COLLOQUIUM

IN GENERAL CHEMISTRY

Minsk BSMU 2021

9 789852 107419

МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ

БЕЛОРУССКИЙ ГОСУДАРСТВЕННЫЙ МЕДИЦИНСКИЙ УНИВЕРСИТЕТ

КАФЕДРА ОБЩЕЙ ХИМИИ

КОЛЛОКВИУМ ПО ОБЩЕЙ ХИМИИ

COLLOQUIUM IN GENERAL CHEMISTRY

Сборник заданий

2-е издание

Минск БГМУ 2021

А в т о р ы: канд. биол. наук, доц. В. В. Хрусталёв; ассист. В. В. Побойнев; канд.
хим. наук, доц. С. В. Ткачёв; канд. хим. наук, доц. Л. Г. Петрушенко; канд. биол. наук,
доц. Т. В. Латушко; ассист. Е. Ю. Кохановская; ассист. О. А. Бондарец

Р е ц е н з е н т ы: канд. мед. наук, доц. А. Г. Кадушкин; каф. биоорганической
химии

TASK № 1. PREPARATION OF SOLUTIONS

1. Find the mass of $Na_2SO_4 \cdot 10H_2O$ that is needed to make 100 ml of sodium sulfate solution with the molar concentration of 0.02 mol/L.

2. What is the mass of $Na_2B_4O_7 \cdot 10H_2O$ that is necessary to make 250 ml of 0.2N sodium tetraborate solution ($f_{eq} = 1/2$)?

3. What is the mass of $Na_2CO_3 \cdot 10H_2O$ that is needed to make 100 ml of sodium carbonate solution with the mass percentage of Na_2CO_3 equal to 2 %? The density of the final solution is equal to 1 g/ml.

4. What mass of $CuSO_4 \cdot 5H_2O$ should we add to the 0.05 M $CuSO_4$ solution to obtain a solution with mass percentage of $CuSO_4$ equal to 5 %? The volume of the initial solution is equal to 200 ml, the density is equal to 1.01 g/ml.

5. What volume of water should we add to 100 g of K_2SO_4 solution with the mass fraction equal to 2 % to make its final mass percentage equal to 1 %?

6. Calculate the mass percentage (%) of ethanol in the solution made by the addition of 30 ml of C_2H_5OH (the density of ethanol is 0.79 g/ml) to the water with a volume of 250 ml (the density of water is 1.00 g/ml).

7. Calculate what volume of hydrochloric acid solution (mass percentage of HCl in that solution is equal to 14 %, the density is equal to 1.073 g/ml) is needed to prepare 300 ml of diluted hydrochloric acid solution with the molar concentration of 0.01 mol/L (the density is equal to 1.000 g/ml).

8. Calculate the mass percentage (%) of ammonia in the solution made by the way of the dissolving of 2 L of NH_3 (normal conditions) in 200 ml of water (the density of water is 1.00 g/ml).

9. Calculate the volume of ammonia (in normal conditions) that one needs to dissolve in 150 g of a solution that already contains 2 % of ammonia by mass to make 5 % ammonia solution?

10. The density of 40 % (by mass) HNO_3 solution is equal to 1.25 g/ml. Calculate the molality of that solution.

11. The density of 12 % (by mass) H_2SO_4 solution is equal to 1.105 g/ml. Calculate the molarity of that solution.

12. Convert the molarity to the mass fraction for 0.15 M NaCl solution. The density is equal to 1 g/ml.

13. Convert the mass percentage to molarity for 5 % solution of glucose. The density is equal to 1 g/ml.

14. Calculate the mole fraction of potassium chloride in a solution that contains 0.003 mol of K^+, 0.002 mol of Na^+ and 0.005 mol of Cl^-. The volume of that solution is equal to 500 ml, the density is equal to 1 g/ml.

15. Calculate the molarity of NaCl solution that has a molality of 0.15 mol/kg. The density is equal to 1 g/ml.

16. Calculate the molality of glucose solution that has a molarity of 0.3 mol/L. The density is equal to 1 g/ml.

17. Find out the normality of $KMnO_4$ solution that has been made of 1 g of a dry potassium permanganate. The volume of a solution is equal to 600 ml. The solution has been prepared with the aim to use it as a titrant.

18. Calculate the normality of H_2SO_4 solution prepared with the aim to use it as a titrant. The mass of that solution is 400 g, the mole fraction of sulfuric acid is 2 %. The density is equal to 1.0661 g/ml.

19. Calculate the titer (g/ml) of 0.004 M solution of a protein with the molar mass of 44 000 g/mole.

20. What is the molar concentration of Cl^- anions in a solution upon AgCl precipitate, if a solubility of AgCl is equal to 0.52 mg per 100 g of water? The density is equal to 1 g/ml.

TASK № 2. COMPLEX COMPOUNDS

Write the complexation reaction in complete and ionic forms. Write the IUPAC names of the following coordination compounds.

1. $Al(OH)_3 + KOH_{excess, conc.} \rightarrow$

2. $Zn(OH)_2 + LiOH_{excess, conc.} \rightarrow$

3. $AlCl_3 + NaOH_{excess,\ conc.} \rightarrow$

4. $ZnSO_4 + LiOH_{excess} \rightarrow$

5. $CrCl_3 + KOH_{excess} \rightarrow$

6. $FeCl_3 + KCN_{excess} \rightarrow$

7. $FeCl_2 + KCN_{excess} \rightarrow$

8. $Cu(NO_3)_2 + NH_3 \rightarrow$

9. $AgCl + NH_3 \rightarrow$

10. $Zn(NO_3)_2 + NH_4OH \rightarrow$

11. $AgBr + NH_4OH \rightarrow$

12. $NiCl_2 + NH_{3\ excess} \rightarrow$

13. $HgI_2 + KI \rightarrow$

14. $Cd(NO_3)_2 + KI_{excess} \rightarrow$

15. $AlCl_3 + NaCl \rightarrow$

16. $AlF_3 + NaF \rightarrow$

17. $BF_3 + LiF \rightarrow$

18. $AlCl_3 + LiH_{excess} \rightarrow$

19. $Ni + CO \rightarrow$

20. $MnSO_4 + H_2O \rightarrow$

TASK № 3. CALCULATIONS IN TITRIMETRIC ANALYSIS

1. 15.40 ml of 0.1000 M HCl solution was used for titration of 20.00 ml of NaOH solution. Calculate the molar concentration of the NaOH solution.

2. 22.15 ml of 0.1313 M sodium thiosulfate solution was used for titration of 25.00 ml of iodine solution. Calculate the molar concentration of the iodine solution.

3. 24.15 ml of 0.05240 N sodium thiosulfate solution was used for titration of 20.00 ml of iodine solution. Calculate the titer of the iodine solution.

4. 21.50 ml of $KMnO_4$ solution was used for titration of 0.02440 g of $H_2C_2O_4·2H_2O$. Calculate the titer of potassium permanganate solution.

5. 100.0 ml of the solution contains 0.2550 g of sodium hydroxide. For the titration of 20.00 ml of this solution 18.50 ml of HCl solution was spent. Determine the molar concentration of the hydrochloric acid solution.

6. 15.00 ml of 0.1000 M H_2SO_4 solution was spent for the titration of NaOH solution. Calculate the mass of sodium hydroxide in that solution.

7. 22.00 ml of 0.09840 M NaOH solution was spent for the titration of $H_2C_2O_4$ solution. What mass of $H_2C_2O_4·2H_2O$ should be taken to prepare this solution?

8. 100.0 ml of the solution contains 1.400 g of $H_2C_2O_4·2H_2O$. The solution was diluted 4 times and 20.00 ml of the resulting solution was titrated by 13.40 ml of NaOH solution. Determine the molar concentration of NaOH solution.

9. 14.50 ml of 0.08620 M HCl solution was spent for the titration of 15.00 ml of NaOH solution. Calculate the mass of NaOH in 500.0 ml of solution.

10. 15.15 ml of 0.1253 M HCl solution was spent for the titration of 10.00 ml of ammonia solution. Calculate the mass of NH_3 in 400.0 ml of this solution.

11. Titration of 1.1250 g of technical $KMnO_4$ sample required 24.10 ml of 0.1500 N $Na_2C_2O_4$ solution. Determine the mass fraction of $KMnO_4$ in the sample.

12. What mass of $Na_2B_4O_7·10H_2O$ had been taken to prepare 2 L of the solution, if 15.00 ml of this solution were titrated by 10.30 ml of HCl solution with a titer of 0.003606 g/cm^3.

13. Titration of 1.086 g of borax ($Na_2B_4O_7·10H_2O$) required 28.22 ml of HCl solution. Hydrochloric acid solution was used to determine the sodium hydroxide solution concentration. It was found that V(HCl)/V(NaOH) = 1.025. Calculate molar concentrations of HCl and NaOH solutions.

14. Solution contains 1.050 g of NaOH. To what volume should this solution be diluted to use 13.20 ml of 0.1041 M hydrochloric acid to titrate 20.00 ml of the obtained sodium hydroxide solution?

15. 15.80 ml of a 0.05000 N $K_2Cr_2O_7$ solution was used for the titration of 20.00 ml of a $FeSO_4$ solution in a sulfuric acid medium. What volume of water should be added to 100.0 ml of a solution of iron (II) sulfate to get a solution of exactly 0.01000 N?

16. A hydrogen peroxide solution was prepared by the way of dilution of the stock solution to 200.0 ml. The mass of the initial solution was 7.310 g. 20.00 ml of the prepared solution was treated with KI and HCl, and 21.50 ml of a 0.1000 N $Na_2S_2O_3$ solution was used to titrate this solution. Determine the mass fraction of hydrogen peroxide in the stock solution.

17. 10.00 ml of 0.1133 N $KMnO_4$ solution was added to the KI solution (in the presence of sulfuric acid). The iodine released during the reaction was titrated by 17.90 ml of $Na_2S_2O_3$ solution. Calculate the molar concentration of the $Na_2S_2O_3$ solution.
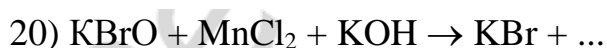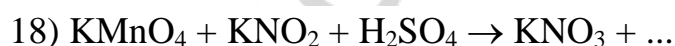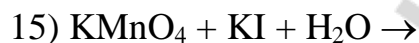
18. 0.02500 g of $K_2Cr_2O_7$ was dissolved in distilled water and then HCl and an excess of KI were added to this solution. 25.50 ml of $Na_2S_2O_3$ solution was used for titration of the iodine released during the reaction. Calculate the molar concentration of the $Na_2S_2O_3$ solution.
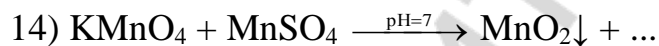
19. 20.00 ml of 0.1000 N $FeSO_4$ was added to 20.00 ml of $K_2Cr_2O_7$ solution in the presence of sulfuric acid. 23.50 ml of a 0.05000N $KMnO_4$ solution was used to titrate the excess of $FeSO_4$. Calculate the mass of $K_2Cr_2O_7$ in 500.0 ml of that solution.

20. 100.0 ml of 0.09500 N iodine solution was added to the solution containing 2.500 g of technical sodium sulfite. 38.1 ml of a sodium thiosulfate solution (100.0 ml of sodium thiosulfate solution contained 1.448 g of sodium thiosulfate) was spent for the titration of the excess of iodine. Determine the mass percentage of Na_2SO_3 in the sample.

