Vinnytsia National Pirogov Memorial Medical University

Biological and General Chemistry Department

Medical chemistry course

Problems and Exercises in Medical Chemistry
Part 1

Vinnytsia 2017

A work sheet and methodical developments (Methodical of recommendation for practical classes from Medical chemistry for 1-st year foreign students) are made by the employees of department of biological and general chemistry of VNMMU Pirogov in accordance with a curriculum, worked out on principles of the European credit-transfer system (ECTS) for higher medical establishments of Ukraine III - IV levels of accreditation for specialities of “Medical Affairs” direction of the preparation “Medicine” is in accordance with education qvalification descriptions (EQD) and scientific proffesional programs (SPP) of the preparation of specialists, approved by an order MES Ukraine from 16.04.03 № 239.

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Contents:

Methods of expressing concentration of solution

The most commonly used ways of expressing such concentration solution.

1. ***Mass fraction*** $\boldsymbol{\varpi}$ – a ratio of the mass of the solute m_x (g) solution to the mass $m_{solution}$:

$$\varpi \frac{m_x}{m_{sol.}} \cdot 100\%$$

Units of mass fraction - percentage or in parts.

Mass of the solution related to the volume and density:

$$m_{solution} = V \cdot \rho,$$

where $m_{solution}$ - the mass of the solution in g;

V – volume of solution in ml;

ρ – density of the solution in g/ml.

Mass of the solution can be termed as the sum of the masses of water and solute mass:

$$m_{solution} = m_{water} + m_x.$$

2. ***Molar concentration of*** $\boldsymbol{C_X}$ - is the amount of solute ν per unit volume of solution:

$$C_X = \frac{\nu}{V}; \quad \text{express} \quad \nu = \frac{m_x}{M_X}, \text{ then}$$

$$C_X = \frac{m_X}{M_X \cdot V},$$

Where, m_X – weight of the substance in g

V – volume of solution in liters.

Units – mol/l or mmol/l.

From the formula of the molar concentration you can find a lot of dissolved substances or hitch:

$$m_X = \boldsymbol{C_X} \cdot M_X \cdot V.$$

3. But the substance does not react in a molar ratio, and the equivalent.

Equivalent - a particle of a substance X, which is equivalent to one proton and one electron. To find the equivalent it is necessary to know the ***equivalence factor*** $\boldsymbol{f_{eqv}}$. - A number that indicates how the particle substance X is equivalent to one proton and one electron.

Equivalence factor is given by: $f_{eqv.} = \frac{1}{z}$

where z is found for each class of compounds:

a) z for acid - is the number of protons, which is replaced by a metal:

For example, $f_{eqv.}(HCl) = \frac{1}{1}$; $f_{eqv.}(H_2SO_4) = \frac{1}{2}$ or $\frac{1}{1}$, if replaced only one proton.

b) z for a reason – this number oxygroup:

For example, $f_{eqv.}(NaOH) = \frac{1}{1}$; $f_{eqv.}(Ca(OH)_2) = \frac{1}{2}$;

c) z for salt - is the total valence of the metal (the product valence of the metal to its number):

For example, $f_{eqv.}(Na_2SO_4) = \frac{1}{2}$; $f_{eqv.}(Al_2(SO_4)_3) = \frac{1}{6}$;

d) z for the oxidation - reduction reactions – this is the number of electrons, which gives a reducing or oxidizing agent accepts:

For example, for the reaction $Fe^{+2} – 1e \rightarrow Fe^{+3}$ $f_{eqv}(Fe^{+2}) = \frac{1}{1}$;

for the reaction of $Mn^{+7} + 5e = Mn^{+2}$ $f_{eqv}(Mn^{+7}) = \frac{1}{5}$.

Using an equivalence factor, molar mass equivalent can be calculated: $M_{f\ eqv.X} = f_{eqv.} \cdot M_X$.

Knowing the molar mass equivalent, we can calculate the molar concentration equivalent $Cf_{eqv}.x$ (formerly the normal concentration of C_N) - is the equivalent amount of a substance per unit volume of solution:

$$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}$$

where m_x – mass of the substance in g

V – volume of solution in liters.

The units mol/l or mmol/l.

From the formula of the molar concentration equivalent we can find a lot of dissolved substances or hitch: $m_X = C_X \cdot M_X \cdot f_{eqv.} \cdot V$.

4) ***Molarity concentration*** $\boldsymbol{b_X}$ - number of substances in ν_x 1kg solvent:

$$b_X = \frac{\nu_X}{m_{solvent}} = \frac{m_X}{M_X \cdot m_{solvent}}$$

The units mol/kg solvent.

5) ***The titre of the solution t*** - a mass of solute in 1 ml of solution:

$$t = \frac{m_X}{V}. \qquad \text{Unit g/ml.}$$

6) To calculate the concentration of the solutions according to the titration use ***the law equivalents - the product of molar solution concentration on the volume of the solution is of constant:***

$$C_{N\,1} \cdot V_1 = C_{N\,2} \cdot V_2.$$

7) To calculate the concentration of solutions using the formula that bind different ways of expressing concentration:

$$C_X = \frac{\varpi\% \cdot \rho \cdot 10}{M_X}; \qquad C_N = \frac{\varpi\% \cdot \rho \cdot 10}{M_X \cdot f_{eqv.}}$$

Examples

A. Preparation of solutions with mass fractions.

If the problem is given by the mass fraction, a solution must be found with the formula of mass fraction.

1) Calculate a sample of preparation 5l of physiological solution (ρ = 1,03).

$V_{sol\text{-}n}$ = 5l
$\rho_{sol\text{-}n}$ = 1,03
ϖ (NaCl) = 0.9%

mx -?

Physiological solution – it is 0,9% NaCl.
Use the formula to calculate the mass fraction:

$$\varpi = \frac{m_x}{m(sol.)}100\%; \qquad m\ (sol\text{-}n) = v\ \rho;$$

1) Find the mass of the solution:

m (sol-n) = 1.03 · 5000 = 5150 (g);

2) Find the mass of the solute:

$$m(x) = \frac{\varpi \cdot m(sol.)}{100\%} = \frac{0{,}9 \cdot 5150}{100} = 46{,}35(g).$$

Answer: 46.35 g NaCl need to take and add water to 5 liters.

2) How much ml of 37% solution of HCI (ρ = 1,18) should be taken to prepare 2 l pharmacopoeia drug HCl with mass fraction of 8,2% (ρ = 1,04).

ϖ_1 (HCl) = 37%
ρ_1 = 1,18
ϖ_2 (HCl) = 8,2%
V_2 = 2 L

V_1 =?

Problem can be solved in two ways.

I Method

denote the parameters of the original 37% solution ρ_2 = 1,04;

numeral 1, and the solution which we must prepare the numeral 2.
Use the formula for calculating the mass fraction:

$$\varpi = \frac{m(x)}{m(sol.)}100\%; \qquad m(sol\text{-}n) = V\ \rho;$$

1) Data for first solution is not enough for the calculation of formula mass fraction, so we use this formula for finding the mass of the second solution:

m_2 (sol-n) = 1.04 · 2000 = 2080 (g);

2) Find the mass of the solute in this solution:

$$m_{x2} = \frac{\varpi_2 \cdot m_{sol.2}}{100} = \frac{8{,}2 \cdot 2080}{100} = 170{,}56(g) \text{ of HCl;}$$

3) The mass of the solute is the same in both races solid solution,

$m_{X1} = m_{X2};$

4) Find the mass of the first solution:

$$m_{sol.1} = \frac{m_{x1}}{\varpi_1} \cdot 100\% = \frac{170{,}56 \cdot 100}{37} = 460{,}97g$$

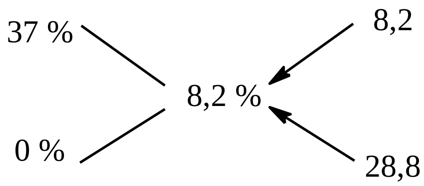
5) Find the volume of the first solution:

$$V_1 = \frac{m_{sol.1}}{\rho_1} = \frac{460{,}97}{1{,}18} = 390{,}65ml.$$

Answer: You should take a 390.65 ml of 37% – the first solution of HCI and add water up to 2 l.

II Method

Settled under the Rules of the cross:



1)
2) Total units: 8.2 + 28.8 = 37 units;
3) Find $m_{sol\text{-}n2}$ = 2000 · 1,04 = 2080g;
4) Find the mass of the solution, which falls to 1 part solution:

2080: 37 = 56.22 g;

5) Find the mass of the first solution:

$m_{sol\text{-}n1}$ = 56,22 · 8,2 = 460,97 g;

6) Find the volume of the first solution:

$$V_1 = \frac{m_{sol.1}}{\rho_1} = \frac{460{,}97}{1{,}18} = 390{,}65 ml.$$

<u>Answer:</u> You should take 390.65 ml of 37% - the first solution of HCl and add water up to 2l.

3) What is the volume of water necessary to dissolve 1 mol of KOH to prepare 5% solution.

ν = 1 mol of KOH
ω = 5%
V (H_2O) =?

1) Find the mass of the solute:
ν = m / M; m = ν · M = 1 · 56 = 56g;
2) Write the formula for the mass fraction:

$$\varpi = \frac{m(x)}{m(sol.)}100\%$$, Hence the mass of the solution: $$m_{sol.} = \frac{m_x}{\varpi}100\% = 1120g$$

3) We expect a lot of water: m_{water} = m_{water} - $m_{substance}$ = 1120 - 56 = 1064g.
<u>Answer:</u> You should take 1064g of water.

4) The patient must enter the 100mg bemegride. How many ml of 0.5% -of the solution is necessary to take?

m_x = 100mg
ω = 0,5%
V (bemegride) =?

Use the formula to calculate the mass fraction:
m (sol-n) = V ρ;
1) Translate a lot of substance in g:
m_x = 100 mg = 0.1 g;
2) Find the mass of the solution, bemegride:

$$m_{sol.} = \frac{m_x}{\varpi}100\% = \frac{0{,}1 \cdot 100}{0{,}5} = 20g.$$

3) Find the volume of the solution, bemegride:

$$V = \frac{m_{sol.}}{\rho} = \frac{20}{1} = 20ml.$$

<u>Answer:</u> 20ml

5) A child who was born in asphyxia was injected ethymizol 1mg per for 1 kg of body weight. How many ml of 1.5% of the solution of this preparation is necessary for a child weighing 2800?

Given	Solution
m_{child} = 2800g	Use a formula to calculate the mass fraction:
dose = 1mg/kg weight	$\varpi = \frac{m(x)}{m(sol.)} 100\%$; m(sol-n) = V ρ;
ω = 1,5%	1) Find the mass ethymizol, which must be
V_{sol-n} -?	1mg ethymizol – to 1kg of body weight

X mg – at 2.8 kg

X = 2.8 mg = 0.0028 g;

2) Find the mass of the solution ethymizol:

$$m_{sol.} = \frac{m_x}{\varpi} 100\% = \frac{0,0028}{1,5} \cdot 100 = 0,187g = 0,19g;$$

3) Since the density of the solution is not given, then take it to 1:

Then, the volume of solution ethymizol equal to its mass, i.e. 0.19 ml.
Answer: you must enter 0, 19ml of solution ethymizol.

6) How many grams of oxalate (oxalic acid) must be dissolved in 200ml water to get 10% solution?

Given	Solution
V_{water} = 200m	**I Method**
ω = 10%	1) If we put a lot of substance m_x, then the mass solution $m_{sol-n} = 200 + m_x$ (200ml H_2O = 200g H_2O);
m_x =?	2) Using a formula mass fraction:

$$\varpi = \frac{m(x)}{m(sol.)} \cdot 100\%; \quad 10 = \frac{m_X}{200 + m_X} \cdot 100\% /$$

The calculation results, the m_x = 22.2 g

Answer: You should get 22.2 g of oxalic acid.

II method

1) What is the mass fraction of water in the solution?

ω (H_2O) = 100% – 10% = 90%;

2) Find the mass of the solution:

$$m_{sol.} = \frac{m(H_2O)}{\varpi} \cdot 100\% = \frac{200}{90} \cdot 100 = 222.2g;$$

3) Find the mass of oxalic acid:

222.2 - 200 = 22.2 g

Answer: You should get 22.2 g of oxalic acid.

B. Preparation of solutions with a molar concentration of C_X.

If the task is given molar concentration, to find the solution begin with the formula of the molar concentration.

1) Calculate the sample of the NaOH for the preparation of 2l 0.3 M solution of it.

