Laboratory work 3
Identification of anions

Anions in most cases do not interfere with each other during identification. Therefore, the identification of anions is most often carried out by the fractional method, i.e. in separate portions of the analyzed solution. In accordance with this, group reagents in the analysis of anions are usually used not to separate groups, but to establish the presence or absence of a particular group.

The classification of anions is based on the different solubilities of the barium and silver salts of the respective acids (Table 20). Special attention must be paid to the acidity of the medium.

Table 20 – Classification of anions

Group	Anions	Group reagent	Brief description of the group
I	$SO_4^{2-}, CO_3^{2-}, PO_4^{3-}, SO_3^{2-}, SiO_3^{2-}, C_2O_4^{2-}, C_4H_4O_6^{2-}, BO_3^{3-}, AsO_4^{3-}, AsO_3^{3-}, CrO_4^{2-}, Cr_2O_7^{2-}, S_2O_3^{2-}$	$BaCl_2$	Barium salts are sparingly soluble in water, soluble in acids (except for $BaSO_4$)
II	$Cl^-, Br^-, I^-, CNS^-, S^{2-}, CN^-, CH_3COO^-, NO_2^-$ $[Fe(CN)_6]^{4-}, [Fe(CN)_6]^{3-}$	$AgNO_3$	Silver salts are sparingly soluble in water and diluted HNO_3
III	$NO_3^-, ClO_3^-, MnO_4^-, ClO^-$	-	Barium and silver salts are soluble in water

Laboratory work 3.1
Reactions for the identification of anions

The goal of the work: to get acquainted with classification of anions, to study the properties of the reaction products.

Procedure

Proceed the reactions for anions. Fill the table below for each performed reaction.

Cation	Reaction equation and conditions	Observation and conclusion

Identification of Cl^- ion

Add the same amount of $AgNO_3$ solution to 2-3 drops of NaCl solution. Centrifuge the obtained precipitate, wash, and treat with NH_3 or $(NH_4)_2CO_3$ solution. The precipitate dissolves and passes into the solution in the form of a complex $[Ag(NH_3)_2]Cl$. If the obtained solution reacts with HNO_3, a precipitate is formed again.

$$NaCl + AgNO_3 = AgCl\downarrow + NaNO_3$$
$$[Ag(NH_3)_2]Cl + 2HNO_3 = AgCl\downarrow + 2NH_4NO_3$$

Identification of Br^- ion

1. Add the same amount of $AgNO_3$ to 2-3 drops of NaBr solution. Compare the precipitate formed with AgCl. The resulting precipitate dissolves in 2M HNO_3 and NH_3 solutions.

$$NaBr + AgNO_3 = AgBr \downarrow + NaNO_3$$

2. Add equal amounts of H_2SO_4, chlorine water ($Cl_2 \cdot H_2O$) and benzene to 2-3 drops of NaBr solution. Released Br_2 colors the organic layer yellow-red.

$$2NaBr + Cl_2 + H_2O = 2NaCl + Br_2 + H_2O$$

Identification of I^- ion

1. Add the same amount of $AgNO_3$ to 2-3 drops of KI solution. Observe the solubility of the formed AgI precipitate in 2M HNO_3 and NH_3 solutions.

$$KI + AgNO_3 = AgI \downarrow + KNO_3$$

2. Add equal amounts of H_2SO_4, chlorine water ($Cl_2 \cdot H_2O$) and benzene to 2-3 drops of KI solution. Released I_2 colors the organic layer purple.

$$2KI + Cl_2 + H_2O = 2KCl + I_2 + H_2O$$

Identification of SCN^- ion

1. Add the same amount of $AgNO_3$ to 2-3 drops of NaSCN solution. Observe the solubility of the formed AgSCN precipitate in 2M HNO_3 and NH_3 solution.