TASK № 4. OXIDATION-REDUCTION PROCESSES

Finish the redox reaction and balance it with the help of the electron-ion method:

1) $FeSO_4 + KMnO_4 + H_2SO_4 \rightarrow$

2) $KMnO_4 + HBr \rightarrow$

3) $K_2Cr_2O_7 + KI + H_2SO_4 \rightarrow$

4) $KMnO_4 + H_2S + H_2SO_4 \rightarrow S\downarrow + ...$

5) $K_2Cr_2O_7 + Na_2SO_3 + H_2SO_4 \rightarrow$

6) $K_2Cr_2O_7 + H_2S + H_2SO_4 \rightarrow S\downarrow + ...$

7) $KMnO_4 + Na_2SO_3 + H_2SO_4 \rightarrow$
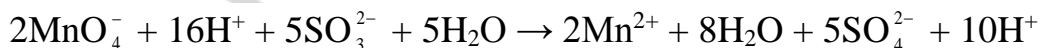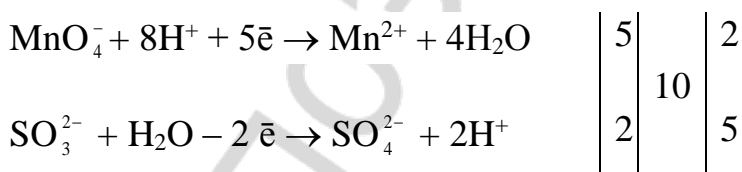
8) $K_2Cr_2O_7 + FeSO_4 + H_2SO_4 \rightarrow$
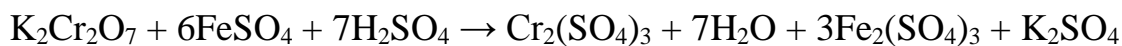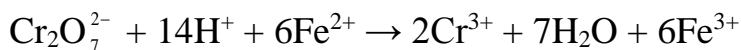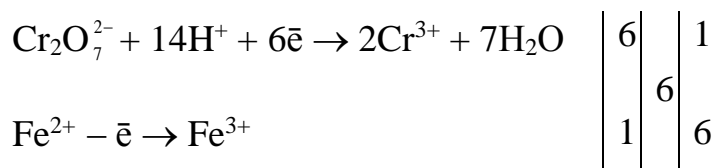
9) $KBrO_3 + KBr + H_2SO_4 \rightarrow Br_2 + ...$
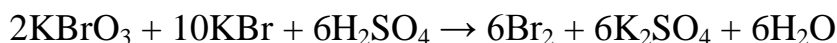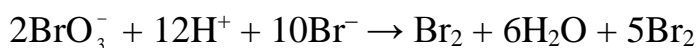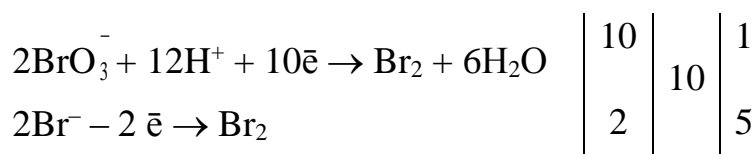
10) $FeSO_4 + KClO_3 + H_2SO_4 \rightarrow KCl + ...$

11) $K_2SO_3 + KMnO_4 + KOH \rightarrow$

12) $KMnO_4 + KNO_2 \xrightarrow{\text{pH=7}} ...$

13) $K_2SO_3 + KMnO_4 \xrightarrow{\text{pH=7}} ...$

14) $KMnO_4 + MnSO_4 \xrightarrow{\text{pH=7}} MnO_2\downarrow + ...$

15) $KMnO_4 + KI + H_2O \rightarrow$
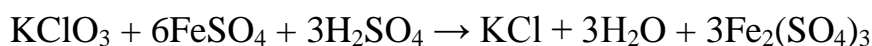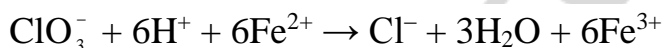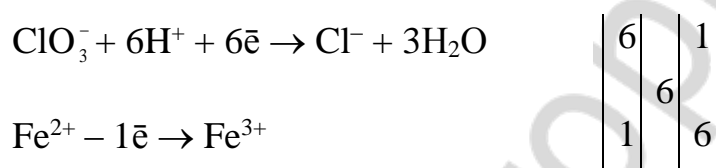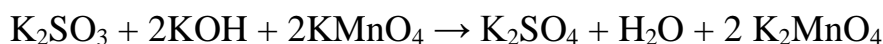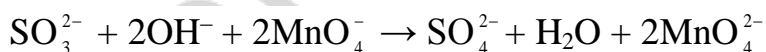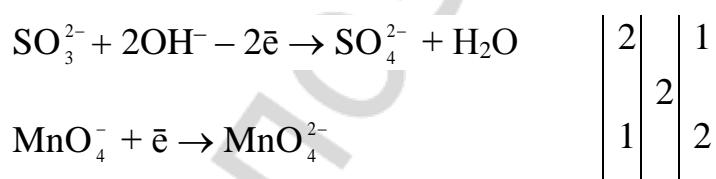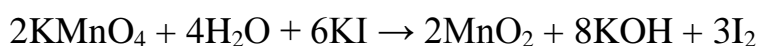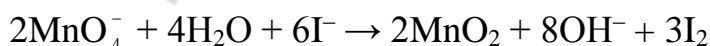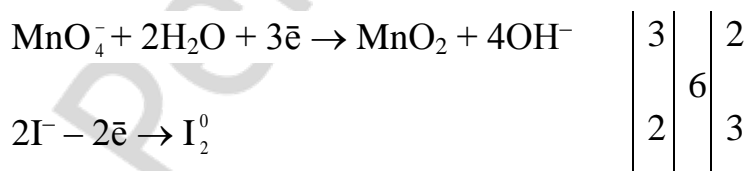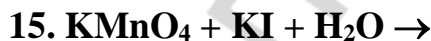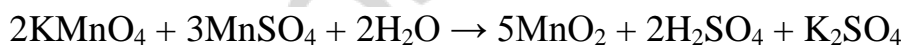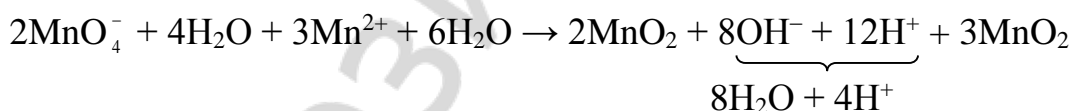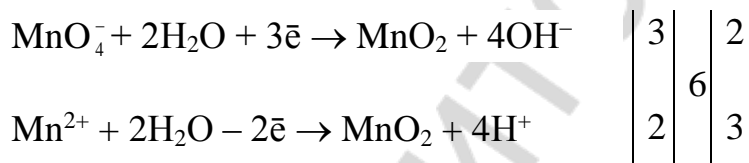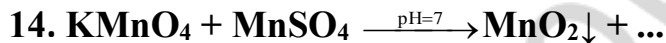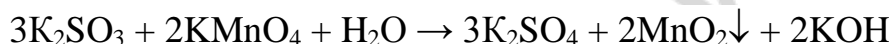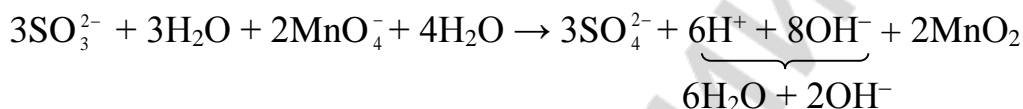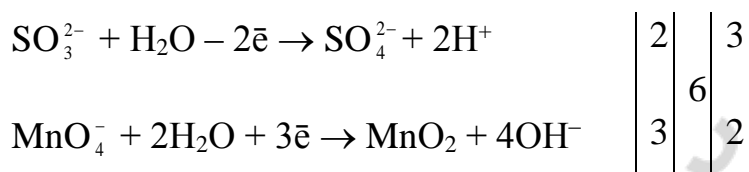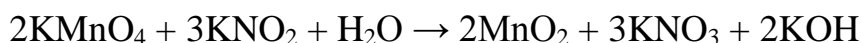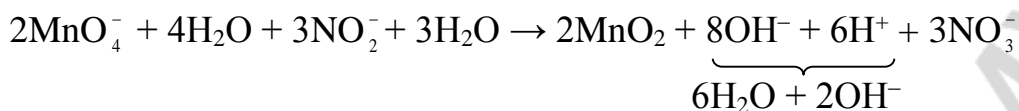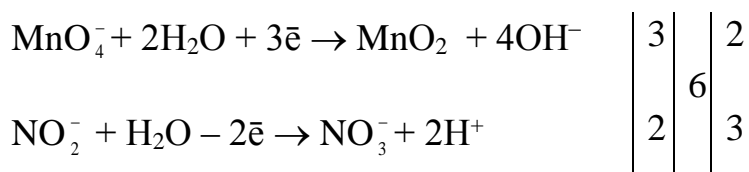
16) $KMnO_4 + H_2C_2O_4 + H_2SO_4 \rightarrow$

17) $Na_2SO_3 + NaI + H_2O \rightarrow S\downarrow$

18) $KMnO_4 + KNO_2 + H_2SO_4 \rightarrow KNO_3 + ...$

19) $KMnO_4 + KNO_2 + KOH \rightarrow$

20) $KBrO + MnCl_2 + KOH \rightarrow KBr + ...$

TASK № 5. COLLIGATIVE PROPERTIES OF SOLUTIONS: CALCULATIONS

1. Calculate the expected vapor pressure at 25 °C upon a solution prepared by dissolving 158 g of common table sugar (sucrose, molar mass = 342.3 g/mol) in 643.5 cm^3 of water. At 25 °C the density of water is 0.99719 g/cm^3 and the vapor pressure is 3.17 kPa.

2. Predict the vapor pressure upon a solution prepared by mixing 35 g of solid Na_2SO_4 (molar mass = 142 g/mol) with 175 g of water at 25 °C. The vapor pressure upon pure water at 25 °C is 3.17 kPa.

3. A solution is prepared by mixing 5.81 g of acetone (C_3H_6O, molar mass = 58.1 g/mol) and 11.9 g of chloroform ($HCCl_3$, molar mass = 119.4 g/mol). The vapor pressures upon pure acetone and pure chloroform at 35 °C are 46.00 kPa and 39.06 kPa, respectively. What is the expected vapor pressure upon this mixture of two volatile liquids?

4. A solution was prepared by dissolving 18 g of glucose in 152.94 g of water. The resulting solution was found to have a boiling point at 100.34 °C. Calculate the molar mass of glucose from these data. Ebullioscopic constant for water is 0.52 kg·K/mol.

5. What mass of ethylene glycol ($C_2H_6O_2$, molar mass = 62.1 g/mol), that is the main component of antifreeze, must be added to 10 dm^3 of water (cryoscopic constant of water is 1.86 kg·K/mol) to produce a solution for use in a car's radiator that freezes at –23.3 °C. Assume the density of water is exactly 1 g/cm^3.

6. A sample of a human hormone that had a mass of 0.546 g was dissolved in 15 g of benzene, and the freezing point depression was found to be 0.24°C. Calculate the molar mass of the hormone if the cryoscopic constant for benzene is 5.12 kg·K/mol.

7. To determine the molar mass of a certain protein, 10^{-3} g of it was dissolved in water to make 1 cm^3 of a solution. The osmotic pressure of this

solution was found to be 0.1493 kPa at 25 °C. Calculate the molar mass of that protein.

8. Calculate the boiling point of an aqueous solution of urea, $CO(NH_2)_2$, with a concentration of 12.0 g/dm^3 at a pressure of 101.3 kPa. Assume that the volume of the solute is negligible compared to that of the solution, and that the boiling point elevation constant for water is 0.52 kg·K/mol.

9. In the solution of iodine in chloroform with the molality equal to 0.1 mol/kg the boiling point has been increased by 0.366 °C, relative to the one of the pure chloroform. Calculate the ebullioscopic constant of chloroform.

10. A solution containing 25.6 g of Sulphur, dissolved in 1000 g of naphthalene, has a freezing point depression equal to 0.680 °C. Calculate the formula of Sulphur molecules. The freezing point depression constant for naphthalene is 6.8 kg·K/mol. The melting point of naphthalene is 80.1 °C.

11. 0.900 g of a solute was dissolved in 100 cm^3 of benzene at 25 °C when its density is 0.879 g/cm^3. This solution boiled at the temperature that is 0.25 °C higher than boiling point of pure benzene. Ebullioscopic constant of benzene is 2.52 kg·K/mol. Calculate the molecular mass of a solute.

12. Calculate the osmotic pressure of a solution containing 4.0 g of non-volatile solute (molar mass is 40 g/mol) per 1 dm^3 of the solution at 27 °C. Consider that a solute is nonelectrolyte.

13. Calculate the osmotic pressure of 1 percent solution of glucose in water at 25 °C. The density of solution is 1 g/cm^3.

14. Calculate the freezing point of a solution made from 7 g of HNO_2 and 100 g of water. The pK_a of nitrous acid at a given temperature is 3.398. The density of the final solution is 1.03 g/cm^3. Cryoscopic constant for water is 1.86 kg·K/mol.

15. Calculate the temperature of boiling for a solution made from 5 g of HCOOH and 100 g of water. The pK_a of formic acid at a given temperature is 3.77. The density of the final solution is equal to 1.01 g/cm^3. Ebullioscopic constant of water is 0.52 kg·K/mol.