Given	Solution
C_X(NaOH) = 0,3 mol/l	1) Write the formula of molar concentration:
V = 2 l	$C_X = \frac{m_X}{M_X \cdot V}$
m_x =?	2) From this formula we find m_X:

$m_X = C_X \cdot M_X \cdot V = 0,3 \cdot 40 \cdot 2 = 24g.$

Answer: You should take 24 g NaOH.

2) Calculate the molar concentration of KOH solution, if 3L solution contains 10 g of the substance.

m_X (KOH) = 10g	1) Write the formula for molar concentration:
V = 3L	$C_X = \frac{m_X}{M_X \cdot V}$
C_X =?	2) Calculate the C_X:

$$C_X = \frac{100}{56 \cdot V} = 0{,}59 mol/l.$$

Answer: the molar concentration of – 0.59 mol/l

3) Calculate the amount of 15% solution of H_2SO_4 (ρ = 1,105) required for preparation 4 l 0.5 M solution?

ω_1 = 15% ρ_1 = 1.105 V_2 = 4 l Cx_2 = 0.5 mol / l	1) Data of the first solution is not enough to be calculated by formula mass fraction, so we use the formula for molar concentration finding the mass of the solute m_X: $C_X = \frac{m_X}{M_X \cdot V}$ hence $m_X = C_X \cdot M_X \cdot V = 0{,}5 \cdot 98 \cdot 4 = 196g$; 2) Mass of solute is the same in both solutions, $m_{X1} = m_{X2}$;
V_1 =?	3) Using the mass fraction, we find the mass of the source solution 1:

$$\varpi = \frac{m(x)}{m(sol.)} 100\%, \text{ hence } m_{(sol.)} = \frac{m_X}{\varpi} 100\% = \frac{196}{15} \cdot 100 = 1306{,}7g;$$

4) Find the volume of initial solution: $V = \frac{m_{(sol.)}}{\rho} = \frac{1306{,}7}{1{,}105} = 1182{,}5ml.$

Answer: You should take 1182.5 ml of 15% - of the solution and bring the water to 4 l.

4) What is the molar concentration that corresponds to a solution of hydrochloric acid in gastric juice if the mass fraction of HCl it 0,5-0,54%?

ω (HCI) = 0.5-0,54%	**I Method**
C_X =?	1) Find the average content of hydrochloric acid in gastric juice:

$$\varpi_{\text{arithmetic mean}} = \frac{0{,}5 + 0{,}54}{2} = 0{,}52\%;$$

2) Suppose we have 100g of gastric juice. It contains 0.52 g of HCI. Molar concentration is calculated on 1000 ml of solution. Taking density of the gastric juice of 1, we find a lot of hydrochloric acid in 1000 ml of solution:

in 100g of solution - 0.52 g HCI
at 1000g (ml) – X

X = 5.2 g of HCI;

3) Find the molar concentration of C_X:

$$C_X = \frac{5{,}2}{36{,}5 \cdot 1} = 0{,}142 mol/l.$$

Answer: the molar concentration of hydrochloric acid in gastric juice is 0.142 moles per liter.

II method.

1) Find the average content of hydrochloric acid in gastric juice:

$$C_X = \frac{5,2}{36,5 \cdot 1} = 0,142 mol/l.$$

2) Using a formula that relates the two ways of expressing solution concentration C_X and ω:

$$C_X = \frac{\varpi\% \cdot \rho \cdot 10}{M_X} = \frac{0,52 \cdot 1 \cdot 10}{36,5} = 0,142 mol/l.$$

Answer: the molar concentration of hydrochloric acid in gastric juice is 0.142 moles per liter.

B. Preparation of solutions with a molar concentration equivalent C_N.

If the problem is given by the molar concentration equivalent to find a solution, start with the formula of the molar concentration equivalent.

1) In 250 ml of solution contains 26.5 g of Na_2SO_3. Calculate C_N.

V = 250ml

m_X = 26,5 g

C_N =?

1) Write the formula for molar concentration equivalent and calculate it (the volume of solution express in l):

$$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}. = \frac{26,5}{106 \cdot 1/2 \cdot 0,25} = 2 \text{ mol/l}$$

Answer: the molar concentration equivalent solution of baking soda - 2 mol/l.

2) How much $KMnO_4$ is necessary for the preparation of 2N. Solution with C_N = 0.1 mol/l, if $f_{eqv.}$ $KMnO_4$ = 1/5?

C_N = 0.1 mol / l

V = 2 l

$f_{eqv.}$ $KMnO_4$ = 1/5

m ($KMnO_4$) =?

1) Write the formula for molar concentration equivalent:

$$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}$$

hence: $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0,1 \cdot 158 \cdot 1/5 \cdot 2 = 31,6g.$

Answer: Mass $KMnO_4$ is 31.6g

3) Compute the C_N solution H_2SO_4 with w = 30% (ρ = 1,22, f_{eqv}. = 1/2).

ω = 30%

ρ = 1,22

f_{eqv}. = 1/2

C_N =?

1) Using a formula that relates the C_N and ω:

$$C_N = \frac{\varpi\% \cdot \rho \cdot 10}{M_X \cdot f_{eqv.}} = \frac{30 \cdot 1,22 \cdot 10}{98 \cdot 1/2} = 7,47 mol/l.$$

Answer: 30%-th solution corresponds to a solution with C_N = 7.47 mol/litre.

4) What volume of 30% solution of H_3PO_4 (ρ = 1,18) is necessary for cooking 5 l solution with C_N = 2 mol / l phosphate acid if it reacts completely?

ω_1 = 30%

ρ_1 = 1,18

V_2 = 5l

C_N = 2 mol/l

Denote the parameters of the original 30% solution numeral 1, and the solution which we must prepare, 2H-th - the number 2

1) data from the first solution is insufficient to calculate the formula of mass fraction, so using the formula of the molar concentration equivalent to finding

V_1 =? the mass of C_N substance in the second solution

$$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}$$, hence $m_{X2} = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0{,}2 \cdot 98 \cdot 1/3 \cdot 5 = 326{,}6g$

the (As phosphate acid reacts completely, all three hydrogen atoms are replaced by metal, then the equivalence factor equal to 1/3).
2) The mass of the solute is the same in both solutions

$$m_{X1} = m_{X2.}$$

3) Using the mass fraction, we find the mass of the first solution:

$$\varpi = \frac{m(x)}{m(sol.)} 100\%,$$

Hence $m_{(sol.)} = \frac{m_X}{\varpi} 100\% = \frac{326.6}{30} 100 = 1088g;$

4) Find the volume of the 30th solution:

$$V = \frac{m_{sol.}}{\rho} = \frac{1088}{1.18} = 922ml.$$

Answer: You should take 922ml 30 -% of mud and water to dolt 5l.

5) How will the concentration of the solution with HCI C_N = 0.2 mol / l, if up to 50ml to 100ml refill of water?

C_{N1} (HCl) = 0,2 mol/l
Vsol-n = 50 ml
V_{water} = 100ml

C_{N2} (HCl) =?

1) Volume of the solution after adding water:
50 + 100 = 150 ml;
2) According to the law of equivalents:

$$C_{N1} \cdot V_1 = C_{N2} \cdot V_2;$$

3) Find the concentration after the addition of water:

$$C_{N2} = \frac{C_{N1} \cdot V_1}{V_2} = \frac{0{,}2 \cdot 50}{150} = 0.067 mol/l.$$

Answer: 0.067 mol / litre.

Problems

1) Calculate a sample of NaCl for the preparation of 4 l hypertonic solution with ω = 10% (answer: 42.8 g)
2) How much ml 30% solution of H_2O_2 (ρ = 1,11) should be taken for the preparation of 2l. pharmacopoeic drug with ω (H_2O_2) = 3% (ρ = 1.007)? (Answer: 181 ml)
3) Children at the rate of 2mg/kg body weight (ρ = 1.04). How many mg/kg of 2% solution of this preparation is necessary to introduce into a child weighing 25kg? (Answer: 0,2 ml)
4) It is known that 1 IU of insulin promotes the absorption in the body 5g glucose. How many units of insulin should be added to 500 ml 5% - of the glucose solution? (Answer: 5 U)
5) The patient weighing 76 kg it is necessary to introduce a solution of $NaHCO_3$ on the basis of 0.66 mmol/kg body weight. How many ml of 4.2% solution is necessary to take?(Answer:100 ml)
6) What is the volume of water necessary to dissolve 2 M NaOH to obtain 10% solution? (Answer: 320 g)

7) A solution of aminophylline releases 2.4% - 10 ml. How many mg of pure substance in a vial? (Answer: 240 mg)
8) To introduce the patient to anaesthesia use ox butyrate sodium (GHB) which is produced by 20% - 10 ml. Patient weight 60 kg. The drug is administered at the rate of 70 mg / kg. How many ml must enter the patient? (Answer: 21ml)
9) Calculate the sample of NaOH to prepare 2 litres of solution with C_N = 1 mol / l, which is used in pharmacy for the establishment of titer of phosphoric acid. (Answer: 80 g)
10) What is the volume of 20% solution of H_3PO_4 (ς = 1,18) is required for preparation 4 l of solution it with C_N = 1.5 mol / l (f_{eq} = 1/3). (Answer: 553.67 ml)
11) Calculate the hitch for the preparation of 0,5 l solution of ascorbic acids with a mass fraction of 5% (ρ = 1,08). (Answer: 27 g)
12) Prepare 3 liters of saline solution (ρ = 1,03) (do necessary calculations). (Answer 27.8 g)
13) How many ml of 10% solution of H_2SO_4 (ρ = 1,065) is required for preparation of 5 l of a solution with C_N = 0.1 mol / l (f_{eqv} = 0,5). (Answer: 230 ml)
14) Calculate the sample of the solution for the preparation of 4 l $FeSO_4$ with C_N = 0.1 mol/l, if the reaction proceeds by the scheme: $Fe^{+2} \rightarrow Fe^{+3}$. (Answer: 60.8 g)
15) Calculate the hitch for the preparation of 3 l 0.1 M solution of HCl. (Answer: 10.96 g)
16) Calculate the C_X solution which contains 30 g NaOH in a 2l solution. (Answer: 0.375 mol/l)
17) What is the volume of water necessary to dissolve 1.5 mol of NaOH for receiving 5% of solution? (Answer: 1140ml)
18) In what ratio should take a 37% solution of HCl and water to making 8.2% solution (pharmacopoeia drugs (Answer: 1 ml 37% solution of HCl and 3.5 ml of water)
19) How many ml of water must be added to 50g of 2% solution of NaClI for get 0.9% solution? (Answer: 48.9 ml of water)
20) The patient weighing 60kg must enter the 0.1% solution adrenaline at the rate of 0.5 mg / kg. How many mL of this solution should be taken?
21) If the poisoning compounds arsenic unitiol injected at the rate of 56mg of matter at 10kg body weight. Calculate the volume of a 5% solution unitiol, which you must enter the patient weight of 60kg. (P solution is 1.12). (Answer: 6 ml)

Volumetric analysis

Volumetric or titrimetric analysis is based on an accurate measurement of the volume of titrant spent in the reaction with the substance under investigation.
Titrated solution is called with exactly known concentration.
The initial call substances that can prepare a solution of accurate weigh.
Indicators – are weak organic acids or bases that change their colour depending on the pH of the solution.
The interval transition colour indicator – this pH range in which the indicator changes its colour.

Indicator	Colour in the acidic environment	Transition interval colour (pH)	color in the alkaline environment
Methyl orange	Pink	3,1 – 4,4	Yellow
Phenolphthalein	Colourless	8,2 – 10,5	Raspberry
Methyl red	Red	4,2 – 6,2	Yellow
Litmus	Red	5 – 8	Blue

The method of neutralization

Neutralization method –is a method of volumetric analysis, which uses volumetric solution of acids and alkalis.
The method is based on neutralization reaction: $H^+ + OH^- \rightarrow H_2O$.
Depending on the method of neutralization of the titrant is divided into alkalimetry and acidimetry.

Alkalimetry – a method for determination of acids and salts, which give the hydrolysis of an acid reaction using volumetric solution of alkali.
Titrant bases NaOH and KOH are preparing for a rough hitch, and then establish their title, the exact concentration of precursor – oxalate (oxalic acid) $N_2S_2O_4 \cdot 2H_2O$ and succinate (succinic acid) NOOS – – CH_2CH_2COOH – alkaline solutions are prepared at about the same concentration as the starting material, a sample of alkali calculated, knowing the concentration of the original substance.