$$NaSCN + AgNO_3 = AgSCN \downarrow + NaNO_3$$

2. Add 1-2 drops of $FeCl_3$ solution to 2-3 drops of NaSCN solution, the solution turns dark red:

$$3NaSCN + FeCl_3 = Fe(SCN)_3 + 3NaCl$$

Identification of SO_4^{2-} ion

Barium salts form a white precipitate $BaSO_4$ with sulfate ions in an acidic medium, the resulting precipitate is insoluble in both acid and alkali. Add a few drops of 2M HCl, 1-2 drops of $BaCl_2$ solution to 2-3 drops of salt with sulfate ions.

$$Na_2SO_4 + BaCl_2 = BaSO_4 \downarrow + 2NaCl$$

Identification of SO_3^{2-} ion

1. Barium chloride forms a white precipitate with sulfite ion, the resulting precipitate dissolves in acids:

$$Na_2SO_3 + BaCl_2 = BaSO_3 \downarrow + 2NaCl$$

2. Oxidation reaction to SO_4^{2-} ion is used to establish SO_3^{2-} ion. Add $BaCl_2$ to the studied solution, dissolve the formed white precipitate in diluted HCl, add chlorine water and heat it. After some time, a white precipitate, $BaSO_4$, is formed, which is insoluble in HCl:

$$BaSO_3 + HCl + Cl_2 + H_2O = BaSO_4 \downarrow + 3HCl$$

Identification of CO_3^{2-} ion

When the CO_3^{2-} ion reacts with acid, CO_2 gas is released. The obtained CO_2 makes lime or barite water turbid.

Add 5-6 drops of Na_2CO_3 and 5-6 drops of 2M HCl to the test tube, close it using a stopper with a gas-permeable tube, and put the other end of the tube in lime or barite water. As a result of heating, notice that the solution becomes turbid:

$$Na_2CO_3 + 2HCl = 2NaCl + CO_2 \uparrow + H_2O$$
$$CO_2 + Ba(OH)_2 = BaCO_3 + H_2O$$

Identification of $S_2O_3^{2-}$ ion

An excess of silver nitrate with thiosulfate ions gives a white precipitate of $Ag_2S_2O_3$, which quickly turns yellow, then darkens and turns black because of conversion to silver sulfide:

$$Na_2S_2O_3 + 2AgNO_3 = Ag_2S_2O_3 \downarrow + 2NaNO_3$$
$$Ag_2S_2O_3 + H_2O = Ag_2S \downarrow + H_2SO_4$$

Add 3-5 drops of $AgNO_3$ to 2-3 drops of the $S_2O_3^{2-}$ ion solution, heat and stir the mixture.

Identification of PO_4^{3-} ion

1. Add 4-5 drops of magnesium mixture to a solution containing 2-3 drops of phosphate ions and mix. A white crystalline precipitate is formed, which is soluble in HCl and CH_3COOH solutions, but insoluble in ammonia:

$$Na_2HPO_4 + MgCl_2 + NH_3 = MgNH_4PO_4 \downarrow + 2NaCl$$

2. Add 8-10 drops of molybdenum-containing solution to 2-3 drops of phosphate ions solution and heat the mixture. A yellow crystalline precipitate corresponding to ammonium phosphormolybdate should precipitate:

$$H_3PO_4 + 12(NH_4)_2MoO_4 + 21HNO_3 = (NH_4)_3[PMo_{12}O_{40}] \downarrow + 12H_2O + 21NH_4NO_3$$

Identification of F^- ion

F^- ion with calcium salts gives a white precipitate of CaF_2, which is soluble in mineral acids, and insoluble in CH_3COOH. Add 3-4 drops of $CaCl_2$ to a solution containing 2-3 drops of fluoride ions:

$$CaCl_2 + 2NaF = CaF_2 \downarrow + 2NaCl$$

Identification of NO_3^- ion

1. If the solution does not contain nitrogen-containing anions ($NO_2^-, SCN^-, [Fe(CN)_6]^{4-}, [Fe(CN)_6]^{3-}$), NO_3^- ion can be determined by reducing it to ammonia.