16. Calculate the osmotic pressure of the butanoic acid solution at 25 °C. The mass of the acid in 300 cm³ of such solution is equal to 2.5 g. The pK_a of butanoic acid is equal to 4.82.

17. After the dissolving of 322 g of organic substance in 300 cm³ of water (the density of water is 1 g/cm³) the pressure of saturated vapor upon the solution has become 0.14 kPa lower. The pressure of saturated vapor upon clear water at the same temperature is 3.17 kPa. Calculate the molar mass of an organic substance that is nonelectrolyte.

18. The temperature of freezing of the solution made by the way of the dissolving of 5 g of HNO_2 in 100 g of water is equal to –2.02 °C. Calculate the constant of dissociation for nitrous acid if the density of the obtained solution is 1.03 g/cm³. The cryoscopic constant of water is 1.86 kg·K/mol.

19. The temperature of boiling of the solution made by the way of the dissolving of 5 g of HCOOH in 100 g of water is equal to 100.58 °C. Calculate the constant of dissociation of formic acid if the density of the obtained solution is 1.01 g/cm³. Ebullioscopic constant of water is equal to 0.52 kg·K/mol.

20. A solution containing 8 g of a substance in 100 g of diethyl ether boils at 36.86 °C, whereas the pure ether boils at 35.60 °C. Determine the molecular mass of the solute. The value of the ebullioscopic constant for ether is 2.02 kg·K/mol.

TASK № 6. CHEMICAL THERMODYNAMICS

1. Calculate the ΔH^0_r of the reaction between hydrogen sulfide and oxygen (the molar ratio is 2:1, respectively). ΔH^0_f (H_2S) = –20.6 kJ/mol, ΔH^0_f (H_2O) = –285.8 kJ/mol.

2. Calculate ΔG^0_r of the reaction of ammonia and hydrogen chloride, if ΔG^0_f (HCl) = –94.8 kJ/mol, ΔG^0_f (NH_3) = –16.7 kJ/mol, ΔG^0_f (NH_4Cl) = –203.2 kJ/mol.

3. Calculate ΔS^0_r for the reaction between aluminum and dilute sulfuric acid. $S^0(Al) = 28.35$ J/mol·K, $S^0(H_2SO_4) = 156.9$ J/mol·K, $S^0(Al_2(SO_4)_3) = 239.2$ J/mol·K, $S^0(H_2) = 130.6$ J/mol·K.

4. Calculate ΔG^0_r of the reaction of potassium superoxide formation in standard conditions, if $\Delta H^0_r = -280.00$ kJ/mol, $\Delta S^0_r = -229.29$ J/mol·K.

5. Calculate the enthalpy of hydration for magnesium sulfate, if the enthalpy of the dissolving of $MgSO_4 \cdot 7H_2O$ in water is equal to $+16.14$ kJ/mol, while the enthalpy of the dissolving of dry $MgSO_4$ in water is equal to -85.06 kJ/mol.

6. Calculate ΔH^0_r for the reaction between copper (II) oxide and carbon, if carbon monoxide is formed in that reaction.

$$\Delta H^0_f(CuO) = -162.0 \text{ kJ/mol}, \quad \Delta H^0_f(CO) = -110,6 \text{ kJ/mol}$$

7. Calculate the value of ΔS^0_r for a reaction between CaO and water, if $S^0(CaO) = 39.75$ J/mol·K, $S^0(H_2O) = 69.95$ J/mol·K, $S^0(Ca(OH)_2) = 83.39$ J/mol·K.

8. Calculate ΔG^0_r of the esterification reaction between ethanol and acetic acid, if $\Delta G^0_f(C_2H_5OH) = -174.78$ kJ/mol, $\Delta G^0_f(CH_3COOH) = -173.991$ kJ/mol, $\Delta G^0_f(CH_3COOC_2H_5) = -251.12$ kJ/mol, $\Delta G^0_f(H_2O) = -237.129$ kJ/mol.

9. Calculate the value of ΔG^0_r of the reaction: $SO_{2(g)} + 2H_2S_{(g)} = 3S_{(s)} + 2H_2O_{(l)}$.

$$\Delta G^0_f (SO_2) = -300.4 \text{ kJ/mol}; \quad \Delta G^0_f (H_2O) = -237.3 \text{ kJ/mol};$$
$$\Delta G^0_f (H_2S) = -33 \text{ kJ/mol}$$

10. Calculate the enthalpy of hydration for $CuSO_4$, if the enthalpy of the dissolving of $CuSO_4 \cdot 5H_2O$ in water is equal to $+11.7$ kJ/mol, while the enthalpy of the dissolving of dry $CuSO_4$ in water is equal to -66.1 kJ/mol.

11. Calculate the heat effect of the reaction between lithium and water, if $\Delta H^0_f (H_2O) = -237.129$ kJ/mol, $\Delta H^0_f (LiOH_{(s)}) = -484.93$ kJ/mol, and the final product is the solid lithium hydroxide.

12. Calculate the heat effect of the reaction between lithium and water, if $\Delta H^0_f (H_2O) = -237.129$ kJ/mol, $\Delta H^0_f (LiOH_{(aq)}) = -508.48$ kJ/mol, and the final product is the aqueous lithium hydroxide.

13. Calculate the heat effect of the dissolving of a dry copper sulfate $CuSO_4$, if the heat effect of the dissolving of its salt hydrate ($CuSO_4 \cdot 5H_2O$) is equal to -11.7 kJ, while the heat of hydration for a dry salt is equal to 77.8 kJ.

14. Find out the value of thermodynamical probability for 1 mole of a solid water (the ice) in standard conditions, if its $S^0 = 41.00$ J/mol·K.

15. Find out the value of thermodynamical probability for 1 mole of a liquid water in standard conditions, if its $S^0 = 69.95$ J/mol·K.

16. Find out the value of thermodynamical probability for 1 mole of a gaseous water (vapor) in standard conditions, if its $S^0 = 188.84$ J/mol·K.

17. The value of ΔH^0_r is equal to 30 kJ/mol. What is the value of ΔS^0_r for this reaction, if it is in the state of equilibrium in standard conditions?

18. The value of ΔS^0_r is equal to -55 J/mol·K. What is the value of ΔH^0_r for this reaction, if it is in the state of equilibrium in standard conditions?

19. Calculate the constant of equilibrium for a chemical reaction with $\Delta G^0 = -100$ kJ/mol.

20. Calculate the constant of equilibrium for a chemical reaction with $\Delta G^0 = -2$ kJ/mol.

TASK № 7. CHEMICAL KINETICS

1. For a homogeneous reaction in the container with a volume of 3 L the amount of a reactant decreased from 5 to 2.2 mol in 5 seconds. Calculate the average rate of that reaction.

2. For a homogeneous reaction in the container with a volume of 8 L the amount of a product increased from 0 to 7.3 mol in 60 seconds. Calculate the average rate of that reaction.

3. Calculate the rate constant for a simple reaction between two gaseous substances (A + B = C), if the rate of a reaction is equal to 0.02 mol/L·sec, the concentration of A is 0.02 mol/L, and the concentration of B is 0.03 mol/L.

4. Calculate the rate constant for a simple reaction between two gaseous substances (A + 2B = C), if the rate of a reaction is equal to 0.08 mol/L·sec, the concentration of A is 0.01 mol/L, and the concentration of B is 0.04 mol/L.

5. Calculate the rate constant for a simple reaction between two substances $(A_{(g)} + 2B_{(s)} = C)$, if the rate of a reaction is equal to 0.04 mol/L·sec, the concentration of A is 0.01 mol/L.

6. In the equilibrium state in the reaction $2SO_2(g) + O_2(g) \rightleftarrows 2SO_3(g)$ concentrations of SO_2, O_2 and SO_3 (mol/L) are equal to 0.3; 0.2 and 0.7. Find the constant of equilibrium according to the law of mass action.

7. There is a system in equilibrium: $2SO_{2(g)} + O_{2(g)} \rightleftarrows 2SO_{3(g)}$. The equilibrium concentration of SO_3 is equal to 0.25 mol/L. Calculate the equilibrium concentration of oxygen (mol/L), if you know that 15% of the initial amount of oxygen has been consumed until the establishment of equilibrium.

8. Calculate vant Hoff's coefficient of a reaction, if after the increase in temperature that is equal to 40 °C the rate of the reaction increased 16 times?

9. Vant Hoff's coefficient of a reaction is equal to 3. At what temperature one should run this reaction to increase its rate 81 times. Initial temperature is 25 °C.

10. Calculate the vant Hoff's coefficient of a reaction at 25 °C, if its energy of activation is equal to 100 kJ/mol. The preexponential factor in the Arrhenius equation stays the same.

11. Calculate the vant Hoff's coefficient of a reaction at 75 °C, if its energy of activation is equal to 100 kJ/mol. The preexponential factor in the Arrhenius equation stays the same.

12. Calculate the vant Hoff's coefficient of a reaction at 25 °C, if its energy of activation is equal to 5 kJ/mol. The preexponential factor in the Arrhenius equation stays the same.

13. Calculate the vant Hoff's coefficient of a reaction at 75 °C, if its energy of activation is equal to 5 kJ/mol. The preexponential factor in the Arrhenius equation stays the same.

14. How many times the rate of the reaction will increase after the growth of temperature from 20 to 50 °C, if the preexponential factor in the Arrhenius equation stays the same, and the energy of activation is 50 kJ/mol?

15. How many times the rate of the reaction will decrease after the decline of temperature from 40 to 20 °C, if the preexponential factor in the Arrhenius equation stays the same, and the energy of activation is 160 kJ/mol?

16. Calculate the energy of activation, if the rate of the reaction decreased 9 times after the decline of temperature from 50 to 30 °C. The preexponential factor in the Arrhenius equation stays the same.

17. Find the energy of activation, if the rate of the reaction increased 10 times after the growth of temperature from 30 to 50 °C. The preexponential factor in the Arrhenius equation stays the same.

18. What is the fraction of activated particles in a certain reaction, if the value of the energy of activation is equal to 20 kJ/mol at the temperature of 37 °C?

19. Kinetics of a certain chemical reaction has been studied, the Arrhenius plot has been built. The dependence between lnK and (1/T) is described by the following equation: y = –12033x + 65. Calculate the energy of activation.

20. Kinetics of a certain chemical reaction has been studied, the Arrhenius plot has been built. The dependence between lnK and (1/T) is described by the following equation: y = –66037x + 77. Calculate the preexponential factor.

TASK № 8. ACIDITY OF WATER SOLUTIONS

1. Calculate the pH of a solution that contains 0.000048 mol/L of H^+ cations.

2. Calculate the pH of a solution that contains 0.000033 mol/L of OH^- anions.

3. Calculate the pH of HNO_3 solution, if the concentration of nitric acid is equal to 0.0003 mol/L. The coefficient of activity is equal to 1.

4. Calculate the pH of HNO_3 solution with the mass percentage of nitric acid equal to 0.005 %. The coefficient of activity is equal to 1, the density of the solution is equal to 1 g/ml.

5. Calculate the pH in 300 ml of H_2SO_4 solution with mass percentage 0.002 %, if the activity coefficient is equal to 0.87 and the density of a solution is equal to 1g/ml.

6. Calculate the pH of CH_3COOH solution, if the concentration of acetic acid is equal to 0.17 mol/L and its dissociation constant (K_a) is equal to $1.75 \cdot 10^{-5}$.

7. Calculate the pH of HF solution with mass percentage of hydrogen fluoride equal to 0.01 %, if $pK_a = 3.17$ and the density of a solution is equal to 1.01 g/ml.

8. Calculate the dissociation degree of HCOOH in its solution with the concentration equal to 0.01 mol/L, if $K_a = 1.8 \cdot 10^{-4}$.

9. Calculate the pH of NH_4OH solution with mass percentage of ammonium hydroxide equal to 5 %, if the density of that solution is 0.99 g/ml and pK_b (NH_4OH) = 4.75.

10. Calculate the pH in HCN solution with the concentration of prussic acid equal to 0.03 M, if its dissociation degree is 0.8 %.

11. Calculate the pH of KOH solution, if the concentration of potassium hydroxide is equal to $4.2 \cdot 10^{-4}$ mol/L. The coefficient of activity is equal to 1.

