UNIWERSYTET PRZYRODNICZY w Lublinie
WYDZIAŁ MEDYCYNY WETERYNARYJNEJ

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Identification of selected cations and anions

ACT WITH GREAT CAUTION!
DO NOT COVER A TEST TUBE WITH YOUR FINGER

ACT WITH GREAT CAUTION!
HEAT ONLY ONE TEST TUBE OVER A BURNER AT A TIME

Task 1

The aim of the task is to detect Ca^{2+} (calcium) ions

Procedure

a. Test with $C_2O_4^{2-}$ (oxalate) ions

Add about 0.5 cm^3 of 0.2 mol/dm^3 ammonium oxalate ($NH_4C_2O_4$) to 0.5 cm^3 of Ca^{2+} solution.

Reaction:

$$Ca^{2+} + C_2O_4^{2-} \Rightarrow \downarrow CaC_2O_4$$

The resulting CaC_2O_4 precipitate is white, crystalline. If you add several drops of ammonia to a test tube, in which the reaction has occurred, the amount of precipitate is greater. Calcium oxalate is soluble in mineral (inorganic) acids, and insoluble in acetic acid.

b. Test with SO_4^{2-} (sulphate) ions

Add several drops of concentrated H_2SO_4 (sulphuric acid) to 0.5 cm^3 of Ca^{2+} solution.

Reaction:

$$Ca^{2+} + SO_4^{2-} \Rightarrow \downarrow CaSO_4$$

Reaction with sulphuric acid results in the precipitation of white $CaSO_4$ (copper sulphate).

Task 2

The aim of the task is to detect NH_4^+ (ammonium) ions

Procedure

Add about 0.5 cm^3 of 2mol/dm^3 NaOH to 0.5 cm^3 of NH_4^+ solution, and heat the contents of the test tube over a burner.

Reaction:

$$NH_4^+ + 2NaOH \Rightarrow \uparrow NH_3 + 2Na^+ + H_2O$$

Observe the change of litmus paper colour and the characteristic odour of escaping ammonia at the mouth of the test tube.

Task 3

The aim of the task is to detect Cu^{2+} (copper) ions

Procedure

Take two test tubes, pour into each 0.5 cm^3 of Cu^{2+} solution, and then add 0.5 cm^3 of 2 mol/dm^3 NaOH. After the precipitation of $Cu(OH)_2$, heat one test tube over a burner, and add 0.5 cm^3 of concentrated $NH_3 \cdot H_2O$ to the other test tube.

Reactions:

$$Cu^{2+} + 2\ OH^- \Rightarrow \downarrow Cu(OH)_2$$

$$Cu(OH)_2 gel \Rightarrow \downarrow CuO + H_2O$$

$$Cu(OH)_2 + 4NH_3 \Rightarrow [Cu(NH_3)_4]^{2+} + 2OH^-$$

Task 4

The aim of the task is to detect Fe^{3+} (iron) ions

Procedure

a. Test with potassium thiocyanate

Add 0.5 cm^3 of 1 mol/dm^3 KSCN (potassium thiocyanate) to 0.5 cm^3 of Fe^{3+} solution.

Reaction:

$$Fe^{3+} + 3\ SCN^- \Rightarrow Fe(SCN)_3$$

Observe the change of solution colour. Fe^{2+} ions do not give this reaction.

b. Test with sodium hydroxide

Add 0.5 cm^3 of 2mol/dm^3 NaOH to 0.5 cm^3 of Fe^{3+} solution.

Reaction:

$$Fe^{3+} + 3\ OH^- \Rightarrow \downarrow Fe(OH)_3$$

Observe the formation of red-brown $Fe(OH)_3$ precipitate, which is insoluble in an excess of the reagent.

Task 5

The aim of the task is to detect Ag^+ (silver) ions

Procedure

a. Test with Cl^- (chlorine) ions

Take two test tubes, pour into each 0.5 cm^3 of Ag^+ solution, and then several drops of concentrated HCl (hydrochloric acid). One test tube expose to sunlight and after some time observe photochemical reaction occurring in the test tube. Carefully heat the other test tube and observe the precipitate. Cool the test tube, then add drop by drop 2 mol/dm^3 $NH_3 \cdot H_2O$ until the formation of soluble silver diamine chloride ($[Ag(NH_3)_2]Cl$),and next add drop by drop concentrated HNO_3 until the reappearance of AgCl precipitate.