Add 4-5 drops of 2M NaOH and granular Al to the solution containing NO_3^- ion and heat it. By applying wet litmus to the surface of the test tube, observe the change of the paper. Blue litmus paper indicates that NH_3 has been released:

$$3NaNO_3 + 8Al + 5NaOH + 2H_2O = 3NH_3 \uparrow + 8NaAlO_2$$

2. If there are no oxidizing anions in the solution, then the NO_3^- ion is determined by diphenylamine. Mix 2 drops of the diphenylamine solution in concentrated H_2SO_4 and 2-3 drops of NO_3^- ion on the glass. Notice that the solution turns blue.

Questions for self-control

1. What conditions should be observed in the analysis of bromide and iodide ions with chlorine water?
2. Iodine and bromine ions in the solution are extracted with what organic compound after oxidation? Why is extraction used in analysis?
3. Under what conditions is the nitrate ion reduced to: a) ammonia, b) nitrite ion?
4. If there are anion-oxidizing agents in the solution, is it possible to determine the nitrate ion with diphenylamine? What is the reason?
5. Under what conditions and with what reagent can the carbonate ion be discovered?
6. Write the reactions of the white precipitate of $Ag_2S_2O_3$ turning yellow, then turning brown and turning into a black precipitate.

Laboratory work 3.2
Effect of oxidizing and reducing agents, sulfuric acid, $BaCl_2$ and $AgNO_3$ on anions

Goal of the work: to study the effect of oxidizing and reducing agents, sulfuric acid, $BaCl_2$ and $AgNO_3$ reagents on anions. Fill in the obtained results in the laboratory journal.

In order to analyze anions, it is necessary to carry out several tests in advance, for the ease of further ion identification. Such a preliminary test is carried out using the following reagents:

1. Dilute sulfuric acid. Dilute sulfuric acid reacts with the following anions: $CN^-, NO_2^-, S^{2-}, CH_3COO^-\ (Ac^-), CO_3^{2-}, SO_3^{2-}, SiF_6^{2-}, S_2O_3^{2-}, SiO_3^{2-}, ClO^-, CrO_4^{2-}$.

Anion	Reaction	Analytical signal
CN^-	$2NaCN + H_2SO_4 \rightarrow Na_2SO_4 + 2HCN \uparrow$	Smell of bitter almonds
NO_2^-	$2NaNO_2 + H_2SO_4 = 2HNO_2 + Na_2SO_4$ $HNO_2 = H_2O \uparrow + NO \uparrow$ $2NO + O_2 = 2NO_2 \uparrow$	Brown gas
S^{2-}	$2Na_2S + H_2SO_4 = Na_2SO_4 + H_2S \uparrow$	Smell of rotten eggs
CH_3COO^-	$2NaAc + H_2SO_4 = Na_2SO_4 + 2HAc \uparrow$	Smell of acetic acid
CO_3^{2-}	$Na_2CO_3 + H_2SO_4 = CO_2 \uparrow + H_2O + Na_2SO_4$	Gas
SO_3^{2-}	$Na_2SO_3 + H_2SO_4 = SO_2 \uparrow + H_2O + Na_2SO_4$	Gas
$S_2O_3^{2-}$	$Na_2S_2O_3 + H_2SO_4 = SO_2 \uparrow + S \downarrow + H_2O + Na_2SO_4$	Solution becomes cloudy
SiF_6^{2-}	$Na_2SiF_6 + H_2SO_4 = H_2SiF_6 + Na_2SO_4$ $H_2SiF_6 = 2HF + SiF_4 \uparrow$	Gas
SiO_3^{2-}	$Na_2SiO_3 + H_2SO_4 = H_2SiO_3 \downarrow + Na_2SO_4$	Cold icy precipitate

ClO^-	$2NaClO + H_2SO_4 = 2HClO + Na_2SO_4$ $HClO = 2HCl\uparrow + O_2\uparrow$	Gas
CrO_4^{2-}	$2Na_2CrO_4 + 2H_2SO_4 = H_2Cr_2O_7 + H_2O + 2Na_2SO_4$	Color change from yellow to deep yellow