12. Calculate the pH of NH_4OH solution, if the concentration of ammonia is equal to 1 mol/L and the dissociation constant of ammonium hydroxide (K_b) is equal to $1.77 \cdot 10^{-5}$.

13. Calculate the pOH of HCN solution with the concentration equal to 0.2 N, the dissociation degree is 0.03.

14. Calculate the dissociation constant of an acid, if its concentration is equal to 0.08 mol/L and pH = 2.4.

16

15. Calculate pK_a of an acid, if in the solution with its concentration equal to 0.02 mol/L pH is equal to 3.6.

16. Calculate the molar concentration of CH_3COOH in a solution, if pH = 3 and $K_a = 1.75 \cdot 10^{-5}$.

17. Calculate the mass of HCOOH in 300 ml of its solution, if pH = 3.04 and $K_a = 1.77 \cdot 10^{-4}$.

18. Calculate potential acidity of gastric juice (mol/L), if its pH = 2.2 and to titrate 10 ml of that juice 8.8 ml of 0.1M NaOH solution have been used.

19. Calculate the pH of the solution, if we add 0.5 ml of 0.1 M NaOH solution to 500 ml of pure water.

20. How many times the hydrogen ion concentration in blood (pH = 7.4) is higher than that in the cerebrospinal fluid (pH = 7.6)?

TASK № 9. BUFFER SYSTEMS

1. Two liters of buffer solution contains 13.6 g of KH_2PO_4 and 17.4 g of K_2HPO_4. Determine the pH level in this solution if K_d ($H_2PO_4^-$) = 6,23·10^{-8}.

2. Determine the pH level in the solution obtained by mixing 10 ml of 0.1 M solution of propanoic acid and 20 ml of 0.1 M solution of potassium propionate. pK_a for propanoic acid is 4.88.

3. Determine the pH level of the solution obtained after the addition of 20.5 g of CH_3COONa to 2 liters of 0.15 M acetic acid solution. K_d (CH_3COOH) = 1.75·10^{-5}.

4. Determine the pH level in the solution obtained by adding 5 ml of 0.05 M NaOH solution to 50 ml of 0.02 M propanoic acid solution. pK_a of propanoic acid is 4.88.

5. KOH (0.04 mol) was added to 100 ml of a buffer solution containing 0.1 mol of formic acid and 0.2 mol of potassium formate. What is the pH level of the solution after the addition of KOH (pK_a (HCOOH) = 3.75)?

6. HCl (0.005 mol) was added to 500 ml of buffer solution containing 0.2 mol of NH_4OH and 0.4 mol of NH_4Cl. What is the pH level of the solution after the addition of HCl (pK_b (NH_4OH) = 4.75)?

7. Calculate the pH level of ammonia buffer solution containing 0.02 mol of NH_4OH and 0.2 mol of NH_4Cl. (pK_b (NH_4OH) = 4.75)

8. Is it possible to prepare an acetate buffer with pH = 5.0, if K_d (CH_3COOH) = $1.75 \cdot 10^{-5}$? The answer must be confirmed by calculations.

9. Acetate buffer solution with a concentration of each component equal to 0.25 mol/l has a pH level equal to 4.76. What is the buffer capacity (mmol/L·pH unit) for a given solution, if after the addition of 20 ml of 0.01 M HCl solution to 0.5 L of that buffer solution, the pH deceased to 4.59.

10. What is the buffer capacity of the phosphate buffer, if after the addition of 0.00015 mol of HCl to 100 ml of this solution, its pH changed by 0.15 units?

11. What is the buffer capacity of the phosphate buffer, if after the addition of 5.015 g of 0.01 N HCl solution to 0.025 L of that buffer pH changed from 7.4 to 7.2? (the density of HCl solution is equal to 1.003 g/ml).

12. What is the buffer capacity of the phosphate buffer, if after the addition of 1 ml of hydrochloric acid with a molar concentration of HCl equal to 0.02 mol/L to 0.1 L of buffer solution, its pH changed by 0.1 unit.

13. In what molar ratio one should take sodium propionate and propanoic acid for the buffer solution preparation with pH = 4. pK_a for propanoic acid is 4.88.

14. In what molar ratio one should take Na_2HPO_4 and NaH_2PO_4 for the preparation of buffer solution with pH = 7.4. K_d ($H_2PO_4^-$) = $6,2318 \cdot 10^{-8}$.

15. Determine the pH level of the buffer system obtained by the way of the dissolving KH_2PO_4 and K_2HPO_4 in water at a molar ratio of 1 : 12. K_d ($H_2PO_4^-$) = $6,23 \cdot 10^{-8}$.

16. What volume of 0.25 M potassium acetate solution should be added to 50 ml of 1.0 M acetic acid solution to obtain a buffer solution with pH = 3.0? K_d (CH_3COOH) = $1.75 \cdot 10^{-5}$.

17. What mass of sodium acetate should be added to 100 ml of 1.0 M acetic acid solution to obtain a buffer solution with pH = 3.5? K_d (CH_3COOH) = $1.75 \cdot 10^{-5}$.

18. Determine the pH level of the solution obtained by mixing together equal volumes of CH_3COOH solution (C = 0.2 mol/L) and CH_3COOK solution (C = 0.2 mol/L). K_d (CH_3COOH) = $1.75 \cdot 10^{-5}$.

19. Determine the pH level of the buffer solution obtained by mixing 50 ml of 0.15 M potassium dihydrogen phosphate solution and 30 ml of 0.2 M potassium hydrogen phosphate solution. pK_a ($H_2PO_4^-$) = 7.21.

20. What mass of anhydrous sodium acetate should be added to 400 ml of a solution with molar concentration of CH_3COOH = 1 mol/L for the preparation of a solution with pH equal to 4.1? K_d (CH_3COOH) = $1.75 \cdot 10^{-5}$.

Task № 10. STRUCTURE OF COLLOID PARTICLES

1. Write the scheme of the micelle of sol made by the way of the mixing equal volumes of 0.1 N KCNS solution and 0.008 N $AgNO_3$ solution.

2. Write the scheme of the micelle of sol made by the way of the mixing the excess of $Pb(NO_3)_2$ solution and a drop of NaCl solution.

3. Write the scheme of the micelle of sol made by the way of the mixing equal volumes of 0.005 M $AgNO_3$ solution and 0.3 M Na_3PO_4 solution.

4. Write the scheme of the micelle of sol made by the way of the mixing equal volumes of $AgNO_3$ and K_2CrO_4 solutions. In the electric field, the granules moved to the anode.

5. Write the scheme of the micelle of sol made by the way of the mixing equal volumes of 0.002 M KBr solution and 0.096 M $AgNO_3$ solution.

6. Write the scheme of the micelle of sol made by the way of the mixing 20 ml of 0.001 N $MnSO_4$ solution and 5 ml of 0.2 N Na_3PO_4 solution.

7. Write the scheme of the micelle of sol made by the way of the mixing the excess of $CoSO_4$ solution and a drop of $(NH_4)_2S$ solution.

8. Write the scheme of the micelle of sol made by the way of the mixing equal volumes of $CoSO_4$ and $(NH_4)_2S$ solutions. In the electric field, the granules moved to the anode.

9. Write the scheme of the micelle of sol made by the way of the mixing 10 ml of 0.05 N $Ba(NO_3)_2$ solution and 15 ml of 0.001 N H_2SO_4 solution.

10. Write the scheme of the micelle of sol made by the way of the mixing 25 ml of 0.08 N KBr solution and 10 ml of 0.0001 N $AgNO_3$ solution.

11. Write the scheme of the micelle of sol made by the way of the mixing the excess of $BaCl_2$ solution and a drop of K_2CrO_4 solution.

12. Write the scheme of the micelle of sol made by the way of the mixing 20 ml of 0.01 N KI solution and 30 ml of 0.0007 N $AgNO_3$ solution.

13. Write the scheme of the micelle of sol made by the way of the mixing 30 ml of 0.01 N $(NH_4)_2S$ solution and 25 ml of 0.0005 N $CuSO_4$ solution.

14. Write the scheme of the micelle of sol made by the way of the mixing the excess of Na_2SO_4 solution and a drop of $Pb(NO_3)_2$ solution.

15. Write the scheme of the micelle of sol made by the way of the mixing equal volumes of $Pb(NO_3)_2$ and Na_2SO_4 solutions. In the electric field, the granules moved to the cathode.

16. Write the scheme of the micelle of sol made by the way of the mixing 10 ml of 0.85 % NaCl solution and 25 ml of 0.001 N $AgNO_3$ solution.

17. Write the scheme of the micelle of sol made by the way of the mixing the excess of $BaCl_2$ solution and a drop of $(NH_4)_2CO_3$ solution.

18. Write the scheme of the micelle of sol made by the way of the mixing the excess of $(NH_4)_2CO_3$ solution and a drop of $BaCl_2$ solution.

19. Write the scheme of the micelle of sol made by the way of the mixing 25 ml of 0.001 N $MnCl_2$ solution and 8 ml of 0.2 N $(NH_4)_2S$ solution.

20. Write the scheme of the micelle of sol made by the way of the mixing the excess of KI solution and a drop of $Pb(NO_3)_2$ solution.

TASK № 11. TITRIMETRIC ANALYSIS

1. The volume of a single drop pouring out from a burette is equal to _____ ml.

2. At the moment of the completion of a reaction between the titrant and the defined substance _____ is reached.

3. One has to choose the indicator used in acid-base titration according to its _____ that has to correspond to the jump on a titration curve.

4. The point of equivalence on the curve of titration of 0.1 M hydrochloric acid solution by 0.1 M sodium hydroxide solution is situated at pH = ____.

5. The point of equivalence on the curve of titration of 0.1 M acetic acid solution by 0.1 M alkali solution is situated in _____ medium.

6. The point of equivalence on the curve of titration of 0.1 M ammonia solution by 0.1 M hydrochloric acid solution is situated in _____ medium.

7. Give a formula of a hydrate that can be used as primary standard for alkali solution standardization in the acid-base titration.

8. Write a formula of borax that can be used as primary standard for acid solution standardization in the acid-base titration.

9. Which indicator is used to fix the equivalence point in permanganometry?

10. Write the law of equivalence equation.

11. In the method of permanganometry the main titrant is _____

12. As an indicator in iodometry we use water solution of _____

13. The higher the standard redox potential for a pair of oxidizer and reducer, the _____ the oxidizing agent from that pair.

14. We use _____ technique of titration to determine the concentration of reducing agents in permanganometry.

15. We use, as a rule, _____ titration technique to determine the concentration of oxidizing agents in permanganometry.

16. Iodometric determination of oxidizing agents is carried out using the technique of _____ titration.

17. Write the formula of a hydrate that can be used as a primary standard for $KMnO_4$ solution.

18. The oxidizer in the method of iodometry is _____

19. The reducer in the method of iodometry is _____

20. Primary standard must be a substance with _____ stoichiometric content.

TASK № 12. COLLIGATIVE PROPERTIES OF SOLUTIONS: THEORY

1. The major contribution into the osmotic pressure of blood plasma is made by _____ cations.

2. The major contribution into the osmotic pressure of intracellular liquid is made by _____ cations.

3. A solution in which red blood cells (erythrocytes) are hemolyzed (burst) is _____ relative to the blood plasma.

4. The part of the osmotic pressure of blood plasma that is due to the presence of proteins is called _____ pressure.

5. The major contribution into the osmotic pressure of blood plasma is made by _____ anions.

6. The major contribution into the osmotic pressure of intracellular liquid is made by _____ anions.

7. Sodium chloride solution is isotonic relative to the blood plasma, if the mass fraction of NaCl inside it is equal to _____. Glucose solution is isotonic to blood plasma if its mass fraction is _____.

8. Write the formula for the calculation of osmotic pressure in solutions of nonvolatile electrolytes.

9. Boiling point is the temperature at which the vapor pressure of the liquid becomes equal to the _____.

10. The vapor pressure upon a solution is _____ by the addition of a nonvolatile solute.

11. At freezing point, the vapor pressure upon the solid and the liquid phase is the _____.

12. Osmotic pressure in a solution of an electrolyte is _____ than in a solution of a nonelectrolyte of the same molarity.

13. Solutions with the same values of osmolarity are _____ to each other.

14. One dm^3 of a solution with osmotic pressure of 2.27 kPa at 0 °C contains _____ moles of nonelectrolyte.

15. The boiling point of the solutions of carbamide and of glucose $C_6H_{12}O_6$ with the same concentration (mol/kg) will be _____.