Challenges for the preparation of solutions in alkalimetry

1) Calculate the sample of the solution for preparation 2 l NaOH, if the title will be set to 0.1 N solution of oxalate (oxalic acid).

V = 2 l
$C_N(H_2S_2O_4)$ = 0,1 mol/l
m(NaOH) =?

1) As the title of alkali will establish by 0.1 N solution $H_2S_2O_4$, the alkaline solution should be also 0.1N.
2) To calculate the mass of alkali, use the formula C_N:

$$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}.$$

hence $m_x = C_N \cdot m_x \cdot f_{eqv} \cdot V = 0,1 \cdot 40 \cdot 1 \cdot 2 = 8$g.

Answer: The weight of alkali 8g.

2) Calculate the hitch for the preparation of 1 litre of 0.15 N KOH solution.

V = 1 l
C_N = 0.15 mol/l
m(KOH) =?

1) For the calculation we write the formula, C_N

$$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}$$

hence, $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0,15 \cdot 56 \cdot 1 \cdot 1 = 8,4$ g

Answer: The weight of 8.4g, the alkali

3) Calculate the sample of the solution for preparation 2l KOH, if the title will be set at 0.1 N solution of succinic acid.

V = 2 l
$C_N (S_4N_6O_4)$ = 0,1 mol/l
m (KOH) =?

1) As the title of alkali is established by 0.1 N solution $S_4N_6O_4$, the solution by 0.1 N solution $S_4N_6O_4$, the solution should be also 0.1 N
2) To calculate the mass use of alkali formula C_N:

$$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}$$

Hence $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0,1 \cdot 56 \cdot 1 \cdot 2 = 11.2$g

Answer: The weight of alkali is 11.2 g

4) What volume of 30% solution H_2SO_4 (ρ = 1,18) is necessary for preparation 2 l working solution with C_N = 0.1 mol/L, if acid reacts completely?

ω_1 = 30%
= 1,18

Denote the parameters of the original 30% solution ; numeral 1, and the ρ_1 ρ solution which we must prepare –0,1 N - the numeral 2.

V_2 = 2 l C_{N2} = 0,1 mol/l ——— V_1 =?	1) data from the first solution is insufficient to calculate formula of mass fraction, so use the formula for molar concentration C_N equivalent to finding the mass of material in the second solution: $$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}$$

Hence $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V$ = 0,1 · 98 · 1/2 · 2 = 9.8g

(As sulphuric acid reacts completely, ie all two hydrogen atoms are replaced by metal, then the equivalence factor is 1/2).

2) The mass of the solute is the same in both solutions

$$mx_1 = mx_2.$$

3) Using the mass fraction, we find the mass of the first solution:

$$\varpi = \frac{m(x)}{m(sol.)}100\%, \quad \text{hence } m_{sol}. = \frac{m_X}{\varpi} \cdot 100\% = \frac{9{,}8}{30} \cdot 100\% = 32{,}7.$$

4) Find the volume of the 30% solution:

$$V = \frac{m_{sol.}}{\rho} = \frac{32{,}7}{1{,}18} = 27{,}68 ml.$$

<u>Answer:</u> We need to take 27.68 ml 30% of the solution and pour water to 2 l.

<u>Problems:</u>

1) How many ml of 50% solution H_2SO_4 (ρ = 1,7) is necessary for cooking 3 l desktop solution with C_N = 0.1 mol/l, if acid reacts completely? (16.66 g)
2) Calculate the sample of the KOH cooking 3l solution if its titre is set to 0.1 N solution of oxalate. (16,8 g)
3) Compute C_N hydrochloric acid, if the titration of 5 ml of solution spent 5.1 ml of 0.1 N KOH solution. (0.1 mol/l)
4) Calculate the sample of the oxalate to prepare 4 l 0.1 N solution.
5) Calculate the sample of the phosphate acid for the preparation of 2 l 0.1 N solution, if it reacts completely. (6.53 g)

Acidimetric- is a method of determining the bases and salts, which give the hydrolysis of alkaline reaction, with the help of titrant acid.
Titrant acid HCI and H_2SO_4 are preparing for a rough hitch, and then establish their titre, the exact concentration of precursor – sodium carbonate Na_2CO_3, sodium tetra borate (borax) $Na_2B_4O_7 \cdot 10H_2O$ and sodium oxalate $Na_2S_2O_4$. Acid solutions are prepared about the same concentration as the starting material, sample of the acid is calculated knowing the concentration of the substance.

Problems for preparing solutions in acidimetric

1) Calculate the mass of hydrochloric acid necessary for the preparation of 3 l of the solution, if the titre will be installed on the 0.1 N solution of sodium carbonate.

V = 3 l (Na_2SO_3) = 0,1 mol/l ——— m (HCl) =?	1) As the title of hydrochloric acid will set to 0.1 N solution CN of Na_2SO_3, then the acid solution should be too 0.1 N 2) To calculate the mass of the acid we use the formula C_N: $$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}$$

Hence $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V$ = 0.1· 36.5 · 1· 3 = 10.5g.

<u>Answer:</u> The mass of acid was 10.5g

2) Calculate the molar concentration of H_2SO_4, if in 400 ml of solution containing 49g acid.

Given	Solution
V = 400ml	1) Write the formula for molar concentration:
m (H_2SO_4) = 49g	$C_X = \frac{m_X}{M_X \cdot V} = \frac{49}{98 \cdot 0{,}4} = 1{,}25 mol/l.$
C_X =?	

<u>Answer:</u> C_X (H_2SO_4) = 1,25 mol/l.

3) Calculate a sample of Na_2SO_3 to prepare 1 l titrated solution with C_N = 0.1 mol/litre.

Given	Solution
V = 1 l	1) To calculate the mass of Na_2SO_3 use the formula C_N:
C_N(Na_2SO_3) = 0,1 mol / l	$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}$
(Na_2SO_3) =?	hence $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V$ = 0,1 · 106 · 1/2 · 1 = 5.3 g

<u>Answer:</u> The mass of carbonate 5.3 g

4. Calculate the mass of a phosphate acid necessary for the preparation of 2 l of the solution, if the titre will be installed on the 0.1 N solution of borax.

Given	Solution
V = 2 l	1) Since the titre of the phosphate acid will set to 0.1 N solution of borax, then the acid solution should be too 0.1 N.
C_N ($Na_2V_4O_7$) = 0,1 mol/l	
m (H_3PO_4) =?	2) To calculate the mass of the acid we use the formula C_N: hence $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V$ = 0,1 · 202 · 1 / 2 · 2 = 20.2g

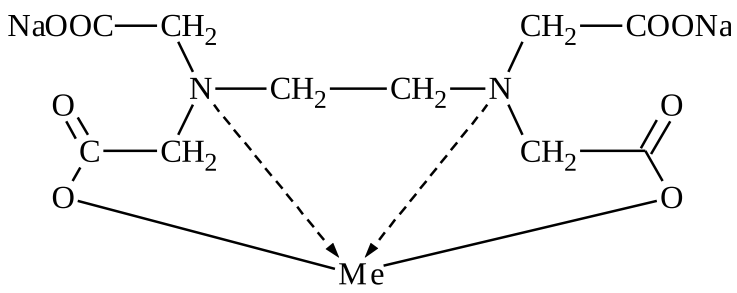
<u>Answer:</u> The mass of acid was 20.2g

<u>Problems:</u>

1) Calculate the sample of the drills for the preparation of 0,5 l titrant with C_N = 0.1 mol / liter. (Answer: 4,55 g)
2) Calculate the C_N acid phosphate solution, if it contains 1,5 l 7.5 g of the acid. (Answer: 0,15 mol / l)
3) Calculate the molar concentration of hydrochloric acid, if in 700ml solution contains 3.5 g of it. (Answer: 0.13 mol / l)
4) Calculate the molar concentration of sulphuric acid equivalent, if 600ml of solution containing 5.5 g of it .. (Answer: 0,18 mol / l)
5) Calculate the HF solution of hydrochloric acid, if in 200ml of solution contained 15g acid. (Answer: 0.2 mol / l)

<u>*Chelatometry*</u>

Chelatometry is a method of volumetric analysis, which uses titrant complexing.
Complexones – amino polycarbonic acids and their derivatives.
Increasingly using ethylenediaminetetr -acetic acid (**Trilon B)**, which will give chelates metal cations:



To determine the end of the titration using indicators - Black T, blue chromogen, murexid.

The chemistry of the method:

$$\underset{\text{blue}}{\text{Ind}} + \text{Me} \rightarrow \underset{\text{cherry}}{\text{Me-Ind}};$$

$$\underset{\text{cherry}}{\text{Me-Ind}} + \text{TrB} \rightarrow \text{Me-TrB} + \underset{\text{red}}{\text{Ind}}$$

The starting materials of the method: MgO; $CaCO_3$, Zn.

Examples

1) How many grams of Trilon B is necessary for the preparation of 250ml solution with C_N = 0.05 mol / l?

V = 250ml
C_N= 0.05mol/l

M_X =?

1) Since the problem is given by the molar concentration equivalent of C_N, the solution begins with the formula C_N:

$$C_N = \frac{m_X}{M_X \cdot f_{\text{eqv.}} \cdot V}$$

Hence $m_X = C_N \cdot M_X \cdot f_{\text{eqv.}} \cdot V = 0{,}05 \cdot 372 \cdot 1/2 \cdot 0{,}25 = 2.3$ g

Answer: The weight of Tr.B was 2.3 g

2) On titration 10ml $MgCl_2$ solution with C_N = 0.1 mol/l spent 11.9 ml of working solution of Trilon B. Calculate the concentration of solution of Trilon B.

V ($MgCl_2$) = 10ml
C_N ($MgCl_2$) = 0,1mol/l
V (Tr.B) = 11.9ml

C_N (Tr B) =?

1) to solve using the law equivalence:

$C_N(MgCl_2) \cdot V(MgCl_2) = C_N(\text{Tr.B}) \cdot V(\text{Tr.B})$;

hence $C_N(\text{Tr. B}) = \dfrac{C_N(MgCl_2) \cdot V(MgCl_2)}{V(\text{Tr.B})}$

$$= \frac{0{,}1 \cdot 10}{11{,}9} = 0.084 mol/l.$$

Answer: C_N (Tr B) = 0.084 mol/l.

3) Calculate the total hardness of water, if the titration of 30ml of it spent 2.7 ml of 0.1 N Trilon B.

V (H_2O) = 30 ml
V (Tr.B) = 2.7 ml
C (Tr.B) = 0,1 mol/l

1) To solve using the law equivalence:

$C_N(H_2O) \cdot V(H_2O) = C_N(v) \cdot V(\text{Tr B})$

hence $C_N(H_2O) = \dfrac{C_N(\text{Tr B}) \cdot \text{V(Tr B)}}{\text{V}(H_2O)}$

C (H_2O)=?	$= \frac{0,1 \cdot 2,7}{30} = 0,009 = 9 mol/l.$

Answer: The total water hardness 9mol/liter.

4) Calculate a sample of Trilon B to prepare 1 liter of solution if the titer (the exact concentration) will be set as 0.1 N solution of the starting material MgO.

V (Tr.B) = 1 ml	1) Since the titre will be set by Tr B 0.1 N solution of starting
C (MgO) = 0,1 mol/l	material MgO, a sample of the Tr B is also counting on the basis of concentration of 0.1 mol / litre. Since the problem given molar
m (MgO) =?	concentration equivalent C_N, the solution begins with the formula C_N:

$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}$ hence $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0,1 \cdot 372 \cdot 1/2 \cdot 1 = 18.6g$

Answer: The weight of Tr B was 18.6 g

5) Calculate a sample of zinc sulphate for the preparation of 200g of a solution with mass fraction of salt 1,5%.

$m_{sol\text{-}n}$ = 200g	1) Since the problem is given by the mass fraction, then use the formula:
ω ($ZnSO_4$) = 1,5%	$\varpi = \frac{m(x)}{m(sol.)} 100\%$, hence $m_X = \frac{\varpi \cdot m_{sol.}}{100\%} = \frac{1,5\% \cdot 200}{100} = 3g.$
m ($ZnSO_4$) =?	

Answer: Response; linkage $ZnSO_4$ – 3g.

