

    b. $C_nH_{2n+2}O_2$ d. $C_nH_{2n-1}COOH$

3. Esters are isomers of:

    a. esters   c. alcohols

    b. aldehydes   d. carboxylic acids

4. Which substances react with both phenol and ethanol?

    a. NaOH   b. Na   c. HCl   d. H_2

5. Choose the final products of glucose alcoholic fermentation:

    a. H_2O b. CO_2 c. C_2H_5OH d. CH_3COOH

6. Methylacetate is:

    a. ether   c. salt

    b. ester   d. carboxylic acid

7. Reaction with Fehling's solution (usually written as $Cu(OH)_2$) can be used to approve the presence of:

    a. aldehyde   c. glucose

    b. glycerol   d. fructose

8. Calculate the sum of all coefficients in the reaction between acetaldehyde (CH_3CHO) and the excess of Fehling's solution ($Cu(OH)_2$):

    a. 6   b. 7   c. 8   d. 9

9. How many isomers can you suggest for butanal molecule?

    a. 2   b. 3   c. 4   d. 5

10. Choose the product of propanal reduction by hydrogen:

    a. propane   c. propyne

    b. propene   d. propanol

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

ethanol → diethyl ether → ethanol → ethyl propionate → sodium propionate

1. _____

2. _____

3. _____

4. _____

Write the first reaction at higher temperature (higher than 170 °C):

_____

2. **Draw a structure of a fat molecule made from two residues of palmitic acid and one residue of stearic acid:**

Write the reaction of saponification (with sodium hydroxide) for this fat:

3. **Find the mass of sodium stearate that can be obtained in the reaction of saponification of 500 g of the fat from the previous exercise.**

_____

_____

_____

_____

4. **What is the mass of an ester produced in the reaction between 5 g of acetic acid and 6 g of propanol?**

_____

_____

_____

_____

5. **Ethyl butanoate has been hydrolyzed with the help of sodium hydroxide. Then sodium butanate has been decarboxylized. The mass of propane is 4 g. Find the mass of ethyl butanoate used in this process. The yield of the first step is 85 %, the yield of the second step is 55 %.**

_____

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   1-bromopropane → 1-propanol → propanal → propionic acid → ethyl propanoate

   1. _____

   2. _____

   3. _____

   4. _____

   Write the third reaction with another oxidizer:

   _____

2. **Draw a structure of a fat molecule made from one residues of oleic acid, one residue of linolenic acid, and one residue of stearic acid:**

Write the reaction of saponification (with potassium hydroxide) for this fat:

3. **Find the mass of potassium oleate that can be obtained in the reaction of saponification of 300 g of the fat from the previous exercise.**

   _____
   _____
   _____
   _____

4. **What is the mass of an ester produced in the reaction between 7 g of propionic acid and 9 g of ethanol?**

   _____
   _____
   _____
   _____

5. **Propyl propionate has been hydrolyzed with the help of potassium hydroxide. Find the yield of this process if the mass of propanol is 24 g, while the mass of an ester was 50 g.**

   _____
   _____
   _____
   _____
   _____

LESSON 49. CARBOHYDRATES

EXERCISES FOR CLASSWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

    glucose → ethanol → ethene → 1,2-dichloroethane → ethylene glycol

    1. _____

    2. _____

    3. _____

    4. _____

    Write the process of lactic acid and not alcoholic fermentation (the first reaction):

    _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

    starch → glucose → sucrose → fructose → sorbitol

    1. _____

    2. _____

    3. _____

    4. _____

    Which substance from this chain shows a positive silver mirror test? Write the corresponding reaction:

    _____

3. **Draw the structural formula of ribose:**

4. **Calculate the mass of glucose produced from 20 g of sucrose in the hydrolysis reaction.**

    _____

    _____

    _____

    _____

5. **Find the mass of starch needed to make 200 g of ethanol in the alcoholic fermentation process if the yield is 75 %.**

_____

_____

_____

_____

6. **What mass of silver will be formed in the silver mirror test with 15 g of glucose?**

_____

_____

_____

_____

_____

<div align="center">EXERCISES FOR HOMEWORK</div>

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

glucose → ethanol → ethanal → acetic acid → sodium acetate

1. _____

2. _____

3. _____

4. _____

Write the last reaction with another reactant:

_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

sucrose → glucose → ethanol → diethyl ether → carbon dioxide

1. _____

2. _____

3. _____

4. _____

Draw the structural formula of an isomer of the fourth substance which can react with metallic sodium:

3. **Draw the structural formula of deoxyribose:**

4. **Calculate the mass of glucose produced from 300 g of starch in the hydrolysis reaction.**