Ag^+ ions, occurring in neutral or acid solutions, react with Cl^- ions forming white, cheese-like precipitate of silver chloride (AgCl), which decomposes when exposed to light and darkens due to the precipitation of colloidal silver.

$$Ag^+ + Cl^- \Rightarrow \downarrow AgCl$$

$$2\downarrow AgCl \Rightarrow 2\downarrow Ag + \uparrow Cl_2$$

AgCl precipitate is insoluble in both cold and hot pure water but in the presence of ammonium ions it forms soluble, colourless, complex ion$[Ag(NH_3)_2]^+$.

$$2\downarrow AgCl \Rightarrow 2\downarrow Ag + \uparrow Cl_2$$

$$\downarrow AgCl + 2NH_3 \cdot H_2O \Rightarrow [Ag(NH_3)_2]Cl + 2H_2O$$

The addition of nitric acid causes the reprecipitation of AgCl.

b. Test with CrO_4^{2-} (chromate) ions

Add 0.5 cm^3 of 0.1 mol/dm^3 K_2CrO_4 to 0.5 cm^3 of Ag^+ solution.

After the precipitation of Ag_2CrO_4, add several drops of concentrated nitric acid to the test tube. Observe the course of reaction.

$$2Ag^{+} + CrO_4^{2-} \Rightarrow 2 \downarrow Ag_2CrO_4$$

Potassium chromate (K_2CrO_4) causes the precipitation of red-brown silver chromate (Ag_2CrO_4) from the solutions containing Ag^{+} ions. This reaction has found practical application in the quantitative determination of silver in jewellery because the intensity of colour of formed Ag_2CrO_4 depends on the amount of silver in the alloy, from which jewellery has been made.

Task 6

The aim of the task is to detect Pb^{2+} (lead) ions

Procedure

a. Test with Cl^{-} (chlorine) ions

Add several drops of concentrated HCl to 0.5 cm^3 of Pb^{2+} solution.

Reaction:

$$Pb^{2+} + 2 Cl^{-} \Rightarrow \downarrow PbCl_2$$

The precipitate of lead chloride (II) is formed. Add 2 cm^3 of distilled water to the test tube and heat until the precipitate is dissolved. After cooling, observe the formed crystals.

Cl^{-} ions, added to the solutions containing Pb^{2+} ions, cause the precipitation of white, crystalline lead chloride (II), which quickly settle on the test tube bottom.

This precipitate dissolves after heating in the test tube, and after cooling it reprecipitates in the form of needle-like crystals.

Test with heating silver and lead chlorides is important because it is used to easily distinguish AgCl from $PbCl_2$ (AgCl is insoluble in hot water).

a. Test with chromate

Add 0.5 cm^3 of 0.1 mol/dm^3 K_2CrO_4 to 0.5 cm^3 of Pb^{2+} solution. After a few minutes, examine the formed precipitate.

$$Pb^{2+} + CrO_4^{2-} \Rightarrow \downarrow PbCrO_4$$

Potassium chromates ($K_2CrO_4$and $K_2Cr_2O_7$), added to the solutions containing Pb^{2+} ions, causes the precipitation of yellow lead chromates (II).

Task 7

The aim of the task is to detect Ba^{2+} (barium)ions

Procedure

a. Test with SO_4^{2-} (sulphate)ions

Add 0.5 cm^3 of 0.1 mol/dm^3 H_2SO_4 to 0.5 cm^3 of Ba^{2+} solution.

Reaction:

$$Ba^{2+} + SO_4^{2-} \Rightarrow \downarrow BaSO_4$$

Sulphuric acid (VI) causes the precipitation of white $BaSO_4$, which is insoluble in water.

b. Test with CO_3^{2-} (carbonate)ions

Add 0.5 cm^3 of 0.2mol/dm^3 Na_2CO_3 to 0.5 cm^3 of Ba^{2+} solution. After the precipitation of $BaCO_3$, add 1 cm^3 of concentrated CH_3COOH.

Reactions:

$$Ba^{2+} + CO_3^{2-} \Rightarrow \downarrow BaCO_3$$

$$BaCO_3 + 2\ CH_3COOH \Rightarrow Ba(CH_3COO)_2 + CO_2 + H_2O$$

Carbonate ions, added to the solutions containing Ba^{2+} ions, cause the precipitation of white barium carbonate (II), which is easily soluble in acetic acid. If the precipitate is not dissolved, you can add 1 $cm^3$of CH_3COOH more.

Task 8

The aim of the task is to detect Cl^- (chloride)ions

Procedure

a. Test with Ag^+ (silver)ions

Add drop by drop about 0.5 cm^3 of 0.1 mol/dm^3 $AgNO_3$ to 0.5 cm^3 of Cl^- solution. Dissolve the resulting precipitate adding 2 mol/dm^3 $NH_3{\cdot}H_2O$ drop by drop. Then add several drops of concentrated HNO_3 in order to cause the reprecipitation of AgCl.