Problems

1) Compute a sample of Trilons B to prepare 0.5 litres of solution if the titre (the exact concentration) will be set as 0.1 N solution of the starting material $CaCO_3$. (Answer: 9.3 g)
2) Compute a sample of nickel sulphate for the preparation of 400 g solution with mass fraction of salt 1,5%. (Answer: 6g)
3) How many grams of Trilon B is necessary for the preparation of 250ml solution with C_N = =0.05 mol /l? (Answer: 2.325 g)
4) Calculate a sample of mercury (II) nitrate for the preparation of 500ml 0.1 N solution. (Answer: 6.575 g)

METHOD OF PERMAGANATION

Permanganation- is a method of volumetric analysis, which uses potassium permanganate titrant $KMnO_4$. The main reaction is the method:

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

$KMnO_4$ titrant is prepared for a rough hitch, and then set the title of the original substance - $H_2C_2O_4$ or $Na_2C_2O_4$.
Titration is carried out in an acidic medium. End of titration set for the appearance of pink color when adding one extra drop of solution $KMnO_4$.

Examples of solving problems

1) Compute a sample of 400 ml to prepare solution $KMnO_4$. If the title will be set to 0.1 N solution of starting material $H_2C_2O_4$

V (sol-n) = 400 ml
C ($H_2C_2O_4$) = 0,1 mol/l
m ($KMnO_4$) =?

1) Since the titre of $KMnO_4$ solution will set on 0.1 N solution $H_2C_2O_4$, then $KMnO_4$ solution concentration must also be 0.1 mol/litre. Use the formula of the molar concentration of equivalent: $C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}$.

Hence $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0,1 \cdot 158 \cdot 1/5 = 0.4 \cdot 12.64$g

Answer: The mass of $KMnO_4$ is 12.64g

2) The laboratory has 10% solution of $KMnO_4$ ($\rho = 1,4$). Calculate C_N.

ω ($KMnO_4$) = 10%
ρ = 1,4
C_N =?

1) Using a formula that relates the C_N and ω:

$$C_N = \frac{\varpi\% \cdot \rho \cdot 10}{M_X \cdot f_{eqv.}} . = \frac{10\% \cdot 1,4 \cdot 10}{158 \cdot 1/5} = 4,43 mol/l.$$

Answer: C_N ($KMnO_4$) = 4.43 mol/litre.

3) Compute a sample of $Na_2C_2O_4$ for the preparation of 500 ml 0.1 N solution.

V (sol-n) = 500 ml
C_N = 0.1 N
m ($Na_2C_2O_4$) -?

1) Use the formula of the molar concentration equivalent:

$$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}.$$

hence, $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0,1 \cdot 134 \cdot 1/2 \cdot 0,5 = 3.35$g

Answer: The mass was $Na_2C_2O_4$ 3.35 g

4) How many grams of iron (II) sulphate is necessary for the preparation of 100ml of solution, if there is a volumetric solution $KMnO_4$ with C_N = 0.08 mol/litre.

V (sol-n) = 100 ml
($KMnO_4$) = 0.08 mol/l
Use the ($FeSO_4$) =?

1) Since titration carried 0.08 N $KMnO_4$ solution, the solution of C_N $FeSO_4$ necessary to prepare the same concentration.

Formula of molar concentration equivalent of C_N

$$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V},$$

hence, $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0,08 \cdot 152 \cdot 1 \cdot 0,1 = 1.216$g,

Answer: The mass of $FeSO_4$ 1,216g

5) Calculate the volume of 30% solution of H_2O_2 ($\rho = 1,27$) for the preparation of 2 l of the solution, if the titration is carried out 0.09 N solution $KMnO_4$ in acidic medium.

ω_1 (H_2O_2) = 30%
ρ_1 = 1.27
$V_{sol\text{-}n\ 2}$ (H_2O_2) = 2 l
C_N ($KMnO_4$) = 0.09 mol/l
$V_{sol\text{-}n\ 1}$ (H_2O_2) =?

1) Since the titration is carried 0.09N $KMnO_4$ solution, the solution of H_2O_2 necessary to prepare the same concentration. Using the formula molar concentration equivalent C_N find the mass of H_2O_2 in 200 ml of 0.09 N solution:

$$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}$$

hence $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0,09 \cdot 34 \cdot 1 / 2 \cdot 2 = 3.06$ g;

2) The mass of hydrogen peroxide is the same in solutions 1 and 2:

$$m_{X1} = m_{X2};$$

3) Using the mass fraction, we find the mass of a 1:

$$\varpi = \frac{m(x)}{m(sol.)}100\% \ ; \quad \text{hence, } m_{sol.1} = \frac{m_{x1}}{\varpi_1} \cdot 100\% = \frac{3{,}06 \cdot 100}{30} = 10{,}2g$$

4) Find the volume of solution 1:

$$V = \frac{m_{sol.}}{\rho} = \frac{10{,}2}{1{,}27} = 8{,}03ml.$$

Answer: The volume of 30% solution of hydrogen peroxide, 8.03 ml.

Problems

1) Compute a sample of 400 ml to prepare solution $KMnO_4$. If the titre will be set to 0.1 N solution of starting material $H_2C_2O_4$. (Answer: 1.26 g)
2) Calculate the HF solution of H_2O_2, if the titration of 5 ml of it spent 4.8 ml of 0.09 N solution of $KMnO_4$ (titration carried out in acidic medium). (Answer: 0.086)
3) In the laboratory, there is a 5% solution of potassium permanganate (ρ = 1,15).
How many ml of this solution is necessary for the preparation of 1 litre of 0.1 N solution of potassium permanganate? (Answer: 54.96 g)
4) How many ml of 5% solution of $Na_2C_2O_4$ (ρ = 1,1) is necessary for preparation of 200ml 0.1N solution? (Answer: 24.36 ml)

METHOD IODOMETRY

Iodometry - a method of volume analysis, which uses titrant I_2 or I^-.
The basic equation of the method:

$$I_2 + 2\bar{e} \leftrightarrow 2I^-$$

Since the titration of iodine is slow, then to the test solution was added an excess of iodine, and the residue titrated sodium thiosulphate $Na_2S_2O_3$:

$$2\ Na_2S_2O_3 + I_2 \rightarrow 2NaI + Na_2S_4O_6.$$

The precursor method – I_2.
Titration is carried out in acidic or neutral media. Indicator is starch. End of titration is set by the disappearance of blue color of iodine with starch.

Examples

1) Compute a sample of iodine for the preparation of 500 ml 0.1 N solution.

V(sol-n) = 500 ml
C_N = 0.1 N

$m(I_2)$ =?

1) As the problem is given by the molar concentration equivalent of C_N, then use the formula:

$$C_N = \frac{m_X}{M_X \cdot f_{eqv.} \cdot V}.$$

hence $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0{,}1 \cdot 254 \cdot 1/2 \cdot 0{,}5 = 6.35$ g;

Answer: The linkage of iodine was 6.35 g

2) Compute a sample of $Na_2S_2O_3 \cdot 5H_2O$ for preparing 200ml of solution, if the titre is set at 0.1 N solution of I_2.

V (sol-n) = 200 ml
$C_N (I_2)$ = 0,2 mol/l
$m(Na_2S_2O_3 \cdot 5H_2O)$ -?

1) Since the titre is set to $Na_2S_2O_3$ 0.1 N iodine solution, the concentration thiosulphate should be about the same concentration Since the problem is given by thiosulphate should be about the same concentration. Since the problem is given by the molar concentration equivalent to C_N, then use the formula: $C_N = \dfrac{m_X}{M_X \cdot f_{eqv.} \cdot V}$

hence $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0,1 \cdot 248 \cdot 1 \cdot 0,2 = 4.96$ g;

Answer: The linkage $Na_2S_2O_3 \cdot 5H_2O$ 4,96 g

3) To determine the titer of the solution $Na_2S_2O_3 \cdot 5H_2O$ use as potassium dichromate $K_2Cr_2O_7$. Calculate the C_N solution if it took titration 5ml 4.8 ml of 0,1 N solution potassium dichromate.

Vsol-n $(Na_2S_2O_3)$ = 5 ml
$C_N(K_2Cr_2O_7)$ = 0,1 mol/l
Vsol-n$(K_2Cr_2O_7)$ = 4,8 m
$C_N(Na_2S_2O_3)$ =?

1) Using the equation of the law equivalence:

$C_N(Na_2S_2O_3) \cdot V(Na_2S_2O_3) = C_N(K_2Cr_2O_7) \cdot V(K_2Cr_2O_7)$,

hence $C_N(Na_2S_2O_3) = \dfrac{C_N(K_2Cr_2O_7) \cdot V(K_2Cr_2O_7)}{V(Na_2S_2O_3)}$

$= \dfrac{0,1 \cdot 4,8}{5} = 0,096 mol/l.$

Answer: $C_N(Na_2S_2O_3)$ = 0,096 mol/liter.

4) In the laboratory, there is a 5% solution of iodine (ρ = 1,15). How many ml of this solution is necessary for the preparation of 1 liter of 0.1 N iodine solution?

ω_1 = 5%
ρ_1 = 1,15
V_2 = 1 l
C_N = 0,1 mol/l
V_1 =?

1) Data for the calculation of V_1 on the mass fraction is not enough, so we use the formula molar concentration equivalent to C_N finding the mass of the substance in solution: $C_N = \dfrac{m_X}{M_X \cdot f_{eqv.} \cdot V}$.

hence $m_X = C_N \cdot M_X \cdot f_{eqv.} \cdot V = 0,1 \cdot 254 \cdot 1/2 \cdot 1 = 12.7$g

2) The mass of iodine in both solutions is the same:

$m_{X1} = m_{X2}$;

3) Using the mass fraction, we find the mass of a 1:

$$\varpi = \frac{m(x)}{m(sol.)} 100\% \;;\quad \text{hence } m_{sol.1} = \frac{m_{x1}}{\varpi_1} \cdot 100\% = \frac{12,7 \cdot 100}{5} = 254g$$

4) Find the volume of solution 1:

$$V = \frac{m_{sol.}}{\rho} = \frac{254}{1,15} = 220,87 ml.$$

Answer: The amount of 5% iodine solution was 220.87 ml.

Problems

1) Compute a sample of $Na_2S_2O_3 \cdot 5H_2O$ for preparing 400ml of solution, with C_N = 0.05 mol/l. (Answer: 4.96 g)

2) Compute a sample of iodine to prepare 1,000 ml 0.1 N solution. (Answer: 12,7 g)

3) How many ml of 10% iodine solution (ρ = 1,32) is necessary for preparation 500ml 0.1 N iodine solution?

4) Calculate a sample of $K_2Cr_2O_7$, to determine the exact concentration of $Na_2S_2O_3$ (approximate concentration was 0.1 mol/l). Volume of solution $K_2Cr_2O_7$ - 200ml. Titration is carried out in an acidic medium. (Answer: 1.96 g)

REACTION MEDIUM WATER SOLUTIONS - pH

Water - a weak electrolyte - dissociates by the equation:

$$H_2O \leftrightarrow H^+ + OH^-$$

Ionic product of water - a product of the concentration of hydrogen ions (protons) on the concentration of hydroxide ions:

$$[H^+] + [OH^-] = 10^{-14}$$

It is a constant at a given temperature.
Dissociation of acids follows the scheme:

$$CH_3COOH \leftrightarrow H^+ + CH_3COO^-$$

Active acidity - is a concentration drowned.
Potential acidity - is a concentration dissociating acid molecules.
Total acidity - is the total concentration of acid in the mole eq.
The amount of active and potential acidity equal to the total acidity.
When the titration is determined by the total acidity.
Total alkalinity - is the concentration of hydroxide - anions.
Potential alkalinity - is the concentration of dissociated molecules of the base.
Total alkalinity - is the total concentration of alkali in the mole eq.
The amount of active and potential alkalinity equal total alkalinity.
When the titration is determined by the total alkalinity, the reaction medium is determined by the concentration of protons.

10^{-1}.................. 10^{-7}.....................10^{-14}

acid condition | neut. condition | alkaline condition

Concentration of protons in an acid solution is calculated by the formula:

$$[H^+] = \alpha \cdot [acid]$$

strong acid	strong acid
$\alpha = 1$	$\alpha = 1$
$[H^+] = \alpha \cdot [acid]$	$[H^+] = \sqrt{Cd \cdot [acid]}$

α – acid degree of dissociation

The dissociation of the base form of hydroxide anions, whose concentration is calculated as follows:

$$[OH^-] = \alpha \cdot [base]$$

strong base	strong base
$\alpha = 1$	$\alpha = 1$
$[OH^-] = \alpha \cdot [base]$	$[OH^-] = \sqrt{Cd \cdot [base]}$

α – base degree of dissociation

The reaction medium is more convenient to express the solution via the pH.
pH - is the negative logarithm of hydrogen ion concentration:

$$pH = – lg [H^+].$$

Similarly, we can calculate the pOH:

$$pOH = – lg [OH^–].$$

Based on the negative logarithm of the ion product of water is:

$$pOH + pH = 14.$$

blood pH = 7.36;
gastric juice pH = 0,9 - 1,5.