16. Plasmolysis of red blood cells happens in a solution that is _____ to the blood plasma.

17. Osmosis is a movement of solute molecules from the region with _____ osmolarity to the region with _____ osmolarity through the semipermeable membrane.

18. The distribution of water between capillaries and tissues depends on _____ and _____.

19. Van't Hoff isotonic coefficient for $BaCl_2$ in a dilute solution is approximately equal to _____.

20. The higher the ionic strength of a solution, the _____ the coefficient of activity for each ion.

TASK 13. ACIDITY OF BIOLOGICAL FLUIDS

1. What are the limits of urine pH level in a healthy person?

2. What are the limits of blood plasma pH level in a healthy person?

3. What are the limits of gastric juice pH level in a healthy person?

4. What are the limits of pancreatic juice pH level in a healthy person?

5. What are the limits of saliva pH level in a healthy person?

6. Total acidity is the total concentration of _____ and _____ acids.

7. Active acidity is equal to the concentration of active _____ in the solution.

8. Total acidity is determined by the _____ method.

9. Active acidity is determined with the help of _____.

10. Potential acidity is equal to the concentration of _____ acids.

11. The value of potential acidity is equal to the difference between the values of _____ and _____.

12. The _____ method of active acidity determination is more accurate than _____ method.

13. If the concentration of H^+ cations in blood plasma has an increased value, this state is called _____.

14. If the concentration of H^+ cations in body fluids has a decreased value because of the increase of concentration of acidic metabolites, this state is called _____.

15. If the concentration of H^+ cations in blood plasma has a decreased value, this state is called _____.

16. If the concentration of H^+ cations in body fluids has a decreased value because of the loss of acidic metabolites, this state is called _____.

17. In acidic medium concentration of H^+ is _____ than concentration of OH^-.

18. In basic medium concentration of H^+ is _____ than concentration of OH^-.

19. Because of the dissolving of carbon dioxide from the air, pH of distilled water becomes _____.

20. If we dissolve ammonia in distilled water, the value of pH will _____.

TASK № 14. BUFFERING SYSTEMS OF HUMAN BODY

1. The ability of some solutions to keep the concentration of hydrogen cations (pH) almost constant after the addition of small amount of acid or base and at dilution is called _____ action.

2. Write the equation that is used to calculate the pH of a buffer system consisting of a weak base and its salt?

3. At what molar ratio of a weak acid and its salt the pH of buffer solution is equal to the pK_a?

4. Buffer system effectively maintains the concentration of hydrogen cations if the value of pH in a solution is within _____ from pK_a of a weak acid.

5. Buffer solutions may consist of _____ bases and their _____.

6. Hemoglobin has a quaternary structure, which gives it the ability to regulate the addition and cleavage of oxygen and characteristic _____: after joining the first oxygen molecule, the binding of the subsequent ones is facilitated.

7. The higher the concentration of components of a buffer system, the _____ its buffer capacity.

8. In tissues, hemoglobin associated with oxygen is exposed to _____, that is why the release of oxygen occurs.

9. _____ and _____ buffer systems make a major contribution to the maintenance of pH level in red blood cells.

10. The contribution of _____ buffer system into the total buffer capacity of blood is about 53 %.

11. The unit of buffer capacity is _____.

12. When a small amount of strong acid is added to the buffer solution the pH of the solution becomes _____.

13. In the phosphate buffer system _____ plays a role of an acid according to the protolytic theory.

14. Will there be a buffer system if one pours together 200 ml of 0.2 M NH_4OH solution and 100 ml of 0.04 M HCl solution?

15. Will there be a buffer system if one pours together 100 ml of 0.2 M NaOH solution and 100 ml of 0.1 M HCl solution?

16. The main contribution into the maintenance of pH in cells is made by a salt buffer system consisting of _____ and _____.

17. The largest buffer capacity, among buffer solutions with the same molarity, has the one in which _____.

18. _____ is the amount of carbon dioxide that can be dissolved in 100 ml of blood plasma, previously brought into equilibrium with a gas medium in which the partial pressure of carbon dioxide is 40 mm.Hg.

19. If the ratio $[HCO_3^-]:[CO_2]$ is lower than 20, there is an _____.

20. If the ratio $[HCO_3^-]:[CO_2]$ is higher than 20, there is an _____.

TASK № 15. HETEROGENEOUS EQUILIBRIA

1. Precipitate will be formed if the product of activities of ions of the hardly soluble substance in powers equal to the coefficients in the dissociation equation is _____ than the thermodynamic solubility product constant.

2. There will be no precipitate after the mixing of two solutions if the product of the activities of ions of hardly soluble substance in powers of coefficients in its dissociation equation is _____ than the value of its thermodynamic solubility product constant.

3. If the product of the activities of ions of hardly soluble substance in powers of coefficients in its dissociation equation is equal to the value of its thermodynamic solubility product constant, the solution is _____.

4. If the product of concentrations for ions that make a hardly soluble electrolyte is a little bit higher than K_s, but there is no precipitate in a solution, it means that _____.

5. Single-type heterogeneous equilibrium is shifted towards the formation of _____ insoluble precipitate from ions that formed _____ insoluble one.

6. Simple comparison of K^0_S values for silver iodide and silver phosphate _____ be considered to predict which precipitate will be formed in a solution containing identical concentrations of I^- and PO_4^{3-} ions after the addition of silver nitrate.
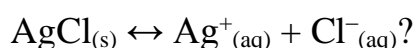
26

7. Will the precipitate of calcium oxalate be dissolved after the addition of acetic acid to the system with a given equilibrium:
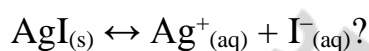
$$CaC_2O_{4(s)} \leftrightarrow Ca^{2+}_{(aq)} + C_2O_4^{2-}_{(aq)}?$$

8. Will the precipitate of calcium oxalate be dissolved after the addition of hydrochloric acid to the system with a given equilibrium:

$$CaC_2O_{4(s)} \leftrightarrow Ca^{2+}_{(aq)} + C_2O_4^{2-}_{(aq)}?$$

9. Will the precipitate of silver chloride be dissolved after the addition of ammonia solution to the system with a given equilibrium:

$$AgCl_{(s)} \leftrightarrow Ag^+_{(aq)} + Cl^-_{(aq)}?$$

10. Will the precipitate of silver iodide be dissolved after the addition of ammonia solution to the system with a given equilibrium:

$$AgI_{(s)} \leftrightarrow Ag^+_{(aq)} + I^-_{(aq)}?$$

11. Write the formula for thermodynamic solubility product constant calculation for silver sulfate (Ag_2SO_4).

12. Write the formula for concentration solubility product constant calculation for lead chloride ($PbCl_2$).

13. Write the equation for thermodynamic solubility product constant calculation for hardly soluble lithium phosphate.

14. Write the equation for concentration solubility product constant calculation for hardly soluble calcium phosphate.

15. Will there be a precipitate if we add dry calcium chloride to the saturated solution of calcium sulfate?

16. Will there be a precipitate if we add dry calcium chloride to the saturated solution of lead (II) chloride?

17. Solubility of calcium sulfate is 0.21 g per 100 g of water. Calculate its K_S value.

18. The value of K_S for silver chloride is $1.77 \cdot 10^{-10}$. Calculate its molar solubility (mol/L).

19. Write the simplest formula of the major mineral component of bones.

20. Write the simplest formula of fluoroapatite.

TASK № 16. LAWS OF THERMODYNAMICS

1. Write the general equation of the first law of thermodynamics.

2. Write the equation of the first law of thermodynamics for the isobaric process.

3. Write the equation of the first law of thermodynamics for the isochoric process.

4. Write the equation of the first law of thermodynamics for the isothermic process.

5. According to the first law of thermodynamics, the process in which all the energy supplied to a system in a form of heat turns to the increase in internal energy is called _____.

6. One can calculate the heat effect of hydration from the heat effect of the dissolving of a dry salt and the heat effect of the dissolving of a salt hydrate according to the _____ law.

7. Write the Boltzmann equation describing the statistical interpretation of the second law of thermodynamics.

8. Write the Clausius inequality reflecting the second law of thermodynamics for thermodynamically irreversible processes.

9. Write the Clausius equation reflecting the second law of thermodynamics for thermodynamically reversible processes.

10. Spontaneous processes in an isolated system cannot lead to the decrease of _____.

11. _____ system can exchange only energy with the environment.

12. Write the combined equation of the first and the second law of thermodynamics with ΔG, ΔH, T and ΔS.

13. _____ system can exchange energy and matter with the environment.

14. _____ system cannot exchange energy or matter with the environment.

15. According to the third law of thermodynamics the entropy of a substance at 0 K is equal to _____.

16. Molar heat capacity is equal to the amount of heat required to increase the temperature of 1 mole of a substance _____.

17. To calculate the absolute entropy of a gaseous substance one needs to find the definite integral from 0 to 298 K of the dependence of _____ on _____.

18. Write the equation connecting the constant of chemical equilibrium with ΔG^0 for a chemical reaction.

19. For a reaction with $\Delta H^0_r > 0$, the higher the temperature, the _____ the constant of equilibrium.

20. For a reaction with $\Delta H^0_r < 0$, the higher the temperature, the _____ the constant of equilibrium.

TASK № 17. ELECTROCHEMISTRY

1. Absolute ion movement rate in aqueous solutions _____ in the Na^+, OH^-, H^+ row.

2. Electric conductivity of water solutions of electrolytes _____ with the increase in temperature.

3. The electrical conductivity of 0.1 M H_2SO_4 solution is _____ than the electrical conductivity of 0.1 M Na_2SO_4 solution.

4. In a row of biological fluids of a healthy person (urine, blood plasma, gastric juice, whole blood), electrical conductivity _____.

5. Specific electric conductivity of the electrolyte solution first _____ and then _____ with the decrease of its concentration.

6. The specific electric conductivity of the gastric juice of a healthy person is _____ than the specific electric conductivity of the whole blood.

7. Write a formula expressing the law of Kohlrausch with mobility values for cations and anions.

8. The ratio between the value of molar electric conductivity and the limiting molar electric conductivity is equal to the _____ of a weak electrolyte.

9. Write the Nernst equation for a metal electrode immersed in a solution of a salt of its cation with a natural logarithm.

10. Write the scheme of a standard hydrogen electrode.

11. The standard potential of the standard hydrogen electrode is equal to _____.

12. Write the scheme of a silver chloride electrode.

13. Silver chloride electrode serves as a _____ electrode in the pH-meter.

14. In the pH-meter, the determination electrode is a _____ electrode.

15. Write the processes taking place at the anode and the cathode in a copper-zinc galvanic cell.

16. The electromotive force of a silver-copper electrochemical cell $Cu\,|\,Cu^{2+}\,\|\,Ag^+\,|\,Ag$ under standard conditions is _____ than the electromotive force of a silver-zinc electrochemical cell $Zn\,|\,Zn^{2+}\,\|\,Ag^+\,|\,Ag$ in the same conditions.

17. In a copper-silver galvanic cell, the copper electrode is an _____ and the silver electrode is a _____.

18. A concentration galvanic cell is an element composed of two identical metals immersed in solutions of the same electrolyte but of _____ concentrations.

19. In a galvanic cell, the oxidation process takes place at an _____ and the reduction process takes place at a _____.

20. The electromotive force of a galvanic cell is determined by the formula $E = \varphi_2 - \varphi_1$, where φ_1 is the potential of an _____, while φ_2 is the potential of a _____.

TASK № 18. SURFACE PHENOMENA

1. Write the Gibbs equation connecting adsorption with the equilibrium concentration of a solute.

2. Surface activity is a derivative of _____ per _____ with a negative sign.

3. Give an example of a surface-inactive amino acid.

4. Surface active substances _____ the surface tension.

5. Surface inactive substances _____ the surface tension.

6. Surface nonactive substances _____ the surface tension.

7. If the number of drops of water solution of a certain substance dropping down from stalagmometer is lower than the number of drops of water, the solute is _____.

8. If the number of drops of water solution dropping down from stalagmometer is higher than the number of drops of water, the substance dissolved is _____.

9. If the number of drops of water solution dropping down from stalagmometer is the same as the number of drops of water, the substance dissolved is _____.

10. The Ducklo–Traube rule states that the surface activity in the row of homologous surface active substances is growing approximately _____ times with the addition of each CH_2 group.

11. Adsorption of a surface active substance on the border between liquid and gaseous phase ends up with the formation of a _____ layer.