Reactions:

$$Ag^+ + Cl^- \Rightarrow \downarrow AgCl$$

$$AgCl + 2NH_3 \cdot H_2O \Rightarrow [Ag(NH_3)_2]Cl + 2H_2O$$

$$[Ag(NH_3)_2]Cl + 2\ H_3O^+ + 2NO_3^- \Rightarrow \downarrow AgCl + 2NH_4NO_3$$

b. Test with potassium permanganate

Add 0.5 cm^3 of 0.1 mol/dm^3 $KMnO_4$ and several drops of concentrated H_2SO_4 to 0.5 cm^3 of Cl^- solution.

Reaction:

$$10Cl^- + 2MnO_4^- + 16H^+ \Rightarrow 5Cl_2 + 2Mn^{2+}\ \ 8H_2O$$

Potassium permanganate, as strong oxidant, is reduced in acid environment (the solution becomes discoloured), while Cl^-, as weak reducer, escapes in the form of gas with a characteristic odour.

Task 9

The aim of the task is to detect CO_3^{2-} ions

Procedure

a. Test with strong acid

Add drop by drop 2 mol/dm^3 H_2SO_4 to 0.5 cm^3 of CO_3^{2-} solution. Observe the course of reaction.

$$CO_3^{2-} + 2\ H_3O^+ \Rightarrow H_2CO_3 + 2H_2O \Rightarrow 3H_2O + \uparrow CO_2$$

b. Test with Ba^{2+} ions

Add 0.5 cm^3 of 0.1 mol/dm^3 $BaCl_2$ to 0.5 cm^3 of CO_3^{2-} solution.

Reaction:

$$Ba^{2+} + CO_3^{2-} \Rightarrow \downarrow BaCO_3$$

White precipitate of barium carbonate is soluble in acetic, nitric and hydrochloric acids, and insoluble in sulphuric acid.

Task 10

The aim of the task is to detect PO_4^{3-} ions

Procedure

Add 5 drops of concentrated HNO_3 and 0.5 cm^3 of $(NH_4)_2MoO_4$ to 0.5 cm^3 of PO_4^{3-} solution. Heat the test tube over a burner.

Reaction:

$$Na_2HPO_4 + 12(NH_4)_2MoO_4 + 23\ HNO_3 \Rightarrow (NH_4)_3P(Mo_3O_{10})_4 + 21\ NH_4NO_3 + 2\ NaNO_3 + 12\ H_2O$$

Task 11

The aim of the task is to detect SO_4^{2-} ions

Procedure

a. Test with Pb^{2+} (lead) ions

Add 0.5 cm^3 of 2 mol/dm^3 $Pb(CH_3COO)_2$ to 0.5 cm^3 of SO_4^{2-} solution.

Reaction:

$$SO_4^{2-} + Pb^{2+} \Rightarrow \downarrow PbSO_4$$

The resulting white precipitate of $PbSO_4$ is insoluble in inorganic acids, except concentrated sulphuric acid (VI), and it is also insoluble in concentrated NaOH and KOH.

b. Test with Ba^{2+} (barium) ions

Add 0.5 cm^3 of 1 mol/dm^3 barium chloride ($BaCl_2$) to 0.5 cm^3 of SO_4^{2-} solution.

Reaction:

$$SO_4^{2-} + Ba^{2+} \Rightarrow \downarrow BaSO_4$$

The resulting white precipitate of $BaSO_4$ is insoluble in HCl and HNO_3 event after heating, while it is soluble in concentrated H_2SO_4.

Task 12

The aim of the task is to detect $C_2O_4^{2-}$ ions

Procedure

a. Test with $CaCl_2$

Add drop by drop 0.5 cm^3 of 1 mol/dm^3 $CaCl_2$ to 0.5 cm^3 of $C_2O_4^{2-}$

solution.

Reaction:

$$Ca^{2+} + C_2O_4^{2-} \Rightarrow \downarrow CaC_2O_4$$

Calcium chloride causes the precipitation of white crystalline precipitate, which is soluble in mineral acids, and insoluble in acetic acid.

b. Test with potassium permanganate

Add 0.5 cm^3 of 0.1 mol/dm^3 $KMnO_4$ and 0.5 cm^3 of concentrated H_2SO_4 to 0.5 cm^3 of $C_2O_4^{2-}$ solution.

Reaction:

$$2MnO_4^{2-} + 5C_2O_4^{2-} + 16H^{+} \Rightarrow 10CO_2 + 2Mn^{2+}\ \ 8H_2O$$

Potassium permanganate becomes discoloured in acid solution containing oxalate ions ($C_2O_4^{2-}$). Characteristic bubbles of CO_2 are formed during this reaction.

Lublin, 20 november 2016.