Examples

A. Calculating the pH of solutions of strong and weak acids and bases.

1) Calculate the pH, if $[H^+] = 10^{-2}$.

$pH = - lg [H^+] =-lg 10^{-2} = 2.$

2) Calculate the pOH if $[OH^–] = 10^{-5}$.

$pOH = -lg [OH^–] =-lg 10^{-5} = 5.$

3) Calculate the pH if $[OH^–] = 10^{-4}$.

$pOH = -lg [OH^–] = -lg 10^{-4} = 4.$
$pH = 14 - pOH = 14 - 4 = 10.5$

4) Calculate the pH of the solution with the concentration of H^+ -ion $3{,}7{\cdot}10^{-5}$ mol / liter.

$[H^+] = 3{,}7{\cdot}10^{-5}$ | $pH = - lg [H^+] = -lg\ 3{,}7 \cdot 10\text{-}5 = -lg\ 3{,}7 - lg10^{-5} = 5 - 0.57 = 4.43.$
pH -?

Answer: pH = 4.43.

5) Calculate the pH of HCl C_N = 0.1 mol/l.

C_N (HCl) = 0,1 mol/l

1)To calculate the pH of the solution, one must know $[H^+]$. Since the pH? strong acid HCl. Then $[H^+]$ = [acid] = 0.1 mol/l = 10^{-1};

2) Find the pH of the solution: $pH = - lg [H^+] =-lg 10^{-1} = 1.$

Answer: pH = 1.

6) Calculate the pH of 0.0001 N HCl solution.

$pH = - lg [HCl] - lg [H^+] =-lg \cdot 10^{-4} = 4.$

7) Calculate the pH of the NaOH with CH = 0.2 mol/liter.

C_N (NaOH) = 0.2 mol/liter 1) Because of the condition given by the foundation, then
pH =? first find $[OH^-]$. In a solution of strong base

$[OH^-]$ = [base] = 0,2 = $2 \cdot 10^{-1}$;

2) Find the pOH: $pOH =-lg[OH^-]= -lg\ 2 \cdot 10^{-1} = - lg2 -lg\ 10^{-1} = 1 - 0.3 = 0.7.$

3) Find the pH: pH = 14 - pOH = 14 - 0,7 = 13,3. Answer: pH = 13.3.

8) Calculate the pH of 0.001 N solution of NaOH.

pOH =-lg [NaOH] =-lg [OH^-] = -lg 10^{-3} = 3.

pH = 14 - pOH = 14 - 3 = 11.

9) Calculate the pH of the solution of HCOOH with C_N = 0.1 mol/l (Kd = 1,8 · 10^{-5})

C_N (HCOOH) = 0.1 mol/l

Cd = 1,8 · 10^{-5}

pH =?

1) To calculate the pH of the solution, one must know [H^+].

Since HCOOH weak acid, then use the formula:

$$[H^+] = \sqrt{Cd \cdot [acid]} = \sqrt{1.8 \cdot 10^{-4} \cdot 0.1} = 4.24 \cdot 10^{-3}$$

2) Find the pH: pH =-lg 4,24 · 10^{-3} = -lg 4,24-lg 10^{-3} = 3 -0.63 = 2.37.

Answer: pH = 2,37.10

10) Calculate the pH of the solution NH_4OH with C_N = 0.15 mol/l (Kd = 1,85 · 10^{-5}).

C_N (NH_4OH) = 015 mol/l

Kd = 1,85 · 10^{-5}

pH -?

1) Because of the condition given by the foundation, then first find [OH^-]. In the solution of a weak base:

$$[OH^-] = \sqrt{Cd \cdot [base]} = \sqrt{1.8 \cdot 10^{-5} \cdot 0.15} = 1.64 \cdot 10^{-3}$$

2) Find the pOH

pOH =-lg 1,64 · 10^{-3} = - lg 1.64 -lg 10 · 10^{-3} = 3 - 0.21 = 2.79.

3) Find the pH: pH = 14 - pOH = 14 - 2.79 = 11.21.

Answer: pH = 11.21.

11) Calculate the pH of the solution H_2SO_4 w = 3% (ρ = 1,1; $F_{eqv.}$ = 1/2).

ω = 3%

ρ = 1,1

$f_{eqv.}$ = 1/2

pH =?

1) Transfer IARF share in the normal concentration equivalents using a formula which connects the C_N and ω:

$$C_N = \frac{\varpi\% \cdot \rho \cdot 10}{M_X \cdot f_{eqv.}} = \frac{3 \cdot 1{,}22 \cdot 10}{98 \cdot 1/2} = 0{,}73 mol/l.;$$

2) Find the [H^+] and pH:

[H^+] = [acid] = 0,73 = 7,3 · 10^{-1};

pH = - lg [H^+] = -lg 7,3 · 10^{-1} = -lg 7,3 - lg10^{-1} = 1 - 0,86 = 0,14

Answer: 0,14

B. Determination of pH of solutions after dilution with water.

12) How to change the pH of the solution HNO_3, if a 40ml solution of 0.1N add 20ml of water?

V_1(HNO_3) = 40 ml

C_{N1} = 0,1 mol/l

V (H_2O) = 20 ml

Δ pH (HNO_3) =?

.

1) Δ pH = pH_1 - pH_2,

where pH_1 - pH solution HNO_3 before adding water

pH_2 is the pH of the solution after the addition of HNO_3 water;

2) Find the pH_1: to calculate the pH of the solution you need to know [H^+]. Since the strong acid HNO_3, then

[H^+]= [acid] = 0.1 mol/L = 10^{-1};

3) Find the solution pH_1: pH_1 = - lg [H^+] = -lg 10^{-1} = 1;

4) Upon dilution with water the acid concentration decreases. Find it using the law of equivalents: $C_{N1} \cdot V_1 = C_{N2} \cdot V_2$; where V_2 - volume of the solution after adding water,

V_2 = 40 + 20 = 60ml;

Hence: $C_{N2} = \frac{C_{N1} \cdot V_{N1}}{V_2} = \frac{0.1 \cdot 40}{60} = 0.067 = 6.7 \cdot 10^{-2}$;

5) Find pH_2: $[H^+]_2$ = [acid] = $6.7 \cdot 10^{-2}$;

$pH_2 = -\lg [H^+] = -\lg 6,7 \cdot 10^{-2} = -\lg 6,7 - \lg 10^{-2} = 2 - 0,83 = 1.17$;

6) Δ pH = 1.17 - 1 = 0.17.

Answer: 0.83.

13) How to change the pH of the solution NH_4OH, if a 50 ml 0.1 N solution of its add 30ml of water? ($Kd = 1,85 \cdot 10^{-5}$).

V (NH_4OH) = 50ml C_N (NH_4OH) = 01mol/l $Kd = 1,85 \cdot 10^{-5}$ V (H_2O) = 30 ml	1) Δ pH = pH_1 - pH_2, where pH_1 - is the solution pH before adding NH_4OH water; pH_2 is the pH of the solution after the addition of NH_4OH water; Since by the condition given by the foundation, then first find $[OH^-]$
Δ pH -?	In the solution of a weak base:

$$[OH^-] = \sqrt{Cd \cdot [base]} = \sqrt{1.8 \cdot 10^{-5} \cdot 10^{-1}} = 1.64 \cdot 10^{-3}$$

2) Find the $pOH_1 = -\lg 1,34 \cdot 10^{-3} = -\lg 1,34 - \lg 10^{-3} = 3 - 0.127 = 2.87$;

$pH_1 = 14 - 2.87 = 11.13$.

3) Upon dilution with water the concentration of base decreases. Find it using the law of equivalents: $C_{N1} \cdot V_1 = C_{N2} \cdot V_2$; where V_2 - volume of the solution after adding water,

$V_2 = 50 + 30 = 80$ ml;

$$C_{N2} = \frac{C_{N1} \cdot V_{N1}}{V_2} = \frac{0,1 \cdot 50}{80} = 0,0625 = 6.25 \cdot 10^{-2};$$

4) Find the pOH_2: $[OH^-] = \sqrt{Cd \cdot [base]} = \sqrt{1.8 \cdot 10^{-5} \cdot 6.25 \cdot 10^{-2}} = 1.06 \cdot 10^{-3}$

$pOH_2 = -\lg 1,06 \cdot 10^{-3} = -\lg 1,06 - \lg 10^{-3} = 3 - 0.025 = 2.975.$;

$pH_2 = 14 - 2.975 = 11.025$.

5) Find the Δ pH: Δ pH = 11.13 - 11.025 = 0.105.

Answer: 0.105.

14) How to change the pH of water if the 80 ml add 20 ml of solution NaOH with C_N = 0.1 mol/l, (α = 1)

V (H_2O) = 80 ml C_N(NaOH) = 0,1 mol/l (NaOH)=20 ml	1) H_2O pH = 7; 2) After you have added to the water solution of NaOH obtained by V solution of the base, the concentration which we find in law
$\Delta pH(H_2O)$ =?	equivalents: $C_{N1} \cdot V_1 = C_{N2} \cdot V_2$;

V_2 = 80 ml + 20 ml = 100 ml.

3) Find the concentration of alkali solution, C_{N2}, $[OH^-]$, pOH and pH:

$$C_{N2} = \frac{V_1 \cdot C_{N1}}{V_2} = \frac{20 \cdot 0,1}{100} = 0,02 = 2 \cdot 10^{-2}$$ – concentration of NaOH in the solution.

$[OH^-]$ = [base] = $2 \cdot 10^{-2}$.

$pOH = -\lg [OH^-] = -\lg 2 \cdot 10^{-2} = -\lg 2 - \lg 10^{-2} = 2 - 0.3 = 1,7$.

pH = 14 - 1.7 = 12.3

4) Find the change in pH of water: Δ pH = 12.3 - 7 = 5,3. Answer: 5.3.

B) Determination of pH after pouring acid solutions and base.

15) Determine the pH of the solution obtained after mixing equal volumes of HCl and C_N = 0.3 mol/l NaOH

Given	Solution
C_N = 0.1 mol/liter $C_N(HCl)$ = 0,3 mol/l $C_N(NaOH)$ = 0,1 mol/l V(HCl) = V(NaOH) pH =?	1) When mixing acid and alkali react according to the equation: $HCl + NaOH \rightarrow NaCl + H_2O$; From the equation it is clear that the acid and alkali react in a ratio of 1: 1. Since from the acid was taken 0.3 mol after reaction in solution remained acid: 0,3 - 0,1 = 0,2 mol. Since the volume of the mixture

increased 2 times, the concentration of acid in solution: 0,2/2 = 0.1 mol/l;

2) Find the pH of the resulting solution:

$[H^+] = [acid] = 0,1 = 10^{-1}$.

$pH = - lg [H^+] = - lg 10^{-1} = 1$.

Answer: pH = 1.

16) Determine the pH of the solution obtained after mixing equal volumes of solutions of H_2SO_4 and C_N = 0.2 mol/l NaOH with C_N = 0.6 mol/l.

Given	Solution
$C_N (H_2SO_4)$ = 0,2 mol/l C_N (NaOH) = 0,6 mol/l $V(H_2SO_4)$ = V(NaOH) pH =?	1) When mixing acid and alkali react according to the equation: $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$; From the equation it is clear that the acid and alkali react in the ratio 1: 2. Since acid was taken 0.2 mole, then:

1 mol H_2SO_4 — 2 mol NaOH

0.2 mol H_2SO_4 — x mol NaOH

x = 0.4 mol NaOH.

By the condition of the problem given 0.6 mol NaOH, then left after the reaction 0.6 - 0.4 = 0.2 mol NaOH. Since the volume of the mixture increased 2 times, the concentration of NaOH solution: 0,2/2 = 0.1 mol/l;

2) Find the $[OH^-]$, pOH, pH, the resulting solution:

$[OH^-] = [base] = 0,1 = 10^{-1}$.

$pOH = - lg [OH^-] = - lg 10^{-1} = 1$.

pH = 14 - pOH = 14 - 1 = 13.

Answer: pH = 13.

G. Calculation of $[H^+]$ for a given value of pH and pOH.

17) Calculate the $[H^+]$ in the blood if the pH = 7.36.