$Cl^-, Br^-, I^-, CNS^-, [Fe(CN)_6]^{3-}, [Fe(CN)_6]^{4-}, BO_3^{3-}, AsO_3^{3-}, AsO_4^{3-}, PO_4^{3-}, SO_4^{2-}, F^-, NO_3^-, ClO_3^-, MnO_4^-, C_2O_4^{2-}, C_4H_4O_6^-$ anions do not cause visible changes. If heated for a long time, $[Fe(CN)_6]^{3-}, [Fe(CN)_6]^{4-}$ anions can change as follows:

$$2Na_3[Fe(CN)_6] + 6H_2SO_4 = 3Na_2SO_4 + Fe_2(SO_4)_3 + 12HCN\uparrow$$

2. Concentrated sulfuric acid reacts with many anions depending on its oxidizing and water absorption properties:

Anion	**Reaction**	**Analytical signal**
Cl^-	$2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl\uparrow$	Gas
Br^-	$2NaBr + 2H_2SO_4 \rightarrow Br_2 + Na_2SO_4 + SO_2\uparrow + 2H_2O$	
I^-	$2NaI + 2H_2SO_4 \rightarrow I_2 + Na_2SO_4 + SO_2\uparrow + 2H_2O$	
CN^-	$2NaCN + 2H_2SO_4 + H_2O \rightarrow Na_2SO_4 + 2CO\uparrow + (NH_4)_2SO_4$	
CNS^-	$NaCNS + H_2SO_4 \rightarrow COS\uparrow, CS_2\uparrow, CO\uparrow, NH_3\uparrow$	Gas when boiled
$[Fe(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$	$2Na_3[Fe(CN)_6] + 12H_2SO_4 + 12H_2O \rightarrow$ $\rightarrow 3Na_2SO_4 + Fe_2(SO_4)_3 + 12CO\uparrow + 6(NH_4)_2SO_4$	Gas
S^{2-}	$2Na_2S + H_2SO_4 = Na_2SO_4 + H_2S\uparrow$	Smell of rotten eggs
CH_3COO^-	$2NaAc + H_2SO_4 = Na_2SO_4 + 2HAc\uparrow$	Smell of acetic acid
CO_3^{2-}	$Na_2CO_3 + H_2SO_4 = CO_2\uparrow + H_2O + Na_2SO_4$	Gas
SO_3^{2-}	$Na_2SO_3 + H_2SO_4 = SO_2\uparrow + H_2O + Na_2SO_4$	Gas
$S_2O_3^{2-}$	$Na_2S_2O_3 + H_2SO_4 = SO_2\uparrow + S\downarrow + H_2O + Na_2SO_4$	Solution becomes cloudy
SiF_6^{2-}	$Na_2SiF_6 + H_2SO_4 = H_2SiF_6 + Na_2SO_4$ $H_2SiF_6 = 2HF + SiF_4\uparrow$	Gas
SiO_3^{2-}	$Na_2SiO_3 + H_2SO_4 = H_2SiO_3\downarrow + Na_2SO_4$	White precipitate
ClO^-	$2NaClO + H_2SO_4 = 2HClO + Na_2SO_4$ $HClO = 2HCl\uparrow + O_2\uparrow$	Gas
CrO_4^{2-}	$Na_2CrO_4 + H_2SO_4 = CrO_3 + H_2O + Na_2SO_4$	Red color
$C_2O_4^{2-}$	$Na_2C_2O_4 + H_2SO_4 = CO_2\uparrow + CO\uparrow + H_2O + Na_2SO_4$	Gas

$BO_3^{3-}, AsO_3^{3-}, AsO_4^{3-}, PO_4^{3-}, SO_4^{2-}, NO_3^-, MnO_4^-$ anions do not cause visible changes.