12. The equation of adsorption isotherm according to the Langmuir monomolecular adsorption theory at high concentrations of a solute can be written as follows _____.

13. Write the Langmuir equation.

14. Adsorption of a substance on the solid phase may not be finished after the formation of a _____ layer.

15. Freundlich equation describes the process of adsorption well only for _____ values of concentration or partial pressure.

16. Write the Freundlich equation.

17. _____ molecules are well adsorbed on the polystyrene surface.

18. The stronger the affinity between a solid phase and a substance, the _____ the retention time during the column chromatography.

19. Affine chromatography is used for the purification of _____ from a serum on a column with immobilized antigen.

20. During the gel-filtration _____ molecules are washed from a column faster than _____ molecules.

TASK № 19. COLLOID SOLUTIONS

1. It is _____ to obtain a colloid solution by the way of the dissolving of ethanol in water in standard conditions.

2. Colloid solution is a thermodynamically _____ system.

3. Colloid solution is a kinetically _____ system.

4. A dispersed system is a heterogeneous system consisting of a _____ and a _____.

5. The particle size of the dispersed phase of the colloid solution is in the range from _____ to _____ nanometers.

6. The opalescence of colloid solutions occurs due to _____.

7. At the same mass concentration of a solute, the osmotic pressure of the glucose solution is _____ than the osmotic pressure of the iron (III) hydroxide sol.

8. The lower the average mass of colloid particles, the higher the _____ stability of a sol.

9. The smaller the average size of diffuse layer for colloid particles, the _____ the aggregative stability of a sol.

10. The aggregate and the adsorption layer of a colloid particle build up together a _____.

11. The aggregate of a colloid particle is made of microcrystals of a _____ substance.

12. Electrolyte ions that are adsorbed directly on a surface of an aggregate are called _____ ions.

13. The granule together with the diffuse layer of counter ions makes up a _____.

14. The electrothermodynamic potential of a colloid particle occurs at the boundary between layers of _____ and _____.

15. The electrokinetic potential of a colloid particle occurs at the boundary between the _____ and the _____.

16. Electrolyte ions adsorbed directly on a crystalline solid surface and giving it an electric charge are called _____ ions.

17. Arrange the ions NO_3^-, PO_4^{3-}, SO_4^{2-} in the order of the decrease of the coagulation threshold for a sol with positively charged granules.

18. The diffusion layer in the sol particles consists of _____.

19. The nucleus of a colloid particle of a sol consists of an _____ and _____ ions.

20. When two sols with oppositely charged granules are mixed together, they will _____.

TASK № 20. SOLUTIONS OF BIOPOLYMERS

1. The value of pH of the medium at which the protein is electrically neutral (has no overall charge), is called _____.

2. For aminodicarboxylic amino acid (for example, aspartic acid) the value of pI is in the _____ medium.

3. For diaminocarboxylic amino acid (for example, lysine) the value of pI is in the _____ medium.

4. The value of pI of a protein depends on _____ values of all its functional groups that can be protonated and deprotonated.

5. If pH of a solution is equal to pI for a given protein, it has a _____ charge.

6. If pH of a solution is lower than pI for a given protein, it has a _____ charge.

7. If pH of a solution is higher than pI for a given protein, it has a _____ charge.

8. At the isoelectric point solubility of a protein demonstrates its _____ value.

9. At the isoelectric point gelatinization rate of a protein solution demonstrates its _____ value.

10. At the isoelectric point the swelling degree of a protein demonstrates its _____ value.

11. At the isoelectric point the stability against the salting out of a solution for a protein demonstrates its _____ value.

12. Write the formula of a salt that is usually used for salting out a protein from its water solution.

13. Salting out process of a protein from its water solution can be explained by the _____ for water molecules between a protein and an electrolyte.

14. Salting in process can be explained by the _____ of ions of an electrolyte by a protein.

15. Which electrode does the protein move to during the process of native gel electrophoresis if pI = 3.0 and the pH of the solution is 5.0?

16. Which electrode does the protein move to during the process of native gel electrophoresis if pI = 5.0 and the pH of the solution is 4.0?

17. Which electrode does the protein move to during the process of native gel electrophoresis if pI = 5.0 and the pH of the solution is 5.0?

18. During the gel electrophoresis proteins pre-treated by SDS (sodium dodecyl sulfate) are separated according to the _____ of their molecules only.

19. The charge of the protein with pI = 9.5 in the aqueous solution with pH = 7.5 is _____.

20. The charge of the protein with pI = 4.5 in the aqueous solution with pH = 6.4 is _____.

ANSWERS TO THE TASKS

Task 1

1. 0.644 g.

2. 9.55 g.

3. 5.40 g.

4. 14.41 g.

5. 100 ml.

6. 8.66 %.

7. 0.73 ml.

8. 0.75 %.

9. 6.24 L.

10. 10.582 mol/kg.

11. 1.35 mol/l.

12. 0.88 % (0.8775).

13. 0.28 mol/l (0.2778).

14. 0.0108 %.

15. 0.1487 mol/l.

16. 0.317 mol/kg.

17. 0.0527 N.

18. 2.176 N.

19. 0.176 g/ml.

20. $3.624 \cdot 10^{-5}$ mol/l.

Task 2

1. $Al(OH)_3 + KOH_{excess, conc.} \rightarrow$ potassium hexahydroxoaluminate

2. $Zn(OH)_2 + LiOH_{excess, conc.} \rightarrow$ lithium tetrahydroxozincate

3. $AlCl_3 + NaOH_{excess, conc.} \rightarrow$ sodium hexahydroxoaluminate + NaCl

4. $ZnSO_4 + LiOH_{excess} \rightarrow$ lithium tetrahydroxozincate + Li_2SO_4

5. $CrCl_3 + KOH_{excess} \rightarrow$ potassium hexahydroxochromate (III) + KCl

6. $FeCl_3 + KCN_{excess} \rightarrow$ potassium hexacyanoferrate (III) + KCl

7. $FeCl_2 + KCN_{excess} \rightarrow$ potassium hexacyanoferrate (II) + KCl

8. $Cu(NO_3)_2 + NH_3 \rightarrow$ tetraamminecopper (II) nitrate

9. $AgCl + NH_3 \rightarrow$ diamminesilver (I) chloride

10. $Zn(NO_3)_2 + NH_4OH \rightarrow$ tetraamminezinc nitrate + H_2O

11. $AgBr + NH_4OH \rightarrow$ diamminesilver (I) bromide + H_2O

12. $NiCl_2 + NH_{3\ excess} \rightarrow$ hexaamminenickel (II) chloride

13. $HgI_2 + KI \rightarrow$ potassium tetraiodomercurate (II)

14. $Cd(NO_3)_2 + KI_{excess} \rightarrow$ potassium tetraiodocadmiate (II) + KNO_3

15. $AlCl_3 + NaCl \rightarrow$ sodium tetrachloroaluminate

16. $AlF_3 + NaF \rightarrow$ sodium hexafluoroaluminate
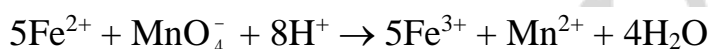
17. $BF_3 + LiF \rightarrow$ lithium tetrafluoroborate

35

18. $AlCl_3 + LiH_{excess} \rightarrow$ lithium tetrahydridoaluminate $+ LiCl$

19. $Ni + CO \rightarrow$ nickel tetracarbonil

20. $MnSO_4 + H_2O \rightarrow$ manganese (II) hexaaquasulfate

Task 3

1. 0.077 M.	**8.** 0.08292 M.	**14.** 382.06 ml.
2. 0.05817 M.	**9.** 1.667 g.	**15.** 295.0 ml.
3. 0.008036 g/ml.	**10.** 1.291 g.	**16.** 5 %.
4. 0.0005692 g/ml.	**11.** 10.15 %.	**17.** 0.06330 M.
5. 0.06892 M.	**12.** 25.914 g.	**18.** 0.02001 M.
6. 0.12 g.	**13.** 0.2015 mol/L (HCl),	**19.** 1.01063 g.
7. 0.1364 g.	0.2065 mol/L (NaOH).	**20.** 15.141 %.

Task 4

1. $FeSO_4 + KMnO_4 + H_2SO_4 \rightarrow$

$$Fe^{2+} - \bar{e} \rightarrow Fe^{3+} \quad \left| \begin{matrix} 1 \\ 5 \end{matrix} \right| 5 \atop \left. \begin{matrix} 5 \\ 1 \end{matrix} \right.$$

$$MnO_4^- + 8H^+ + 5\bar{e} \rightarrow Mn^{2+} + 4H_2O$$

$$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

$$10FeSO_4 + 2KMnO_4 + 8H_2SO_4 \rightarrow 5Fe_2(SO_4)_3 + 2MnSO_4 + 8H_2O + K_2SO_4$$

2. $KMnO_4 + HBr \rightarrow$

$$MnO_4^- + 8H^+ + 5\bar{e} \rightarrow Mn^{2+} + 4H_2O \quad \left| \begin{matrix} 5 \\ 2 \end{matrix} \right| 10 \left| \begin{matrix} 2 \\ 5 \end{matrix} \right.$$

$$2Br^- - 2\bar{e} \rightarrow Br_2^0$$

$$2MnO_4^- + 16H^+ + 10Br^- \rightarrow 2Mn^{2+} + 8H_2O + 5Br_2$$

$$2KMnO_4 + 16HBr = 2MnBr_2 + 8H_2O + 5Br_2 + 2KBr$$

3. $K_2Cr_2O_7 + KI + H_2SO_4 \rightarrow$

$$Cr_2O_7^{2-} + 14H^+ + 6\bar{e} \rightarrow 2Cr^{3+} + 7H_2O \quad \left| \begin{matrix} 6 \\ 2 \end{matrix} \right| 6 \left| \begin{matrix} 1 \\ 3 \end{matrix} \right.$$

$$2I^- - 2\bar{e} \rightarrow I_2$$

$$Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 2Cr^{3+} + 7H_2O + 3I_2$$

$$K_2Cr_2O_7 + 7H_2SO_4 + 6KI \rightarrow Cr_2(SO_4)_3 + 7H_2O + 3I_2 + 4K_2SO_4$$

4. $KMnO_4 + H_2S + H_2SO_4 \rightarrow S\downarrow + ...$

$$MnO_4^- + 8H^+ + 5\bar{e} \rightarrow Mn^{2+} + 4H_2O \quad \begin{vmatrix} 5 \\ \\ 2 \end{vmatrix} 10 \begin{vmatrix} 2 \\ \\ 5 \end{vmatrix}$$

$$H_2S - 2\bar{e} \rightarrow S + 2H^+$$

$2MnO_4^- + 16H^+ + 5H_2S \rightarrow 2Mn^{2+} + 8H_2O + 5S + 10H^+$

$2KMnO_4 + 3H_2SO_4 + 5H_2S \rightarrow 2MnSO_4 + 8H_2O + 5S + K_2SO_4$

5. $K_2Cr_2O_7 + Na_2SO_3 + H_2SO_4 \rightarrow$

$$Cr_2O_7^{2-} + 14H^+ + 6\bar{e} \rightarrow 2Cr^{3+} + 7H_2O \quad \begin{vmatrix} 6 \\ \\ 2 \end{vmatrix} 6 \begin{vmatrix} 1 \\ \\ 3 \end{vmatrix}$$

$$SO_3^{2-} + H_2O - 2\bar{e} \rightarrow SO_4^{2-} + 2H^+$$

$Cr_2O_7^{2-} + 14H^+ + 3SO_3^{2-} + 3H_2O \rightarrow 2Cr^{3+} + 7H_2O + 3SO_4^{2-} + 6H^+$

$K_2Cr_2O_7 + 4H_2SO_4 + 3Na_2SO_3 \rightarrow Cr_2(SO_4)_3 + 4H_2O + 3Na_2SO_4 + K_2SO_4$