Given	Solution
pH = 7,36 $[H^+]$ =?	$[H^+]$ = ant lg pH = ant lg 7,36 = ant lg [8 – 0.64] = $4,36 \cdot 10^{-8}$ mol/l

Answer: $4,36 \cdot 10^{-8}$ mol/l

18) Calculate the $[H^+]$ solution if pOH = 4.29.

Given	Solution
pOH = 4.29 $[H^+]$ =?	1) Find the pH: pH = 14 - pOH = 14 - 4,29 = 9.71; $[H^+]$= ant lg pH = ant lg 9,71 = ant lg [10 – 0.29] = $1,95 \cdot 10^{-10}$mol/l.

Answer: $1,95 \cdot 10^{-10}$mol/l

Problems

1. Calculate the pH of the solution of HCl with a mass fraction of 2%. (Answer: 0.26)
2. Calculate the pH of the solution NN_4ON with C_N = 0.3 mol/l (Kd = $1{,}8\cdot10^{-5}$) (Answer: 11.37)
3. How to change the pH of the solution of HNO_3 with C_N = 0.3 mol/l, if a 20ml solution pour 80 ml of water? (Answer: 0,7)
4. How to change the pH of the solution obtained after mixing equal volumes of solutions H_2SO_4 with C_N = 0.8 mol/l NaOH with C_N = 0.2 mol/l? (Answer: 0.46)
5. Calculate the pH of 4% KOH solution. (Answer: 13.75)
6. How will the pH of the water, when added 50ml of 20 ml of 0.1 N solution NaOH. (Answer: 5.45)
7. Calculate $[H^+]$, if pOH solution 3.58.

BUFFER SYSTEMS

State the **buffer systems**, which steadfastly maintain the pH by adding small amounts of strong acid or alkali, as well as dilution.
There are two types of buffer systems:
a) Acid – consisting of a weak acid and its salts are formed strong bases. Example, acetate buffer: $CH_3COOH + CH_3COONa$.
b) Base – consisting of a weak base and its salts, formed strong acid. For example, an ammonia buffer: $NH_4OH + NH_4Cl$.

Basic equations of the buffer systems

acid type

$$\left[H^+\right] = Cd \cdot \frac{[acid]}{[salt]}$$

basic type

$$\left[OH^-\right] = Cd \cdot \frac{[base]}{[salt]}$$

Henderson's equation – Gasselbaha

acid type

$$pH = pCd - \lg\frac{[acid]}{[salt]}$$

basic type

$$pOH = pCd - \lg\frac{[base]}{[salt]}$$

where $pK_D = -\lg K_D$

Buffering capacity - the number mole equivalents of strong acid or strong base to be added to 1 liter buffer system to shift the pH to 1.
Buffer capacity is determined by titration.

Formulas for calculating the buffer capacity:

by acid

$$B_{acid} = \frac{C}{pH_0 - pH_1};$$

$pH_1 = 4{,}4$

by alkaline

$$B_{alkaline} = \frac{C}{pH_1 - pH_0}.$$

$pH_1 = 8{,}2$

Examples

A. Calculating pH of buffer systems

1) Calculate the pH of acetate buffer consisting of 50 ml 0.1 N solution of CH_3COOH and 40 ml 0.15 N solution CH_3COONa (C_D (CH_3COOH) = 1,8 · 10^{-5}).

50 ml 0.1 N CH_3COOH
40ml 0.15 N CH_3COONa
K_D (CH_3COOH) = 1,8 · 10^{-5}

pH -?

1) To determine the pH of the buffer systems rational first find N concentration in the main equation of the buffer systems of acid type

$$[H^+] = Cd \cdot \frac{[acid]}{[salt]} = 1{,}8 \cdot 10^{-5}\,\frac{50 \cdot 0{,}1}{40 \cdot 0{,}15} = 1{,}13 \cdot 10^{-5};$$

2) pH = – lg[H$^+$] = – lg 1,13 · 10^{-5} = – lg 1,13 – lg 10^{-5} = 5 - 0.053 =4.947.

Answer: pH = 4.947.

2) Calculate the pH of the ammonia buffer consisting of 60ml 0.1 N solution of NH_4Cl and 30ml of 0.2 N NH_4OH solution (C_D (NH_4OH) = 1,8 · 10^{-5}).

60ml 0.1 N NH_4Cl
30ml of 0.2 N NH_4OH
K_D (NH_4OH) = 1,8 · 10^{-5}

pH =?

1) To find the pH of the buffer system of primary type, you must first find the pOH. To find pOH first find a rational concentration of H¯ to the basic equation buffer systems of general type:

$$pOH = pCd - \lg\frac{[base]}{[salt]} = 1{,}8 \cdot 10^{-5} \cdot \frac{30 \cdot 0{,}2}{60 \cdot 0{,}1} = 1{,}8 \cdot 10^{-5};$$

pOH = – lg 1,8 · 10^{-5} = – lg 1,8 – lg 10^{-5} = 5 - 0.25 = 4.75;
pH = 14 – pOH = 14 - 4.75 = 9.25.

Answer: pH = 9.25.

B. Calculation of the ratio of components of buffer systems

3) Compute the ratio of the components of buffer phosphate, pH 6.3, if the concentration of the components of 0,1 mol/l (C_D (NaH_2PO_4) = 1,6 · 10^{-7}).

pH= 6.3
K_D (NaH_2PO_4) = 1,6 ·10^{-7}
C_N = 0.1 mol/l

$$\frac{V(NaH_2PO_4)}{V(Na_2HPO_4)} = ?$$

1) To calculate the ratio of the components use the equation Henderson- Hasselbach for buffer systems acid type:

$$pH = pCd - \lg\frac{[acid]}{[salt]} = -\lg Cd - \lg\frac{[acid]}{[salt]}$$

$$= -\lg Cd - \lg\frac{\cancel{C_N(NaH_2PO_4)} \cdot V(NaH_2PO_4)}{\cancel{C_N(Na_2HPO_4)} \cdot V(Na_2HPO_4)}$$

pK_D(KH_2PO_4) = – lg 1,6· 10^{-7} = – lg 1,6 – lg 10^{-7} = 7 – 0,2 = 6,8;

3) Substitute the data into the equation of Henderson - Hasselbach and find value:

$$6{,}3 = 6{,}8 - \lg\frac{V(NaH_2PO_4)}{V(Na_2HPO_4)}; \quad \lg\frac{V(NaH_2PO_4)}{V(Na_2HPO_4)} = 6{,}8 - 6{,}3 = 0{,}5;$$

$$\frac{V(NaH_2PO_4)}{V(Na_2HPO_4)} = \text{ant lg } 0{,}5 = 3.$$

Answer: $\frac{V(NaH_2PO_4)}{V(Na_2HPO_4)}$ = 3.

4) Calculate the ratio of the components of the ammonia buffer with, pH 8.6, if the concentration of the components of 0,1 mol/l (K_D (NH_4OH)) = 1,8 · 10^{-5}).

pH = 8.6 $C_D(NH_4OH)=1,8 \cdot 10^{-5}$ C_N = 0.1 mol/l	1) To calculate the ratio of the components it is better to use the equation Henderson- Hasselbach for the main buffer systems type: $pOH = pCd - \lg\frac{[base]}{[salt]}$
$\frac{V(NH_4OH)}{V(NH_4Cl)} = ?$	2) Find the pOH of the conditions of the problem:

pOH = 14 - pH = 14 - 8,6 = 5,4;

3) Find the value of pK_D:

pC_D (NH_4OH) = – lg 1,8 · 10^{-5} = – lg 1,8 – lg 10^{-5} = 4.74 - 0.2 = 4.54;

4) Substitute the data into the equation Henderson - Hasselbach and find the ratio of components:

$$5,4 - 4,75 = \lg\frac{V(NH_4OH)}{V(NH_4Cl)};\ \lg C = 4.75 - 5.4 = -0.65;$$

Under the sign of lg change the numerator and the denominator of the logarithm has a positive value:

$$\lg\frac{V(NH_4Cl)}{V(NH_4OH)} = 0,65; \qquad \frac{V(NH_4Cl)}{V(NH_4OH)} = \text{ant. lg } 0,65 = 4,5.$$

Answer: $\frac{V(NH_4Cl)}{V(NH_4OH)} = 4,5.$

B. Calculation of changes in pH (Δ pH) by adding a strong acid or alkali

5) How to change the pH of acetate buffer consisting of 50 ml 0.1 N (CH_3COONa) solution and 80 ml 0.1 N CH_3COOH solution (C_D (CH_3COOH) = 1,8 ·10^{-5}), while adding there to 10 ml 0.1 N solution of NaOH.

80 ml 0.1 N CH_3COOH 50ml 0.15 N CH_3COONa C_D (CH_3COOH) = 1,8 · 10^{-5} 10ml of 0.1 N NaOH	1) So adding alkali, the pH should move to the alkaline side, so Δ pH = pH_1 - pH_2 where pH_2 - is the pH of the solution after adding alkali and pH_1 - before adding the alkali, this initial pH buffer solution.
Δ pH =?	2) To determine the pH of the buffer systems for the

management to find first concentration of H^+ in the basic equation of the buffer systems acid type:

$$[H^+]_1 = Cd \cdot \frac{[acid]}{[salt]} = 1,8 \cdot 10^{-5} \cdot \frac{80 \cdot 0,1}{50 \cdot 0,1} = 2,8 \cdot 10^{-5};$$

pH_1 = – lg $[H^+]_1$ = – lg 2,8· 10^{-5} = – lg 2,8 – lg 10^{-5} = 5 - 0,45 = 4,55.

3) The alkali that is added to the buffer system, reacts with acid by the equation: CH_3COOH CH_3COONa + NaOH = CH_3COONa + H_2O.

Thus, the acid concentration decreases and the concentration of salt increases the number of added bases, 10 · 0,1.

4) From this we find $[H^+]$ and then pH_2:

$$[H^+]_2 = Cd \cdot \frac{[acid]-[base]}{[salt]+[base]} = 1,8 \cdot 10^{-5} \frac{80 \cdot 0,1 - 10 \cdot 0,1}{50 \cdot 0,1 + 10 \cdot 0,1} = 2,1 \cdot 10^{-5};$$

pH_2 = – lg $[H^+]_2$ = – lg 2,1· 10^{-5} = – lg 2,1 – lg 10^{-5} = 5 - 0,32 = 4,68.

5) Find the ΔpH: ΔpH = 4,68 – 4,55 = 0,13. Answer: ΔpH = 0,13.

6) How to change the pH of the ammonia buffer consisting of 30 ml 0.15 N solution NH_4OH ($K_D = 1,8 \cdot 10^{-5}$) and 40 ml 0.1 N solution of NH_4NO_3, when you add to it 5 ml of 0.1 N solution of HNO_3?

30ml 0.15 N NH_4OH
40ml 0.1 N NH_4NO_3
$K_D(NH_4ON) = 1,8 \cdot 10^{-5}$
10 ml of 0.1 N HNO_3
Δ pH =?

1) You add the acid, the pH should move to the acid side, so Δ pH = pH_1 - pH_2 where pH_2 - this is the pH of the solution after adding acid, and pH_1 - before adding the acid, this initial pH buffer solution.

2) For the buffer system of the main type of rationality to first find concentration of OH^- to the basic equation of the buffer systems basic types:

$$[OH^-]_1 = Cd \cdot \frac{[base]}{[salt]} = 1,8 \cdot 10^{-5} \frac{30 \cdot 0,15}{40 \cdot 0,1} = 2,02 \cdot 10^{-5};$$

$pOH_1 = – \lg [OH^-] = – \lg\ 2,02 \cdot 10^{-5} = – \lg 2,02 – \lg 10^{-5} = 5 - 0,3 = 4,7$

$pH_1 = 14 – pOH = 14 – 4,7 = 9,3.$

3) The acid added to the buffer system, reacts with base on the equation:

$HNO_3 + NH_4NO_3 = NN_4OH + H_2O$.

Thus, the concentration of the base decreases, while the concentration salt increases the amount of added acid, i.e. 5 · 0, 1.

4) From this we find the $[OH^-]$, and then pH_2:

$$[OH^-]_2 = Cd \cdot \frac{[base]-[acid]}{[salt]+[acid]} = 1,8 \cdot 10^{-5} \frac{30 \cdot 0,51 - 5 \cdot 0,1}{40 \cdot 0,1 + 5 \cdot 0,1} = 1,6 \cdot 10^{-5};$$

$pOH_2 = – \lg [OH^-]_2 = – \lg\ 1,6 \cdot 10^{-5} = – \lg 1,6 – \lg 10^{-5} = 5 - 2 = 4,8;$

$pH_2 = 14 – 4,8 = 9,2;$

5) Find the Δ pH:

Δ pH = 9,3 - 9,2 = 0,1.