3. Identification of oxidants using KI + 1M H_2SO_4

KI + H_2SO_4 reacts with: $AsO_4^{3-}, ClO_3^-, ClO^-, MnO_4^-, CrO_4^{2-}, NO_2^-, [Fe(CN)_6]^{3-}$. If a starch is added to the reaction, the solution turns blue when free iodine is released.

Anion	**Reaction**	**Analytical signal**
$[Fe(CN)_6]^{3-}$	$K_3[Fe(CN)_6] + KI = K_4[Fe(CN)_6] + 1/2I_2$	

ClO^-	$KClO + 2KI + H_2SO_4 = KCl + K_2SO_4 + H_2O + I_2$	During the reaction, when iodine is released, the color of the solution turns brown, if starch is added, the solution turns blue
CrO_4^{2-}	$2K_2CrO_4 + 6KI + 8H_2SO_4 =$ $= Cr_2(SO_4)_3 + 8H_2O + 3I_2 + 5K_2SO_4$	
NO_2^-	$KNO_2 + KI + H_2SO_4 = NO$ $\uparrow + H_2O + K_2SO_4 + 1/2I_2$	
AsO_4^{3-}	$K_3AsO_4 + 2KI + H_2SO_4$ $= K_3AsO_3 + I_2 + K_2SO_4 + H_2O$	
ClO_3^-	$KClO_3 + 6KI + 3H_2SO_4$ $= KCl + 3H_2O + 3I_2 + 3K_2SO_4$	
MnO_4^-	$2KMnO_4 + 10KI + 8H_2SO_4 =$ $= 2MnSO_4 + 8H_2O + 5I_2 + 6K_2SO_4$	

$Cl^-, Br^-, I^-, CN^-, CNS^-, [Fe(CN)_6]^{4-}, PO_4^{3-}, SO_4^{2-}, F^-, NO_3^-, SiO_3^{2-}, SiF_6^{2-}, S_2O_3^{2-}, C_2O_4^{2-}$, $C_4H_4O_6^-$ anions do not cause visible changes.

4. Identification of strong reducing anions by I_2 + starch

$CN^-, SO_3^{2-}, S^{2-}, AsO_3^{3-}, S_2O_3^{2-}$ anions react with iodine and destroy the iodine-starch complex.

Anion	Reaction	Analytical signal
CN^-	$KCN + I_2 = ICN + KI$	Discoloration of the blue iodine-starch complex
S^{2-}	$Na_2S + I_2 = S \downarrow + 2NaI$	
SO_3^{2-}	$Na_2SO_3 + H_2O + I_2 = 2HI + Na_2SO_4$	
$S_2O_3^{2-}$	$2Na_2S_2O_3 + I_2 = 2NaI + Na_2S_4O_6$	
AsO_3^{3-}	$Na_3AsO_3 + H_2O + I_2 = 2HI + Na_3AsO_4$	

$[Fe(CN)_6]^{4-}, NO_2^-$ anions react with iodine, but these reactions are reversible.

$Cl^-, Br^-, I^-, CNS^-, [Fe(CN)_6]^{3-}, Ac^-, CO_3^{2-}, BO_3^{3-}, AsO_4^{3-}, PO_4^{3-}, SO_4^{2-}, F^-, NO_3^-, SiO_3^{2-}$, SiF_6^{2-}, $ClO_3^-, C_2O_4^{2-}, MnO_4^-, ClO^-, C_4H_4O_6^-, CrO_4^{2-}$ anions do not react with iodine.

5. Identification of reducing anions by $KMnO_4$ + H_2SO_4

$KMnO_4$ + H_2SO_4 can react with dry KCl, KBr salts to release Cl_2, Br_2, although no significant changes are observed in aqueous solutions.