   _____
   _____
   _____
   _____

5. **Find the mass of grape needed to make 300 g of ethanol in the alcoholic fermentation process if the yield is 75 %, the mass percentage of starch in grape is 19 %.**

   _____
   _____
   _____
   _____

6. **What mass of silver will be formed in the silver mirror test with 20 g of the mixture of glucose and sucrose, if the mass percentage of sucrose is 40 %?**

   _____
   _____
   _____
   _____

LESSON 50. AMINES, AMINO ACIDS AND PROTEINS

TEST FOR CLASSWORK

1. What is the difference between polymerization and polycondensation?
   a. there are no subproducts of polycondensation
   b. there are no subproducts of polymerization
   c. polymerization and polycondensation are synonyms
   d. synthesis of a polysaccharide is polycondensation, synthesis of polyethylene is polymerization

2. Nucleotide is a monomer of:
   a. RNA   b. protein   c. glycogen   d. DNA

3. What is the difference between cellulose and starch?
   a. in starch molecules of glucose are connected by $\alpha(1\rightarrow4)$ and $\alpha(1\rightarrow6)$ bonds, while in cellulose they are connected by $\beta(1\rightarrow4)$ bonds
   b. cellulose is unbranched, while starch is branched
   c. starch is unbranched, while cellulose is branched
   d. in starch molecules of glucose are connected by $\alpha(1\rightarrow4)$ bonds, while in cellulose they are connected by $\beta(1\rightarrow4)$ and $\beta(1\rightarrow6)$ bonds

4. Choose the pathway to synthesize alanine from CH_3COOH:
   a. $+ Cl_2 / + NH_3$ c. $+ Br_2 / + NH_3$
   b. $+ NH_3 / + H_2O$ d. $+ H_2 / + N_2$

5. Amino acids in proteins are connected with each other by:
   a. ionic bonds   c. peptide bonds
   b. covalent bonds   d. hydrogen bonds

6. Choose the products of glycine combustion:
   a. CO_2 b. H_2O c. N_2 d. H_2

7. How many atoms are connected to the nitrogen atom of serine in the state of zwitterion?
   a. 1   b. 2   c. 3   d. 4

8. Two strands of DNA are connected together by:
   a. covalent bonds   c. peptide bonds
   b. ionic bonds   d. hydrogen bonds

9. DNA molecule is made from the following chemical elements:
   a. C, N, O, P, H   c. C, N, O, H
   b. C, N, O, S, H   d. C, N, O, P, S, H

10. Human proteins are made from the following chemical elements (ignore posttranslational modifications):

a. C, N, O, H   c. C, N, O, S, H

b. C, N, O, P, H   d. C, N, O, P, S, H

TEST FOR HOMEWORK

1. Choose amino acids with hydrophilic side chains:

a. alanine   c. glutamic acid

b. aspartic acid   d. glycine

2. Glucose is a monomer of:

a. starch   c. glycogen

b. cellulose   d. DNA

3. What is the difference between DNA and RNA?

a. nucleotides of DNA contain deoxyribose, while nucleotides of RNA contain ribose

b. uracil is normally included in RNA, but not in DNA

c. RNA is more stable than DNA

d. in all forms of life, except some types of viruses, DNA and not RNA is used for the storage of genetic information

4. Choose the pathway to synthesize ethyl amine from C_2H_6:

a. $+ Cl_2 / + NH_3$ c. $+ Br_2 / + NH_3$

b. $+ HNO_3 / + H_2$ d. $+ HNO_3 / + O_2$

5. Nucleotides in a single strand of DNA or RNA are connected with each other by:

a. ionic bonds   c. phosphodiester bonds

b. hydrogen bonds   d. covalent bonds

6. Choose the products of methylamine chloride reaction with alkali:

a. CO_2 b. H_2O c. N_2 d. CH_3NH_2

7. How many atoms are connected to the carbon atom of carboxylic group?

a. 1   b. 2   c. 3   d. 4

8. Amino acids can react with:

a. alkalis   b. acids   c. oxygen   d. nitrogen

9. Glycogen is made from the following chemical elements:

a. C, N, O, P   c. C, H, O

b. C, N, O, S   d. C, N, O, P, S

10. Human proteins are made from the following chemical elements (consider the possibility of posttranslational modifications):

a. C, N, O, H c. C, N, O, S, H

b. C, N, O, P, H d. C, N, O, P, S, H

EXERCISES FOR CLASSWORK

1. Write four reactions according to the following classic chain of chemical reactions and balance them:

calcium carbide → acetylene → benzene → nitrobenzene → aniline

1. _____

2. _____

3. _____

4. _____

Write the second reaction with another product:

_____

2. Write four reactions according to the following classic chain of chemical reactions and balance them:

butane → ethane → nitroethane → ethylamine → ethylamine chloride

1. _____

2. _____

3. _____

4. _____

Write the backward process for the fourth reaction:

_____

3. Draw the structural formula of glycyl serinate:

4. **Determine the mass of hydrochloric acid required for the reaction with 20 g of glycine.**

_____

_____

_____

_____

5. **Find the simplest formula of an organic substance. Complete combustion of 1.384 g of that substance resulted in the production of 1 L of carbon dioxide, 0.5 L of nitrogen and 2 g of water.**

_____

_____

_____

_____

6. **Calculate the volume of methylamine (in normal conditions) produced in the reaction between 10 g of methylamine chloride and the excess of potassium hydroxide.**

_____

_____

_____

_____

_____

EXERCISES FOR HOMEWORK

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

ethane → chloroethane → ethylamine → ethylamine chloride → ethylamine

1. _____

2. _____

3. _____

4. _____

Write the first reaction with another halogen:

_____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

methanol → chloromethane → ethane → nitroethane → nitrogen

1. _____

2. _____

3. _____

4. _____

Write the second reaction if the product is propane:

_____

3. **Draw the structural formula of alanyl aspartate:**

4. **Determine the mass of sodium hydroxide required for the reaction with 20 g of glycine.**

_____
_____
_____
_____

5. **The products of the combustion of 20 g of organic substance are 23.172 L of carbon dioxide and 18.621 g of water. Determine the simplest formula of that compound.**

_____
_____
_____
_____

6. **Calculate the volume of propylamine (density is 0.72 g/ml) produced in the reaction between 20 g of propylamine chloride and the excess of sodium hydroxide.**

_____
_____
_____
_____
_____

LESSON 51. THE SAMPLE OF CONTROL TASK #6

1. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   ethane → ethene → bromoethane → ethanol → chloroethane

   1. _____
   2. _____
   3. _____
   4. _____

2. **Write four reactions according to the following classic chain of chemical reactions and balance them:**

   methanol → chloromethane → propane → bromopropane → propene

   1. _____
   2. _____
   3. _____
   4. _____

3. **Acetaldehyde reacted with Tollens' reagent and produced 6.48 g of silver. Determine the mass of acetaldehyde.**

   _____
   _____
   _____
   _____

4. **What is the volume of carbon dioxide produced in the process of alcoholic fermentation of 38 g of glucose. The yield of the reaction was equal to 60 %.**

   _____
   _____
   _____
   _____

5. **The products of the combustion of 10 g of organic substance are 7.304 L of carbon dioxide and 7.826 g of water. Determine the simplest formula of that compound.**

   _____
   _____
   _____
   _____

6. **Find the mass of alanine produced after the complete hydrolysis of 25 g of alanyl glutamate.**

_____
_____
_____
_____

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PERIODIC TABLE OF THE ELEMENTS

GROUPS OF ELEMENTS

Legend:
- Atomic number of element
- Electronegativity
- Symbol of element
- Name of element
- Relative atomic mass