6. $K_2Cr_2O_7 + H_2S + H_2SO_4 \rightarrow S\downarrow + ...$

$$Cr_2O_7^{2-} + 14H^+ + 6\bar{e} \rightarrow 2Cr^{3+} + 7H_2O \quad \begin{vmatrix} 6 \\ \\ 2 \end{vmatrix} 6 \begin{vmatrix} 1 \\ \\ 3 \end{vmatrix}$$

$$H_2S - 2\bar{e} \rightarrow S^0 + 2H^+$$

$Cr_2O_7^{2-} + 14H^+ + 3H_2S \rightarrow 2Cr^{3+} + 7H_2O + 3S + 6H^+$

$K_2Cr_2O_7 + 3H_2S + 4H_2SO_4 \rightarrow Cr_2(SO_4)_3 + 7H_2O + 3S + K_2SO_4$

7. $KMnO_4 + Na_2SO_3 + H_2SO_4 \rightarrow$

$$MnO_4^- + 8H^+ + 5\bar{e} \rightarrow Mn^{2+} + 4H_2O \quad \begin{vmatrix} 5 \\ \\ 2 \end{vmatrix} 10 \begin{vmatrix} 2 \\ \\ 5 \end{vmatrix}$$

$$SO_3^{2-} + H_2O - 2\bar{e} \rightarrow SO_4^{2-} + 2H^+$$

$2MnO_4^- + 16H^+ + 5SO_3^{2-} + 5H_2O \rightarrow 2Mn^{2+} + 8H_2O + 5SO_4^{2-} + 10H^+$

$2KMnO_4 + 5Na_2SO_3 + 3H_2SO_4 \rightarrow 2MnSO_4 + 3H_2O + 5Na_2SO_4 + K_2SO_4$

8. $K_2Cr_2O_7 + FeSO_4 + H_2SO_4 \rightarrow$

$$Cr_2O_7^{2-} + 14H^+ + 6\bar{e} \rightarrow 2Cr^{3+} + 7H_2O \quad \bigg|\,6\,\bigg|\bigg|\,1$$
$$\quad\qquad\qquad\qquad\qquad\qquad\qquad\qquad 6$$
$$Fe^{2+} - \bar{e} \rightarrow Fe^{3+} \qquad\qquad\qquad\quad \bigg|\,1\,\bigg|\bigg|\,6$$

$$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$$

$$K_2Cr_2O_7 + 6FeSO_4 + 7H_2SO_4 \rightarrow Cr_2(SO_4)_3 + 7H_2O + 3Fe_2(SO_4)_3 + K_2SO_4$$

9. $KBrO_3 + KBr + H_2SO_4 \rightarrow Br_2 + ...$

$$2BrO_3^- + 12H^+ + 10\bar{e} \rightarrow Br_2 + 6H_2O \quad \bigg|\,10\,\bigg|\bigg|\,1$$
$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad 10$$
$$2Br^- - 2\bar{e} \rightarrow Br_2 \qquad\qquad\qquad\qquad \bigg|\,2\,\bigg|\bigg|\,5$$

$$2BrO_3^- + 12H^+ + 10Br^- \rightarrow Br_2 + 6H_2O + 5Br_2$$

$$2KBrO_3 + 10KBr + 6H_2SO_4 \rightarrow 6Br_2 + 6K_2SO_4 + 6H_2O$$

10. $FeSO_4 + KClO_3 + H_2SO_4 \rightarrow KCl + ...$

$$ClO_3^- + 6H^+ + 6\bar{e} \rightarrow Cl^- + 3H_2O \quad \bigg|\,6\,\bigg|\bigg|\,1$$
$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad 6$$
$$Fe^{2+} - 1\bar{e} \rightarrow Fe^{3+} \qquad\qquad\qquad \bigg|\,1\,\bigg|\bigg|\,6$$

$$ClO_3^- + 6H^+ + 6Fe^{2+} \rightarrow Cl^- + 3H_2O + 6Fe^{3+}$$

$$KClO_3 + 6FeSO_4 + 3H_2SO_4 \rightarrow KCl + 3H_2O + 3Fe_2(SO_4)_3$$

11. $K_2SO_3 + KMnO_4 + KOH \rightarrow$

$$SO_3^{2-} + 2OH^- - 2\bar{e} \rightarrow SO_4^{2-} + H_2O \quad \bigg|\,2\,\bigg|\bigg|\,1$$
$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad 2$$
$$MnO_4^- + \bar{e} \rightarrow MnO_4^{2-} \qquad\qquad\quad \bigg|\,1\,\bigg|\bigg|\,2$$

$$SO_3^{2-} + 2OH^- + 2MnO_4^- \rightarrow SO_4^{2-} + H_2O + 2MnO_4^{2-}$$

$$K_2SO_3 + 2KOH + 2KMnO_4 \rightarrow K_2SO_4 + H_2O + 2\,K_2MnO_4$$

12. $KMnO_4 + KNO_2 \xrightarrow{\text{pH=7}} ...$

$$MnO_4^- + 2H_2O + 3\bar{e} \rightarrow MnO_2 + 4OH^- \quad \left| 3 \right| \left| 2 \right.$$
$$\left. \right| 6$$
$$NO_2^- + H_2O - 2\bar{e} \rightarrow NO_3^- + 2H^+ \quad \left| 2 \right| \left| 3 \right.$$

$$2MnO_4^- + 4H_2O + 3NO_2^- + 3H_2O \rightarrow 2MnO_2 + \underbrace{8OH^- + 6H^+}_{6H_2O + 2OH^-} + 3NO_3^-$$

$$2KMnO_4 + 3KNO_2 + H_2O \rightarrow 2MnO_2 + 3KNO_3 + 2KOH$$

13. $K_2SO_3 + KMnO_4 \xrightarrow{\text{pH=7}} ...$

$$SO_3^{2-} + H_2O - 2\bar{e} \rightarrow SO_4^{2-} + 2H^+ \quad \left| 2 \right| \left| 3 \right.$$
$$\left. \right| 6$$
$$MnO_4^- + 2H_2O + 3\bar{e} \rightarrow MnO_2 + 4OH^- \quad \left| 3 \right| \left| 2 \right.$$

$$3SO_3^{2-} + 3H_2O + 2MnO_4^- + 4H_2O \rightarrow 3SO_4^{2-} + \underbrace{6H^+ + 8OH^-}_{6H_2O + 2OH^-} + 2MnO_2$$

$$3K_2SO_3 + 2KMnO_4 + H_2O \rightarrow 3K_2SO_4 + 2MnO_2\downarrow + 2KOH$$

14. $KMnO_4 + MnSO_4 \xrightarrow{\text{pH=7}} MnO_2\downarrow + ...$

$$MnO_4^- + 2H_2O + 3\bar{e} \rightarrow MnO_2 + 4OH^- \quad \left| 3 \right| \left| 2 \right.$$
$$\left. \right| 6$$
$$Mn^{2+} + 2H_2O - 2\bar{e} \rightarrow MnO_2 + 4H^+ \quad \left| 2 \right| \left| 3 \right.$$

$$2MnO_4^- + 4H_2O + 3Mn^{2+} + 6H_2O \rightarrow 2MnO_2 + \underbrace{8OH^- + 12H^+}_{8H_2O + 4H^+} + 3MnO_2$$

$$2KMnO_4 + 3MnSO_4 + 2H_2O \rightarrow 5MnO_2 + 2H_2SO_4 + K_2SO_4$$

15. $KMnO_4 + KI + H_2O \rightarrow$

$$MnO_4^- + 2H_2O + 3\bar{e} \rightarrow MnO_2 + 4OH^- \quad \left| 3 \right| \left| 2 \right.$$
$$\left. \right| 6$$
$$2I^- - 2\bar{e} \rightarrow I_2^0 \quad \left| 2 \right| \left| 3 \right.$$

$$2MnO_4^- + 4H_2O + 6I^- \rightarrow 2MnO_2 + 8OH^- + 3I_2$$

$$2KMnO_4 + 4H_2O + 6KI \rightarrow 2MnO_2 + 8KOH + 3I_2$$

39

16. $KMnO_4 + H_2C_2O_4 + H_2SO_4 \rightarrow$

$$MnO_4^- + 8H^+ + 5\bar{e} \rightarrow Mn^{2+} + 4H_2O \quad \left|\begin{array}{c}5\\[8pt]2\end{array}\right| 10 \left|\begin{array}{c}2\\[8pt]5\end{array}\right.$$

$$H_2C_2O_4 - 2\bar{e} \rightarrow 2CO_2 + 2H^+$$

$2MnO_4^- + 16H^+ + 5H_2C_2O_4 \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2 + 10H^+$

$2KMnO_4 + 5H_2C_2O_4 + 3H_2SO_4 \rightarrow 2MnSO_4 + 8H_2O + 10CO_2 + K_2SO_4$

17. $Na_2SO_3 + NaI + H_2O \rightarrow S\downarrow$

$$SO_3^{2-} + 3H_2O + 4\bar{e} \rightarrow S^0 + 6OH^- \quad \left|\begin{array}{c}4\\[8pt]2\end{array}\right| 4 \left|\begin{array}{c}1\\[8pt]2\end{array}\right.$$

$$2I^- - 2\bar{e} \rightarrow I_2$$

$SO_3^{2-} + 3H_2O + 4I^- \rightarrow S^0 + 6OH^- + 2I_2$

$Na_2SO_3 + 3H_2O + 4NaI \rightarrow S\downarrow + 6NaOH + 2I_2$

18. $KMnO_4 + KNO_2 + H_2SO_4 \rightarrow KNO_3 + ...$

$$MnO_4^- + 8H^+ + 5\bar{e} \rightarrow Mn^{2+} + 4H_2O \quad \left|\begin{array}{c}5\\[8pt]2\end{array}\right| 10 \left|\begin{array}{c}2\\[8pt]5\end{array}\right.$$

$$NO_2^- + H_2O - 2\bar{e} \rightarrow NO_3^- + 2H^+$$

$2MnO_4^- + 16H^+ + 5NO_2^- + 5H_2O \rightarrow 2Mn^{2+} + 8H_2O + 5NO_3^- + 10H^+$

$2KMnO_4 + 5KNO_2 + 3H_2SO_4 \rightarrow 2MnSO_4 + 5KNO_3 + 3H_2O + K_2SO_4$

19. $KMnO_4 + KNO_2 + KOH \rightarrow$

$$MnO_4^- + \bar{e} \rightarrow MnO_4^{2-} \quad \left|\begin{array}{c}1\\[8pt]2\end{array}\right| 2 \left|\begin{array}{c}2\\[8pt]1\end{array}\right.$$

$$NO_2^- + 2OH^- - 2\bar{e} \rightarrow NO_3^- + H_2O$$

$2MnO_4^- + NO_2^- + 2OH^- \rightarrow 2MnO_4^{2-} + NO_3^- + H_2O$

$2KMnO_4 + KNO_2 + 2KOH \rightarrow 2K_2MnO_4 + KNO_3 + H_2O$

20. КBrO + MnCl$_2$ + KOH → KBr + ...

$$BrO^- + H_2O + 2\bar{e} \rightarrow Br^- + 2OH^- \quad \left|2\right| \quad \left|1\right.$$

$$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad 2$$

$$Mn^{2+} + 4OH^- - 2\bar{e} \rightarrow MnO_2 + 2H_2O \quad \left|2\right| \quad \left|1\right.$$

$$BrO^- + H_2O + Mn^{2+} + 4OH^- \rightarrow Br^- + 2OH^- + MnO_2 + 2H_2O$$

$$KBrO + MnCl_2 + 2KOH \rightarrow KBr + MnO_2 + H_2O + 2KCl$$

Task 5

1. 3.13 kPa.	**6.** 776.67 g/mol.	**11.** 103.21 g/mol.	**16.** 237.59 kPa.
2. 2.94 kPa.	**7.** 16584 g/mol.	**12.** 249.42 kPa.	**17.** 418.78 g/mol.
3. 42.53 kPa.	**8.** 100.104 °C.	**13.** 137.64 kPa.	**18.** $4.64 \cdot 10^{-4}$.
4. 180.001 g/mol.	**9.** 3.66 kg·K/mol.	**14.** –2,816 °C.	**19.** $7.34 \cdot 10^{-4}$.
5. 7.779 Kg.	**10.** S$_8$.	**15.** 100.572 °C.	**20.** 128.25 g/mol.

Task 6

1. –530.4 kJ/mol.	**8.** –139.478 kJ/mol.	**15.** $50.69 \cdot 10^{23}$.
2. –91.7 kJ/mol.	**9.** –108.2 kJ/mol.	**16.** $136.84 \cdot 10^{23}$.
3. 103.6 J/mol·K.	**10.** –77.8 kJ/mol.	**17.** 100.67 J/mol·K.
4. –211.67 kJ/mol.	**11.** –495.602 kJ/mol.	**18.** –16.39 kJ/mol.
5. –101.2 kJ/mol.	**12.** –542.702 kJ/mol.	**19.** $3.381 \cdot 10^{17}$.
6. 51.4 kJ/mol.	**13.** 66.1 kJ.	**20.** 2.26.
7. –26.31 J/mol·K.	**14.** $29.71 \cdot 10^{23}$.	