Anion	Reaction	Analytical signal
I^-	$10KI + 2KMnO_4 + 8H_2SO_4 =$ $= 5I_2 + 2MnSO_4 + 6K_2SO_4 + 8H_2O$	A faint pink $KMnO_4$ solution is decolorized
$C_2O_4^{2-}$	$5K_2C_2O_4 + 2KMnO_4 + 8H_2SO_4 =$ $= 2MnSO_4 + 6K_2SO_4 + 10CO_2$ $\uparrow + 8H_2O$	
$[Fe(CN)_6]^{4-}$	$5K_4[Fe(CN)_6] + KMnO_4 + 4H_2SO_4 =$ $= 5K_3[Fe(CN)_6] + MnSO_4 + 3K_2SO_4$ $+ 4H_2O$	
NO_2^-	$5KNO_2 + 2KMnO_4 + 3H_2SO_4 =$ $= 5KNO_3 + 2MnSO_4 + K_2SO_4 + 3H_2O$	

S^{2-}	$5K_2S + 2KMnO_4 + 8H_2SO_4 = $ $= 5S + 2MnSO_4 + 6K_2SO_4 + 8H_2O$	
SO_3^{2-}	$Na_2SO_3 + 2KMnO_4 + 3H_2SO_4 = $ $= Na_2SO_4 + 2MnSO_4 + K_2SO_4$ $+ 3H_2O$	
$S_2O_3^{2-}$	$10K_2S_2O_3 + 2KMnO_4 + 8H_2SO_4 = $ $= 5K_2S_4O_6 + 2MnSO_4 + 6K_2SO_4$ $+ 8H_2O$	
AsO_3^{3-}	$Na_3AsO_3 + 2KMnO_4 + 3H_2SO_4 = $ $= Na_3AsO_4 + 2MnSO_4 + K_2SO_4$ $+ 3H_2O$	

$CN^-, CNS^-, Ac^-, CO_3^{2-}, BO_3^{3-}, AsO_4^{3-}, PO_4^{3-}, SiF_6^{2-}, SO_4^{2-}, SiO_3^{2-}, F^-, NO_3^-, ClO_3^-, ClO^-, MnO_4^-, CrO_4^{2-}$ anions do not cause visible changes. $C_4H_4O_6^-$ reacts very slowly. So, if a weak pink KMnO4 solution becomes colorless, it indicates the presence of the following anions in the solution: $Cl^-, Br^-, I^-, [Fe(CN)_6]^{4-}, AsO_3^{3-}, PO_4^{3-}, SO_3^{2-}, S^{2-}, S_2O_3^{2-}, NO_2^-, C_2O_4^{2-}, C_4H_4O_6^-$.

6. Effect of $AgNO_3$ and $BaCl_2$

The acidity of the medium plays a major role when anions are reacted with $AgNO_3$ and $BaCl_2$, i.e. if the medium is acidic or neutral, no precipitate is formed. Classification of anions according to the formation of less soluble barium and silver salts is proposed by Bunsen according to the following sequence:

Reagent	Anions	Solubility
$AgNO_3$ (no reaction with $BaCl_2$)	$Cl^-, Br^-, I^-, CN^-, CNS^-, [Fe(CN)_6]^{3-}, [Fe(CN)_6]^{4-}$	Not soluble in HNO_3
	Concentrated solutions of S^{2-}, NO_2^-, Ac^-	Soluble in HNO_3
$BaCl_2$ (precipitation with $AgNO_3$ is white)	$SO_4^{2-}, SO_3^{2-}, CO_3^{2-}, BO_3^{3-}, C_2O_4^{2-}, C_4H_4O_6^-$	Soluble in HCl (except $BaSO_4$)
$BaCl_2$ (precipitation with $AgNO_3$ is colored)	$AsO_3^{3-}, AsO_4^{3-}, PO_4^{3-}, CrO_4^{2-}, Cr_2O_7^{2-}, S_2O_3^{2-}$	Soluble in HNO_3
No precipitation with $AgNO_3$ and $BaCl_2$	$NO_3^-, ClO_3^-, ClO^-, MnO_4^-$ (because of the formation of Cl^- ions in the light, a white precipitate of AgCl can be formed in the solution)	-

Thus, it is possible to identify a part of anions from the investigated solution by conducting a preliminary test using H_2SO_4 solution, KI + 1M H_2SO_4 + starch, I_2 + starch, $KMnO_4$ + H_2SO_4, or $AgNO_3$ and $BaCl_2$.