Answer: Δ pH = 0,1.

G. Calculation of buffer capacity

7) Calculate the buffer capacity of bicarbonate buffer, which consists of 70ml 0.1 N solution H_2CO_3 ($C_D = 3,3 \cdot 10^{-7}$) and 50 ml 0.1 N solution of $NaHCO_3$, if titrated 5ml of the buffer took 4.8 ml of 0,1 N solution of NaOH.

70ml 0.1 N H_2CO_3
50 ml 0.1 N $NaHCO_3$
$K_D = 3,3 \cdot 10^{-7}$
$V_{buf.syst.}$ = 5 ml
4.8 ml of 0.1 N NaOH
Bb = ?

1) In alkaline buffer capacity is calculated from the formula:

$$B_{alkaline} = \frac{C}{pH_1 - pH_0}.$$

2) Calculate pH_0:

$$[H^+]_1 = Cd \cdot \frac{[acid]}{[salt]} = 3,3 \cdot 10^{-7} \cdot \frac{70 \cdot 0,1}{50 \cdot 0,1} = 4,62 \cdot 10^{-7};$$

$pH_0 = – \lg [H^+] = – \lg\ 4,62 \cdot 10^{-7} = – \lg 4,62 – \lg 10^{-7} = 7 - 0,66 = 6,34;$

3) pH_1 = 8.2, as the alkali titration end when a crimson color;

4) The buffer capacity is calculated at 1 liter buffer system, so find how many would go to the alkali titration of 1 liter or 1,000 ml buffer system:

for 5ml buffer system – 4,8 ml NaOH
to 1000ml – X ml x = 960ml;

5) We calculate the number of mole equivalents of alkali, which would go on titrate 1 liter buffer system:

in 1,000 ml NaOH – 0,1 mol NaOH
in 960ml NaOH – X

X = 0.096 mol equiv.

6) We calculate buffer capacity: $Bb = \frac{0,096}{8,2-6,34} = 0,05\frac{mol \cdot eqv}{pH}$.

<u>Answer:</u> The buffer capacity of alkaline 0.05

8) Calculate the buffer capacity of phosphate buffer, which consists of 100 ml 0.1 N solution of Na_2HPO_4 and 80 ml 0.1 N solution NaH_2PO_4 ($K_D = 1,6 \cdot 10^{-7}$), if titrated 10ml of this buffer took 7.8 ml of 0,1 N solution of HCl.

100ml 0.1 N Na_2HPO_4
80 ml 0.1 N NaH_2PO_4
$K_D = 1,6 \cdot 10^{-7}$
$V_{buf.syst.}$ = 10ml
7.8 ml of 0.1 N HCl

Ba = ?

1) Buffering capacity of acid calculated according to the formula: $B_{acid} = \frac{C}{pH_0 - pH_1}$;

2) Calculate: $pH_0 = -\lg [H^+]_0$;

$$[H^+]_0 = Cd \cdot \frac{[acid]}{[salt]} = 1,6 \cdot 10^{-7}\frac{80 \cdot 0,1}{100 \cdot 0,1} = 1,28 \cdot 10^{-7};$$

$pH_0 = -\lg [H^+] = -\lg 1,28 \cdot 10^{-7} = -\lg 1,28 - \lg 10^{-7} =$

= 7 - 0,107 = 6,89;

3) pH = 4,4, since titration with acid finish when you change the yellow color to pink;

4) The buffer capacity is calculated at 1 liter buffer system, so find how many would go to the acid titration of 1 liter or 1,000 ml buffer system:

in 10ml buffer system – 7,8 ml HCl
to 1000ml – X ml X = 780ml;

5) We calculate the number of mole equivalents of acid, which would go to titrate 1 liter buffer system: in 1000ml HCl – 0,1 mol HCl
in 780ml HCl – X X = 0.078 mol equiv.

6) Calculate the buffer capacity: $B_K = \frac{0,078}{6,89-4,4}.= 0,03\ \frac{mol \cdot eqv}{pH}$.

<u>Answer:</u> The buffering capacity of acid 0,03.

9) Calculate the buffer capacity of the ammonia buffer, which consists of 40 ml 0.1 N solution NH_4OH ($K_D = 1,8 \cdot 10^{-5}$) and 30ml of 0,2 N solution NH_4Cl if titration 7ml it consumed 5.5 ml of 0.1 N HCl solution.

40ml 0.1 NH_4OH
30 ml 0,2 N NH_4OH
($C_D = 1,8 \cdot 10^{-5}$)
V (buf.syst.) = 7ml
5.5 ml of 0.1 N HCl

Ba = ?

1) buffering capacity of acid calculated according to the formula:

$$B_{acid} = \frac{C}{pH_0 - pH_1};$$

2) To find the pH of the buffer system of primary type, you first need to find pOH. For finding the pOH rational first find the concentration of OH^- the core equation of the buffer systems of general type:

$$\left[OH^-\right] = Cd \cdot \frac{[base]}{[salt]} = 1{,}8 \cdot 10^{-5} \cdot \frac{40 \cdot 0{,}1}{30 \cdot 0{,}2} = 1{,}2 \cdot 10^{-5} ;$$

$$pOH = -\lg 1{,}2 \cdot 10^{-5} = -\lg 1{,}2 - \lg 10^{-5} = 5 - 0{,}08 = 4{,}92;$$

$$pH_0 = 14 - pOH = 14 - 4{,}92 = 9{,}08.$$

3) $pH_1 = 4{,}4$, since titration with acid finish when you change the yellow color to pink;
4) The buffer capacity is calculated at 1 liter buffer system, so find how many would go to the acid titration of 1 liter or 1,000 ml buffer system:

in 7ml buffer system – 5,5 ml HCl
to 1000ml – Xml

X = 785.7 ml;

5) We calculate the number of mole equivalents of acid, which would go to titrate 1 liter buffer system:

in 1000ml HCl – 0,1 mol HCl

in 785.7 ml HCl – X

X = 0.07857 mol eq.

6) Calculate the buffer capacity:

$$B_{acid} = \frac{0{,}07857}{9{,}08 - 4{,}4} = 0{,}017 \ \frac{mol \cdot eqv}{pH}.$$

<u>Answer:</u> The buffering capacity of acid 0.017

10) Calculate the buffer capacity of blood serum by acid, if titrated 5ml it took 7.5 ml of 0,1 N solution of HCl.

V (SERUM) = 5 ml
7.5 ml of 0.1 N HCl

Ba = ?

1) buffering capacity of acid calculated as follows:

$$B_{acid} = \frac{C}{pH_0 - pH_1};$$

2) pH_0 - a serum pH = 7.36;
pH_1 - a pH of the solution after the titration, ie, 4.4, as in the serum methyl orange colour yellow, and the titration acid changes color to pink at pH 4.4.
3) The buffer capacity is calculated at 1 liter buffer system, so find how many would go to the acid titration of 1 liter or 1,000 ml buffer system:

for 5ml buffer system – 7,5 ml HCl
to 1000ml – X ml

X = 1,500 ml;

4) We calculate the number of mole equivalents of acid, which would go to titrate 1 liter buffer system:

in 1000ml HCl – 0,1 mol HCl
in 1,500 ml HCl – X

X = 0.15 mol equiv.

6) Calculate the buffer capacity:

$$B_K = \frac{0{,}15}{7{,}36 - 4{,}4} = 0{,}05 \ \frac{mol \cdot eqv}{pH}.$$

<u>Answer:</u> The buffering capacity of acid 0.05 $\frac{mol \cdot eqv}{pH}$

Problems

1) Calculate the pH of phosphate buffer, which consists of 60ml 0.1 N solution of monosodium salt and 40 ml 0.1 N solution of disodium salt ($K_D = 1,6 \cdot 10^{-7}$). (Answer: 6.62)
2) Calculate the pH of the ammonia buffer, which consists of a 70ml 0.15 N NH_4NO_3 solution and 50 ml 0.1 N solution NH_4OH ($K_D = 1,8 \cdot 10^{-5}$). (Answer: 8.93)
3) Compute the ratio of the components of acetate buffer, pH 5.7, if the concentration of the components of 0,1 mol/l (K_D (CH_3COOH) = $1,8 \cdot 10^{-5}$). (Answer: V (salt) / V (acid) = 9).
4) Calculate the ratio of the components of the ammonia buffer, pH 9.3, if the concentration of salt of base 0.2 mol/l (K_D (NH_4OH) = $1,8 \cdot 10^{-5}$). (Answer: V (base) / V (salt) = 1,1.)
5) How to change the pH of citrate buffer, which consists of 50 ml 0.1 N citric acid solution (K_D (acid) = $1,2 \cdot 10^{-3}$) and 60ml 0.1N solution of potassium citrate, adding 15ml 0.1N solution of HCl.
(Answer: 0.24)
6) How will the pH of borate buffer, which consists of 90ml 0,2 N solution $Na_4B_4O_7$ (K_D (H_3BO_3) = $6 \cdot 10^{-10}$) and 60ml 0.15 N solution $Na_4B_4O_7$, by adding 10ml of 0.2 N NaOH solution.
(Answer: 0.14)
7) How to change the pH of the ammonia buffer consisting of 100 ml 0.15 N solution NH_4OH ($K_D = 1,8 \cdot 10^{-5}$) and 80 ml 0.1 N solution of NH_4Cl, by adding there to 15 ml 0.1 N solution of HCl?
(Answer: 0.15)
8) How to change the pH of the ammonia buffer consisting of 70ml 0.1 N NH_4NO_3 and 45ml 0.1 N solution NH_4OH ($K_D = 1,8 \cdot 10^{-5}$), by adding thereto 20 ml 0.1 N solution of NaOH?
(Answer: 0.31).
9) Calculate the buffer capacity of acetate buffer, which consists of 90ml 0.15 N CH_3COOH solution ($K_D = 1,8 \cdot 10^{-5}$) and 70ml of solution 0,12N CH_3COONa if the titration of 5 ml of it consumed 3.5 ml of 0,1 N solution NaOH. (Answer: 0.018)
10) Calculate the capacity of the ammonia buffer, which consists of 150 ml 0.1 N solution NH_4OH ($K_D = 1,8 \cdot 10^{-5}$) and 120ml 0.1 N solution NH_4Cl if the titration of 10ml of it consumed 8.2 ml of 0,1 N solution HCl. (Answer: 0.16)
11) Calculate the buffer capacity of blood serum by acid, if on titration of 20ml it took 3.6 ml of 0,1 N solution of HCl; pH of serum at the same time changed to 7.0. (Answer: 0.05 mol equiv. / unit. pH)

COLLIGATIVE PROPERTIES OF SOLUTIONS. OSMOSIS. CRYOMETRY.

Colligation is a known property of solutions arising from thermal motion and the amount of kinetic particle system.
Osmosis is a spontaneous one-sided diffusion of solvent through a semi permeable membrane toward a solution with higher concentration.
Semi permeable membrane - passes the solvent molecules only. Examples: natural - animal and plant cell membranes, the intestinal wall; artificial – colloid ion, cellophane, gelatin, parchment, clay wall of the vessel filled with sediment membrane.
Osmotic pressure is the excess hydrostatic pressure, which stops osmosis.
Osmotic concentration is the concentration of all the transport of particles of solute in solution.

Law Van't Hoff - the osmotic pressure of a dilute electrolyte solution is equal to the gas pressure that would produce the solute, while in a gaseous state, occupying the volume of the solution at the same temperature.
The equation of osmotic pressure for non-electrolytes:

$$P_{OSM} = CRT$$

where C = concentration of solution in mol/l;
R - universal gas constant, 0.082 L · atm / g mol;

T - temperature in Kelvin.
Equation for osmotic pressure of electrolytes:

$$P_{OSM} = i\,CRT$$

where i - isotonic coefficient of van't Hoff.
Isotonic coefficient Van't Hoff and shows how many times the osmotic pressure of the electrolyte, the osmotic concentration of the electrolyte is greater than the osmotic pressure and osmotic concentration of the non electrolyte, at the same molar concentration.

$$i = \frac{P_{OSM.EL}}{P_{OSM.UNEL}} = \frac{C_{OSM.EL}}{C_{OSM.UNEL}}$$

Isotonic coefficient Van't Hoff related to the degree of dissociation α equation:

$$i = 1 + \alpha(\nu - 1)$$

where ν - the number of ions in the electrolyte which dissociates.
State the **isotonic** solutions with the same osmotic pressure.
Hypotonic solution is called with small osmotic pressure.
Hypertonic solution is called with a large osmotic pressure.
Haemolysis is the destruction of the cell membrane by placing the cells in the hypotonic solution.
Plasmolysis is wrinkling cells by placing it in the hypertensive solution.
Turgor is the elastic state of the cell membrane.
Osmotic blood pressure = 7.7 atm.
Oncotic pressure of blood is part of the osmotic pressure caused by the HMC and is equal to 0.04 atm.
Osmotic pressure 1M solution of nonelectrolyte = 22.4 atm.