Task 7

1. 0.1867 mol/L·sec.	**6.** 27.222.	**11.** 2.78.	**16.** 89392 J/mol.
2. 0.0152 mol/L·sec.	**7.** 0.7083 mol/L.	**12.** 1.0726.	**17.** 93679 J/mol.
3. 33.333.	**8.** 2.	**13.** 1.0525.	**18.** 0.0004265.
4. 5000.	**9.** 65°C.	**14.** 6.7287.	**19.** 100 kJ/mol.
5. 4.	**10.** 4.06.	**15.** 66.4795.	**20.** $1.373 \cdot 10^{32}$.

Task 8

1. 4.32.	**6.** 2.76.	**11.** 10.6.	**16.** 0.0571 mol/L.
2. 9.52.	**7.** 2.73.	**12.** 9.25.	**17.** 0.0648 g.
3. 3.52.	**8.** 0.134.	**13.** 11.78.	**18.** 0.0817 mol/L.
4. 3.1.	**9.** 11.7.	**14.** $1.98 \cdot 10^{-4}$.	**19.** 10.
5. 4.23.	**10.** 3.62.	**15.** 5.5.	**20.** 1.585.

Task 9

1. 7.21.	**8.** Yes.	**15.** 8.29.
2. 5.18.	**9.** 2.35 mmol/L·pH unit.	**16.** 3.48 ml.
3. 4.68.	**10.** 0.01 mol/L·pH unit.	**17.** 0.45 g.
4. 4.40.	**11.** 0.01 mol/L·pH unit.	**18.** 4.76.
5. 4.35.	**12.** 0.002 mol/L·pH unit.	**19.** 7.11.
6. 8.93.	**13.** 0.132.	**20.** 7.18 g.
7. 8.25.	**14.** 1.55.	

Task 10

1. $\{[mAgCNS] \cdot nCNS^- \cdot (n-x)K^+\}^{x-} \cdot xK^+$

2. $\{[mPbCl_2] \cdot nPb^{2+} \cdot (2n-x)NO_3^-\}^{x+} \cdot xNO_3^-$

3. $\{[mAg_3PO_4] \cdot n(PO_4)^{3-} \cdot (3n-x)Na^+\}^{x-} \cdot xNa^+$

4. $\{[mAg_2CrO_4] \cdot nCrO_4^{2-} \cdot (2n-x)K^+\}^{x-} \cdot xK^+$

5. $\{[mAgBr] \cdot nAg^+ \cdot (n-x)NO_3^-\}^{x+} \cdot xNO_3^-$

6. $\{[mMn_3(PO_4)_2] \cdot nPO_4^{3-} \cdot (3n-x)Na^+\}^{x-} \cdot xNa^+$

7. $\{[mCoS] \cdot nCo^{2+} \cdot (n-x)SO_4^{2-}\}^{x+} \cdot xSO_4^{2-}$

8. $\{[mCoS] \cdot nS^{2-} \cdot (2n-x)NH_4^+\}^{x-} \cdot xNH_4^+$

9. $\{[mBaSO_4] \cdot nBa^{2+} \cdot (2n-x)NO_3^-\}^{x+} \cdot xNO_3^-$

10. $\{[mAgBr] \cdot nBr^- \cdot (n-x)K^+\}^{x-} \cdot xK^+$

11. $\{[mBaCrO_4] \cdot nBa^{2+} \cdot (2n-x)Cl^-\}^{x+} \cdot xCl^-$

12. $\{[mAgI] \cdot nI^- \cdot (n-x)K^+\}^{x-} \cdot xK^+$

13. $\{[mCuS] \cdot nS^{2-} \cdot (2n-x)NH_4^+\}^{x-} \cdot xNH_4^+$

14. $\{[mPbSO_4] \cdot nSO_4^{2-} \cdot (2n-x)Na^+\}^{x-} \cdot xNa^+$

15. $\{[mPbSO_4] \cdot nPb^{2+} \cdot (2n-x)NO_3^-\}^{x+} \cdot xNO_3^-$

16. $\{[mAgCl] \cdot nCl^- \cdot (n-x)Na^+\}^{x-} \cdot xNa^+$

17. $\{[mBaCO_3] \cdot nBa^{2+} \cdot (2n-x)Cl^-\}^{x+} \cdot xCl^-$

18. $\{[mBaCO_3] \cdot nCO_3^{2-} \cdot (2n-x)NH_4^+\}^{x-} \cdot xNH_4^+$

19. $\{[mMnS] \cdot nS^{2-} \cdot (2n-x)NH_4^+\}^{x-} \cdot xNH_4^+$

20. $\{[mPbI] \cdot nI^- \cdot (n-x)K^+\}^{x-} \cdot xK^+$

Task 11

1. 0.045.
2. equivalence point.
3. interval of color change.
4. 7.
5. basic.
6. acidic.
7. $H_2C_2O_4 \cdot 2H_2O$.
8. $Na_2B_4O_7 \cdot 10H_2O$.
9. $KMnO_4$ is a self-indicator.
10. $C_{N1} \cdot V_1 = C_{N2} \cdot V_2$.
11. $KMnO_4$.
12. starch.
13. stronger.
14. the direct.
15. reverse.
16. substitutive.
17. $H_2C_2O_4 \cdot 2H_2O$.
18. I_2.
19. $Na_2S_2O_3$.
20. permanent.

Task 12

1. Na^+.
2. K^+.
3. hypotonic.
4. oncotic pressure.
5. Cl^-.
6. HPO_4^{2-} and $H_2PO_4^-$.
7. 0.85–0.90 %; 4.5–5 %.
8. $P = iCRT$.
9. external pressure.
10. lowered.
11. same.
12. higher.
13. isotonic.
14. 0.001.
15. the same.
16. hypertonic.
17. lower, higher.
18. hydrodynamic pressure and oncotic pressure.
19. 3.
20. lower.

Task 13

1. 5–8.
2. 7.36–7.44.
3. 1.5–3.5 (0.9–2.0).
4. 8.6–9.0.
5. 5.6–7.9.
6. strong and weak.
7. concentration of H^+ ions.
8. titrimetric.
9. pH-meter.
10. non-dissociated molecules of weak acids.
11. total acidity, active acidity.
12. potentiometric, calorimetric.
13. acidosis.
14. metabolic acidosis.
15. alkalosis.
16. metabolic alkalosis.
17. more.
18. less.
19. < 7.
20. > 7.

Task 14

1. buffer. 2. $pH = 14 - pK_b - \log (C_{(salt)}/C_{(base)})$. 3. 1 : 1. 4. $\pm$ 1. 5. weak; salts. 6. cooperativity. 7. higher. 8. protonation. 9. hydrocarbonate and hemoglobin. 10. hydrocarbonate. 11. mol/L · pH units. 12. approximately equal (will remain the same). 13. $H_2PO_4^-$. 14. yes. 15. no. 16. K_2CO_3 and $KHCO_3$. 17. absolute

values of the molarity of the components are the largest. **18.** alkaline reserve of blood. **19.** acidosis. **20.** alkalosis.

Task 15

1. more. **2.** less. **3.** saturated. **4.** product of activities of ions of the hardly soluble substance in powers equal to the coefficients in the dissociation equation is less than the thermodynamic solubility constant. **5.** more; less. **6.** can not. **7.** no. **8.** yes. **9.** yes. **10.** no. **11.** $K_s^0 = a^2(Ag^+) \cdot a(SO_4^{2-})$. **12.** $K_s = a(Pb^{2+}) \cdot a^2(Cl^-)$. **13.** $K_s^0 = a^3(Li^+) \cdot a(PO_4^{3-})$. **14.** $K_s = a^3(Ca^{2+}) \cdot a^2(PO_4^{3-})$. **15.** yes. **16.** yes. **17.** $2.37 \cdot 10^{-4}$. **18.** $1.33 \cdot 10^{-5}$. **19.** $Ca_5(PO_4)_3OH$. **20.** $Ca_5(PO_4)_3F$.

Task 16

1. $Q = \Delta U + A$.   **8.** $\Delta S > Q/T$.   **15.** 0 (zero).
2. $Q_p = \Delta H$.   **9.** $\Delta S = Q/T$.   **16.** by one K.
3. $Q_v = \Delta U$.   **10.** entropy.   **17.** heat capacity; temperature.
4. $Q_T = A$.   **11.** closed.   **18.** $\Delta G^0 = -R \cdot T \cdot \ln K_{ch.eq.}$
5. isochoric.   **12.** $\Delta G = \Delta H - T \cdot \Delta S$.   **19.** higher.
6. Hess's.   **13.** opened.   **20.** lower.
7. $S = k \cdot \ln w$.   **14.** isolated.

Task 17

1. increases.   **11.** zero.
2. increases.   **12.** $Ag \,|\, AgCl, KCl$.
3. higher.   **13.** reference.
4. decreases.   **14.** glass.
5. increases; decreases.   **15.** anode: $Zn - 2\bar{e} \rightarrow Zn^{2+}$; cathode: $Cu^{2+} + 2\bar{e} \rightarrow Cu$.
6. higher.   **16.** lower.
7. $\lambda_m^0 = U_{cat} + U_{an}$.   **17.** anode; cathode.
8. dissociation degree.   **18.** different.
9. $\varphi_{Me^{n+}/Me} = \varphi^0_{Me^{n+}/Me} + RT/nF \ln a_{Me^{n+}}$.   **19.** anode; cathode.
10. $(Pt)\, H_2 \,|\, H^+$.   **20.** anode; cathode.

Task 18

1. $\Gamma = (-\Delta\delta/\Delta C) \cdot C/RT$; $(\Gamma = (-d\delta/dC) \cdot C/RT)$.
2. surface tension; concentration.
3. glycine.
4. decrease.
5. increase.
6. don't change.
7. surface inactive substance.
8. surface active substance.
9. surface nonactive substance.
10. 3–3.5.
11. monomolecular.
12. $\Gamma = \Gamma_\infty$.
13. $\Gamma = \Gamma_\infty \cdot C/(K + C)$.
14. monomolecular.
15. medium.
16. $\Gamma = KC^{1/n}$.
17. hydrophobic.
18. higher.
19. antibodies.
20. big; small.

Task 19

1. impossible.
2. unstable.
3. stable.
4. dispersed phase; dispersion medium.
5. 1–100.
6. light scattering.
7. higher.
8. sedimentation.
9. lower.
10. granule.
11. hardly soluble.
12. potential-determining.
13. micelle.
14. potential-determining ions; counterions.
15. granule; diffuse layer.
16. potential-determining.
17. NO_3^-, SO_4^{2-}, PO_4^{3-}.
18. counter ions.
19. aggregate; potential-determining.
20. coagulate.

Task 20

1. isoelectric point.
2. acidic.
3. bacic.
4. pK_a.
5. neutral.
6. positive.
7. negative.
8. lowest.
9. highest.
10. lowest.
11. lowest.
12. $(NH_4)_2SO_4$.
13. competition.
14. adsorption / binding.
15. anode.
16. cathode.
17. the protein will not move.
18. molecular mases.
19. positive.
20. negative.

REFERENCES

1. *Барковский, Е. В.* Общая химия : учеб. пособие / Е. В. Барковский, С. В. Ткачёв, Л. Г. Петрушенко. Минск : Вышэйшая школа, 2013. 639 с.

2. *Болтромеюк, В. В.* Общая химия : учеб. для студ. учреждений высшего образования / В. В. Болтромеюк. Минск : Вышэйшая школа, 2012. 623 с.

3. *Медицинская* химия : учеб. для мед. вузов IV ур. аккр. / под ред. В. А. Калибабчук. 3-е изд., испр. Киев, 2017. 400 с.

4. *Лабораторные* работы по общей химии / В. В. Хрусталёв [и др.]. Минск : БГМУ, 2019. 40 с.

5. *Atkins, P.* Atkins' Physical Chemistry / P. Atkins, J. de Paula. 10th ed. Oxford University Press, 2014. 500 p.

6. *Kontogeorgis, G. M.* Introduction to Applied Surface and Colloid Chemistry / G. M. Kontogeorgis, S. Kiil. Wiley, 2016. 388 p.

CONTENTS