Questions for self-control

1. When analyzing a mixture of anions, which ions can be identified by preliminary testing?
2. How many groups of anions can be grouped according to barium chloride and silver nitrate salts?

3. Depending on the redox properties of anions, what groups can be specified?

4. According to what properties of anions they can be identified using the reactions of: a) oxidation-reduction; b) displacement?

5. What anions are not found in a solution in a strongly acidic medium?

6. Which anion precipitates first when silver nitrate reacts with a solution containing I^-, Br^-, Cl^- anions?

7. SO_3^{2-} anion prevents the identification of CO_3^{2-}, if SO_3^{2-} anion is present in the solution, how is CO_3^{2-} identified?

8. Why are metals in the earth's crust not in the form of acetate, but in the form of sulfides?

9. Determine the equilibrium concentration of Ag^+ cation in the solutions of AgCl, AgBr, AgI, Ag_2S, Ag_3PO_4. Which compound is the most soluble in ammonia?

Laboratory work 3.3
Identification of $SO_4^{2-}, SO_3^{2-}, S_2O_3^{2-}, CO_3^{2-}, PO_4^{2-}, F^-, NO_3^-, Cl^-, Br^-, I^-, CNS^-, BO_3^{3-}, SiO_3^{2-}$ anions in the mixture

Goal of the work: identification of anions in a mixture. Filling out the analysis report in the laboratory notebook.

Before the analysis of anions, it is necessary to get rid of other than alkaline-earth metals, for this purpose, we heat the investigated solution by adding soda, so that all cations, except for alkaline-earth metals, form insoluble carbonates in water, and anions remain in the solution.

Preliminary studies

1. Determine the pH of the medium. There are no $SO_3^{2-}, S_2O_3^{2-}, CO_3^{2-}$ anions in the acidic medium. Alkaline medium can contain all anions.

2. Add dilute sulfuric acid to one part of the solution under study and monitor the evolution of gas. If gas is released, it indicates the presence of $SO_3^{2-}, S_2O_3^{2-}, CO_3^{2-}$ anions. If there is no gas, the given anions are absent or added in very small amounts.

Identification of reducing anions:

a) add I_2 + starch to the solution. If the starch becomes colorless, $SO_3^{2-}, S_2O_3^{2-}$ anions are present;

b) add $KMnO_4 + H_2SO_4$ to the solution; if it becomes colorless, there are $I^-, SO_3^{2-}, S_2O_3^{2-}$ anions.

3. Identify the anions in a neutral or acidic media by reacting with $AgNO_3$ and $BaCl_2$ according to the Bunsen classification.

However, there may be obstacles such as:

1) A precipitate insoluble in nitric acid is formed with $AgNO_3$ solution, and $BaCl_2$ does not form precipitate. Therefore, the solution may contain Cl^-, I^-, Br^-, CNS^-.

Br^- and I^- ions can be determined from the initial solution using chlorine water $Cl_2 \cdot H_2O$ (with addition of benzene or CCl_4). In this case, iodine or bromine is released, and the organic layer turns pink. If an excess amount of chlorine water is added, $I_2 \rightarrow IO_3^-$ reaction takes place, resulting in the formation of a colorless solution. Bromine remains unchanged, only the organic layer turns yellow or brown depending on the concentration of bromine in the solution.

CNS^- ion can be determined by the action of ferric chloride on a part of the solution. If the ion is present, the solution turns blood-red.

2) If a precipitate soluble in nitric acid is formed from $AgNO_3$, and if precipitates from $BaCl_2$ are soluble in HCl, then the solution may contain $SO_3^{2-}, S_2O_3^{2-}, CO_3^{2-}, BO_3^{3-}, PO_4^{3-}$ anions.

Some anions and anion groups are revealed in the preliminary test, and further analysis should be carried out separately.