Example cell: 79 1,42 — **Au** — Gold — 196,967

162

Period	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 2,1 **H** Hydrogen 1.00794																	2 – **He** Helium 4.0026
2	3 0,97 **Li** Lithium 6,941	4 1,47 **Be** Beryllium 9,01218											5 2,01 **B** Boron 10,811	6 2,50 **C** Carbon 12,011	7 3,07 **N** Nitrogen 14,007	8 3,50 **O** Oxygen 15,9994	9 4,10 **F** Fluorine 18,9984	10 – **Ne** Neon 20,1797
3	11 1,01 **Na** Sodium 22,9898	12 1,23 **Mg** Magnesium 24,305											13 1,47 **Al** Aluminum 26,9815	14 1,74 **Si** Silicon 28,086	15 2,10 **P** Phosphorus 30,9738	16 2,60 **S** Sulfur 32,066	17 2,83 **Cl** Chlorine 35,452	18 – **Ar** Argon 39,948
4	19 0,91 **K** Potassium 39,0983	20 1,04 **Ca** Calcium 40,078	21 1,20 **Sc** Scandium 44,956	22 1,32 **Ti** Titanium 47,87	23 1,45 **V** Vanadium 50,942	24 1,56 **Cr** Chromium 51,996	25 1,60 **Mn** Manganese 54,938	26 1,64 **Fe** Iron 55,845	27 1,70 **Co** Cobalt 58,933	28 1,75 **Ni** Nickel 58,693	29 1,75 **Cu** Copper 63,546	30 1,66 **Zn** Zinc 65,39	31 1,82 **Ga** Gallium 69,723	32 2,02 **Ge** Germanium 72,61	33 2,20 **As** Arsenic 74,922	34 2,48 **Se** Selenium 78,96	35 2,74 **Br** Bromine 79,904	36 – **Kr** Krypton 83,80
5	37 0,89 **Rb** Rubidium 85,468	38 0,99 **Sr** Strontium 87,62	39 1,11 **Y** Yttrium 88,906	40 1,22 **Zr** Zirconium 91,224	41 1,23 **Nb** Niobium 92,906	42 1,30 **Mo** Molybdenum 95,94	43 1,36 **Tc** Technetium [98]	44 1,42 **Ru** Ruthenium 101,07	45 1,45 **Rh** Rhodium 102,905	46 1,35 **Pd** Palladium 106,42	47 1,42 **Ag** Silver 107,868	48 1,46 **Cd** Cadmium 112,411	49 1,49 **In** Indium 114,82	50 1,72 **Sn** Tin 118,71	51 1,82 **Sb** Antimony 121,76	52 2,01 **Te** Tellurium 127,60	53 2,21 **I** Iodine 126,904	54 – **Xe** Xenon 131,29
6	55 0,86 **Cs** Cesium 132,905	56 0,97 **Ba** Barium 137,327	57 1,08 ***La** Lanthanum 138,906	72 1,23 **Hf** Hafnium 178,49	73 1,33 **Ta** Tantalum 180,948	74 1,40 **W** Tungsten 183,84	75 1,46 **Re** Rhenium 186,207	76 1,52 **Os** Osmium 190,23	77 1,55 **Ir** Iridium 192,22	78 1,44 **Pt** Platinum 195,08	79 1,42 **Au** Gold 196,967	80 1,44 **Hg** Mercury 200,59	81 1,44 **Tl** Thallium 204,383	82 1,55 **Pb** Lead 207,2	83 1,67 **Bi** Bismuth 208,980	84 1,76 **Po** Polonium [209]	85 1,90 **At** Astatine [210]	86 – **Rn** Radon [222]
7	87 0,86 **Fr** Francium [223]	88 0,97 **Ra** Radium 226,025	89 1,00 ◆**Ac** Actinium [227]	104 – **Rf** Rutherfordium [261]	105 – **Db** Dubnium [262]	106 – **Sg** Seaborgium [266]	107 – **Bh** Bohrium [264]	108 – **Hs** Hassium [265]	109 – **Mt** Meitnerium [268]	110 – **[Uun]** [271]	111 – **[Uuu]** [272]	112 – **[Uub]** [277]	113 – **[Uut]** [282]	114 – **[Uug]** [285]	115 –	116 – **[Uuh]** [289]	117 –	118 – **[Uuo]** [293]

***Lanthanide Series**

		58 1,08 **Ce** Cerium 140,115	59 1,07 **Pr** Praseodymium 140,907	60 1,07 **Nd** Neodymium 144,24	61 1,07 **Pm** Promethium 144,913	62 1,07 **Sm** Samarium 150,36	63 1,01 **Eu** Europium 151,965	64 1,11 **Gd** Gadolinium 157,25	65 1,10 **Tb** Terbium 158,925	66 1,10 **Dy** Dysprosium 162,5	67 1,10 **Ho** Holmium 164,93	68 1,11 **Er** Erbium 167,26	69 1,11 **Tm** Thulium 168,934	70 1,06 **Yb** Ytterbium 173,04	71 1,14 **Lu** Lutetium 174,967

◆**Actinide Series**

		90 1,11 **Th** Thorium 232,038	91 1,14 **Pa** Protactinium 231,035	92 1,22 **U** Uranium 238,028	93 1,22 **Np** Neptunium 237,048	94 1,22 **Pu** Plutonium 244,064	95 1,20 **Am** Americium 243,061	96 1,20 **Cm** Curium 247,07	97 1,20 **Bk** Berkelium 247,07	98 1,20 **Cf** Colifornium 251,079	99 1,20 **Es** Einsteinium 252,083	100 1,20 **Fm** Fermium 257,095	101 1,20 **Md** Mendelevium 258,099	102 1,20 **No** Nobelium 18,9984	103 1,20 **Lr** Lawrencium 260,105
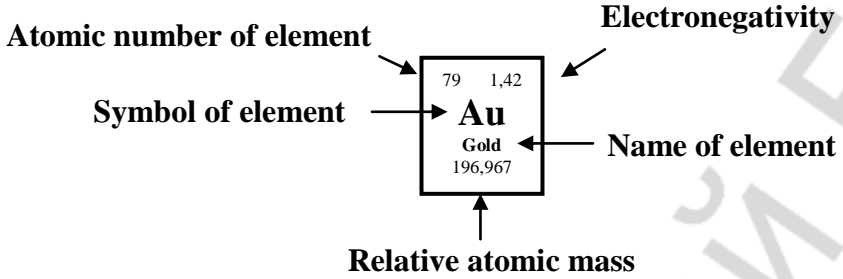
SOLUBILITY OF INORGANIC SUBSTANCES IN WATER