<u>Examples</u>

1) Calculate the osmotic pressure of 0,1 M urea solution.

C_X(urea) = 0.1 mol/l

$P_{OSM.}$ =?

1) Urea is non electrolyte so P_{OSM} is given by:

$P_{OSM.\ UNEL.} = CRT = 0,1 \cdot 0.082 \cdot 273 = 2.24$ atm.

<u>Answer:</u> 2.24 atm.

2) Calculate the osmotic pressure of 0.2 M solution of potassium chloride.

C_X(KCl) = 0.2 mol/l

$P_{OSM.}$ =?

1) Since the KCl electrolyte is then P_{OSM} calculated as follows:

$$P_{OSM.\ EL.} = iCRT$$

2) To find i use the formula:

$$i = 1 + \alpha(\nu - 1)$$

where α = 1, as KCl is a strong electrolyte and dissociates into two ions, so ν = 2.

Hence: $i = 1 + 1\,(2 - 1) = 2$;

3) Calculate the osmotic pressure:

$$P_{OSM.EL.} = 2 \cdot 0.2\ 0.082 \cdot 273 = 8.95 \text{ atm.}$$

<u>Answer:</u> 8.95 atm.

3) Calculate the osmotic pressure of 4% glucose solution.

ω = 4%

$C_6H_{12}O_6$

$P_{OSM.}$ =?

1) Transfer the mass fraction in the molar concentration:

$$C_N = \frac{\varpi\% \cdot \rho \cdot 10}{M_X} = \frac{4 \cdot 1{,}1 \cdot 10}{180} = 0{,}24 mol/l.;$$

2) Find the P_{OSM} glucose as a nonelectrolyte:

$P_{OSM.\ UNEL.} = CRT = 0.24 \cdot 0.082 \cdot 273 = 5.47$ atm.

<u>Answer:</u> 5.47 atm.

4) Calculate the osmotic pressure of 10% solution of sodium chloride ρ = 1,2.

ω = 10% NaCl	1) Transfer the mass fraction in the molar concentration: $C_N = \frac{\varpi\% \cdot \rho \cdot 10}{M_X} = \frac{10 \cdot 1{,}12 \cdot 10}{58{,}5} = 1{,}91 mol/l.$
$P_{OSM.}$ = ?	2) Since the KCl electrolyte is then $P_{OSM.}$ calculated as follows:

$P_{OSM.\,EL.}$= iCRT.

To find i use the formula: i = 1 + α (ν - 1),

where α = 1, since NaCl is a strong electrolyte and dissociates into two ions, so ν = 2.

Hence: i = 1 + 1 (2 - 1) = 2;

3) Calculate the osmotic pressure:

$P_{OSM.\,EL.}$ = 2 · 1.91 · 0.082 · 273 = 49.04 atm.

Answer: 49.04 atm.

5) Calculate the molar concentration of glucose, with no isotonic with blood in the 37°C.

$C_6H_{12}O_6$ t = 37°C	1) Since glucose non isotonic with blood, his $P_{OSM.}$ equals P_{OSM} blood and is equal to 7.7 atm.
C = ?	2) Glucose is non-electrolyte, so $P_{OSM.\,UNEL.}$= CRT

Hence: $C = \frac{P}{RT} = \frac{7{,}7}{0{,}082 \cdot (273 + 37)} = 0{,}303$ mol/l

Answer: 0.303 mol / litre.

6) Whether the isotonic 1% in soluble urea and sodium chloride?

ω ($(NH_2)_2CO$) = 1% ω (NaCl) = 1% ρ = 1,03	1) Since isotonic solutions should be the same osmotic pressure, necessary to calculate the osmotic pressure each solution and compare. 2) Urea is nonelectrolyte so $P_{OSM.}$ is given by: $P_{OSM.\,UNEL.}$ = CRT, pre-translated ω in C:
$P_{OSM.}$ (NaCl) =?	$C_N = \frac{\varpi\% \cdot \rho \cdot 10}{M_X} = ; \frac{1 \cdot 1{,}03 \cdot 10}{60} = 0{,}17 mol/l.;$
$P_{OSM.}$($(NH_2)_2CO$) = ?	$P_{OSM.}$ ($(NH_2)_2CO$) = CRT = 0,17· 0,082· 273 = 3,84 atm.

3) Find the $P_{OSM.}$ (NaCl), given that this electrolyte: $P_{OSM.\,EL.}$= iCRT.

$$C_N = \frac{\varpi\% \cdot \rho \cdot 10}{M_X} = \frac{1 \cdot 1{,}03 \cdot 10}{58.5} = 0{,}17 mol/l.;$$

i = 1 + α (ν - 1) = 1 + 1 (2 - 1) = 2

$P_{OSM.}$ (NaCl) = 2 · 0.17 · 0.082 · 273 = 7.6 atm.

Since the osmotic pressure is of other difference, these solutions are non-isotonic.

Answer: solution is non-isotonic.

Problem

1) Calculate the osmotic pressure of 0.2 M glucose solution.
2) Calculate the osmotic pressure of 0.3 M solution of NaCl.
3) Calculate the osmotic pressure of 10% solution $CaCl_2$.
4) Do isotonic 2% solutions of acetate (acetic acid) and glucose?
5) Calculate the molar concentration of haemoglobin, if 1% N-th solution it is the osmotic pressure of 0.004 atm.

6) Calculate the osmotic concentration of blood.

CRYOMETRY. EBULYOMETRY.

Saturated vapour pressure of solvent over the solution is lower than that of the solvent, since the dissolution of the substance decreases the concentration of solvent per unit volume of solution and thereby decreases the number of water molecules, which leaves the surface of the solution. The larger the C, the greater the pressure drops ΔP.

I Raoul's law: the relative decrease in vapour pressure of solvent over the solution equals the mole fraction of solute in solution:

$$\frac{P_0 - P}{P_0} = \frac{n}{n + n_0}$$

where P_0 – vapor pressure above the pure solvent;

P – vapor pressure above the solution;

P_0 - P – lowering the vapor pressure;

n – number of moles of substance;

n_0 – number of moles of solvent.

Fluid freezes at a temperature at which the vapor pressure of the solid state is equal to the vapor pressure of the substance in the liquid state. For example: when a pair of ice-0°C P = P water vapor. If the substance is dissolved, then P pair solution will be lower. Water vapor than P and P couple of ice, i.e. frozen solution. Therefore it is necessary to lower the temperature of the solution. P to a pair of solution was equal P a couple of ice.

Act II Raoul: temperature decrease (depression) freezing the solution is directly proportional to its molar (molarity) of concentration:

$$\Delta t_{UNEL} = E_{cr} \cdot C$$

where the E_{cr} - Cryoscopy constant, which shows the depression of 1M aqueous solution of nonelectrolyte.

Molar solution of nonelectrolyte Δt = 1.86.

For electrolytes equation is:

$$\Delta t_{EL} = i\,E_{cr} \cdot C$$

where the coefficient of Van't Hoff i shows how many times the depression of the electrolyte solution more depressed non-electrolyte solution at the same molar (molarity) concentration:

$$i = \frac{\Delta t_{EL.}}{\Delta t_{UNEL.}}$$

The liquid boils at a temperature at which the pressure of saturated steam is equal to atmospheric pressure. When dissolved in water pressure of steam decreases, and the solution will boil only when it but equal to atmospheric pressure. For this we need to raise the temperature. For aqueous solutions must be above 100^0C.

Raising the boiling point is calculated by the formula:

$$\Delta t_{UNEL} = E_{eb.} \cdot C \qquad \Delta t_{EL} = i\,E_{eb.} \cdot C$$

$E_{eb.}$ (H_2O) = 0.56.

Examples

1. Calculate depression 3.6% solution of glucose (ρ = 1,014).

ω = 3,6%
ρ = 1,014
Δt =?

1) Since glucose nonelectrolyte, to find depression using the formula:

$$\Delta t_{noneletrolyte.} = E_{cr.} \cdot C ;$$

2) the mass fraction translate into C:

$$C_X = \frac{\varpi\% \cdot \rho \cdot 10}{M_X} = \frac{3{,}6 \cdot 1{,}014 \cdot 10}{180} = 0{,}2 mol/l.;$$

3) Find the depression: Δt = 1,86 · 0,2 = 0,38.

Answer: 0.38.

2. Calculate the freezing point of 2M solution of NaCl.

C_X = 2 mol/l
NaCl
$t_{freezing}$ =?

1) To determine the freezing temperature need to know Δt, as

$\Delta t = 0° - t_{freezing}$, hence: $t_{freezing} = 0° - \Delta t$;

2) Calculate the depression of the solution NaCl:

$$\Delta t_{el} = i \cdot Ecr \cdot C ;$$

$$i = 1 + \alpha(\nu - 1) = 1 + 1(2 - 1) = 2;$$

$$\Delta t_{el.} = 2 \cdot 1{,}86 \cdot 2 = 7{,}44.$$

3) Calculate $t_{freezing} = 0° - \Delta t = 0° - 7{,}44 = -7{,}44°$.

Answer: - 7.440.

3. At what temperature is freezing a 3% solution of ethanol in water?

ω = 3%
C_2H_5OH
$t_{freezing}$ =?

1) To determine the freezing temperature need to know Δt, as

$\Delta t = 0° - t_{freezing}$, hence: $t_{freezing} = 0° - \Delta t$;

2) Calculate the depression of the solution C:

$$C_X = \frac{\varpi\% \cdot \rho \cdot 10}{M_X} = \frac{3 \cdot 1{,}0 \cdot 10}{46} = 0{,}65 mol/l.$$

3) Compute the solution C_2H_5OH depression and $t_{freezing}$:

$\Delta t_{noneletrolyte} = E_{cr} \cdot C = 1.86 \cdot 0{,}65 = 1{,}2$;.

$t_{freezing} = 0° - \Delta t = 0° - 1{,}2 = - 1.20$.

Answer: - 1,20.

4. Calculate the depression of blood at 37°C, if the osmotic blood pressure 7.65 atm.

P_{OSM} = 7.65 atm
T = 37°C
Δt =?

1) The problem refers to the two parameters of blood – depression and osmotic pressure, so write two formulas: $\Delta t = E_{cr.} \cdot C$ и $P_{OSM.} = CRT$. In these formulas, there is a general parameter C; express it from each

Equation: $$C = \frac{\Delta t}{E_{cr.}} \quad and \quad C = \frac{P_{osm}}{RT}$$

Hence $$\frac{\Delta t}{E_{cr.}} = \frac{P_{osm}}{RT} \Rightarrow \Delta t = \frac{P_{osm} \cdot E_{cr.}}{RT}$$

$$\Delta t = \frac{7{,}65 \cdot 1{,}86}{0{,}082 \cdot (273 + 37)} = 0{,}56.$$

Answer: 0.56.

5. Calculate the molar concentration of solution NaCl, which freezes at - 0.56° C.

$t_{freezing}$ = - 0,56°C NaCl	1) $t_{freezing}$ = 0° – Δt; 2) Δt find a solution NaCl: Δt = 0° = 0° $t_{freezing}$ = – (-0,56) = 0,56.
C (NaCl) =?	3) Given that the NaCl electrolyte: Δt_{EL} .. = i · E_{cr} · C; i = 1 α (ν - 1) = 1 1 (2 - 1) = 2;

$$C = \frac{\Delta t}{E_{cr.} \cdot i} = \frac{0.56}{1.86 \cdot 2} = 0.15 mol/l$$

Answer: 0.15 mol / liter.

Problems

1) At what temperature freezes the blood of man? (Answer: -0.56°)
2) Calculate the depression nonelectrolyte solution if its osmotic pressure at 0°C 4.56 atm. (Answer: 0.38)
3) Calculate the osmotic concentration of the blood of the frog, if freezing temperature of its blood - 0.41° C. (Answer: 0.22 mol/l)
4) Whether the two isotonic solution, if the depression of one 0,31. and osmotic pressure at the other 37° C 4.2 atm. (Answer: isotonic)