Questions for self-control

1. Why are salts of alkali metals involved in the analysis of anions?

2. What kind of precipitate can be formed when a mixture of anions reacts with $BaCl_2$ in a weakly alkaline medium?

3. When Br^- and I^- ions are present together in the solution, how can they be determined?

4. When $SO_3^{2-}, S_2O_3^{2-}, SO_4^{2-}$ ions are present in the solution, how can they be determined?

5. Build a mixture analysis sequence for:

a) $AgNO_3$, $NiSO_4$, $MnCl_2$, $NH_3 \cdot H_2O$
b) $AgNO_3$, $KMnO_4$, $BaCl_2$, Na_2SO_3, $NH_3 \cdot H_2O$
c) $AgNO_3$, $BaCl_2$, $CoSO_4$, KI, $NH_3 \cdot H_2O$
d) $AgNO_3$, $SrCl_2$, $CuSO_4$, KI, $NH_3 \cdot H_2O$
e) $CoCl_2$, $MgNH_4PO_4$, HAc, KNO_2
f) $BaCl_2$, $CrCl_3$, $AlCl_3$, H_2O_2, $NH_3 \cdot H_2O$
g) $Ba(NO_3)_2$, $Fe(NO_3)_3$, $AlCl_3$, $MnCl_2$, $(NH_4)_2HPO_4$, HAc
h) $FeCl_3$, $Co(NO_3)_2$, KNO_2, Na_2HPO_4, HAc
i) $FeCl_3$, $AgNO_3$, $BaCl_2$, Na_2HPO_4, HNO_3
j) Hg_2Cl_2, $Cu(NO_3)_2$, Na_2HPO_4, $MgCl_2$, $ZnSO_4$, $NH_3 \cdot H_2O$
k) $BaCl_2$, $Cr(NO_3)_3$, $NiSO_4$, H_2O_2, $NH_3 \cdot H_2O$
l) $MnCl_2$, $AgNO_3$, $Ni(NO_3)_2$, H_2O_2, $NH_3 \cdot H_2O$
m) $AgNO_3$, $SrCl_2$, $K_2Cr_2O_7$, Na_2SO_3, HAc
n) $AgNO_3$, $Ba(NO_3)_2$, $Sr(NO_3)_2$, $K_2Cr_2O_7$, HAc
o) $BaCl_2$, $CuCl_2$, $KMnO_4$, Na_2SO_3, $NH_3 \cdot H_2O$
p) $AgNO_3$, $KMnO_4$, $AlCl_3$, $SrCl_2$, Na_2SO_3, $NH_3 \cdot H_2O$
q) $AlCl_3$, $CdCl_2$, $CoCl_2$, $MgNH_4PO_4$, HAc, KNO_2
r) $Ba(NO_3)_2$, $Fe(NO_3)_3$, $MgCl_2$, $(NH_4)_2HPO_4$, HAc
s) $FeCl_3$, $AgNO_3$, $BaCl_2$, Na_2HPO_4, HAc
t) $PbCl_2$, $CaCl_2$, $ZnCl_2$, $AlCl_3$, $Fe(NO_3)_3$, Na_2HPO_4, NaOH
u) $BaCl_2$, $CaCl_2$, $CrCl_3$, $AlCl_3$, H_2O_2, $NH_3 \cdot H_2O$
v) $FeSO_4$, $MnCl_2$, $AgNO_3$, $CuSO_4$, $BaCl_2$, H_2O_2, $NH_3 \cdot H_2O$
w) $MnSO_4$, $BaCl_2$, $Cr(NO_3)_3$, $NiSO_4$, $Pb(NO_3)_2$, H_2O_2, $NH_3 \cdot H_2O$
x) $MnCl_2$, $AgNO_3$, $Ni(NO_3)_2$, H_2O_2, $NH_3 \cdot H_2O$
y) $AgNO_3$, $MgSO_4$, $PbCl_2$, KI, $NH_3 \cdot H_2O$
z) CuS, $MnO(OH)_2$, ZnS, $BaCO_3$, 2M HCl