	Na$^+$	K$^+$	Li$^+$	Ca^{2+}	Ba^{2+}	Sr^{2+}	NH$_4^+$	Ag$^+$	Mg^{2+}	Mn^{2+}	Zn^{2+}	Cu^{2+}	Fe^{2+}	Hg^{2+}	Pb^{2+}	Fe^{3+}	Al^{3+}	Cr^{3+}	H$^+$
Cl$^-$	S	S	S	S	S	S	S	I	S	S	S	S	S	S	M	S	S	S	S
Br$^-$	S	S	S	S	S	S	S	I	S	S	S	S	S	M	M	S	S	S	S
I$^-$	S	S	S	S	S	S	S	M	S	S	S	–	S	I	I	–	S	S	S
NO$_3^-$	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
NCS$^-$	S	S	S	S	S	S	S	I	S	S	S	–	S	I	I	S	S	S	S
SO$_4^{2-}$	S	S	S	M	I	I	S	M	S	S	S	S	S	S	I	S	S	S	S
F$^-$	S	S	M	I	M	S	S	S	I	S	S	S	M	–	I	M	M	S	S
CH$_3$COO$^-$	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
S^{2-}	S	S	S	M	I	I	S	I	I	I	I	I	I	I	I	–	–	–	S
SO$_3^{2-}$	S	S	S	I	I	I	S	I	M	I	I	I	I	–	I	–	–	–	S
CO$_3^{2-}$	S	S	M	I	I	I	S	I	I	I	I	I	I	I	I	–	–	–	S
SiO$_3^{2-}$	S	S	S	I	I	I	–	I	I	I	I	I	I	–	I	–	–	–	I
PO$_4^{3-}$	S	S	I	I	I	I	S	I	I	I	I	I	I	I	I	I	I	I	S
NO$_2^-$	S	S	S	S	S	S	S	M	S	–	–	–	–	–	–	–	–	–	S
HS$^-$	S	S	S	S	S	S	S	–	S	–	–	–	–	–	–	–	–	–	S
HSO$_3^-$	S	S	S	S	S	S	S	–	S	–	–	–	–	–	–	–	–	–	S
HPO$_4^{2-}$	S	S	–	I	I	I	S	S	M	I	–	–	I	–	M	–	–	–	S
H$_2$PO$_4^-$	S	S	S	S	S	S	S	S	S	S	S	–	S	–	–	–	–	–	S
OH$^-$	S	S	S	M	S	S	S	–	I	I	I	I	I	–	I	I	I	I	

S — Soluble; I — Insoluble; M — Marginally soluble

ELECTROCHEMICAL SERIES OF METALS

$\dfrac{Me^{n+}}{Me^0}$	$\dfrac{Li^+}{Li^0}$	$\dfrac{K^+}{K^0}$	$\dfrac{Sr^{2+}}{Sr^0}$	$\dfrac{Ba^{2+}}{Ba^0}$	$\dfrac{Ca^{2+}}{Ca^0}$	$\dfrac{Na^+}{Na^0}$	$\dfrac{Mg^{2+}}{Mg^0}$	$\dfrac{Al^{3+}}{Al^0}$	$\dfrac{Zn^{2+}}{Zn^0}$	$\dfrac{Cr^{2+}}{Cr^0}$	$\dfrac{Fe^{2+}}{Fe^0}$	$\dfrac{Ni^{2+}}{Ni^0}$	$\dfrac{Sn^{2+}}{Sn^0}$	$\dfrac{Pb^{2+}}{Pb^0}$	$\dfrac{2H^+}{H_2^0}$	$\dfrac{Bi^{3+}}{Bi^0}$	$\dfrac{Cu^{2+}}{Cu^0}$	$\dfrac{Ag^+}{Ag^0}$	$\dfrac{Hg^{2+}}{Hg^0}$
e^0,V	–3.04	–2.92	–2.89	–2.90	–2.87	–2.71	–2.37	–1.70	–0.76	–0.74	–0.44	–0.25	–0.14	–0.13	0	+0.21	+0.34	+0.80	+0.85

CONTENTS