

LABORATORY WORK No. 19

PROOF REACTIONS OF CATIONS

- By proof reactions, following particular cations can be determined: Ag^+ , Pb^{2+} , Cu^{2+} , Bi^{3+} , Fe^{3+} , Al^{3+} , Mg^{2+} , Ba^{2+} , Ca^{2+} , NH_4^+ .

These are the selected proof reactions of cations in aqueous solutions. More detailed evidence and dividing of mixtures will be discussed in analytical chemistry. Particular reactions can be carried out either in a tube or on a spot test plate, possibly also on filter paper.

TASK No.1 PROOF REACTIONS OF SELECTED CATIONS

- CHEMICALS:**

cations: Ag^+ , Pb^{2+} , Cu^{2+} , Bi^{3+} , Fe^{3+} , Al^{3+} , Mg^{2+} , Ba^{2+} , Ca^{2+} , NH_4^+

agents: HCl (c = 2 mol / l), 5% K_2CrO_4 solution, 5% KI solution, 5% $\text{K}_4[\text{Fe}(\text{CN})_6]$ solution, 10% NH_3 solution, 5% KSCN solution, H_2SO_4 (c = 2 mol/l), 5% oxalic acid solution, thiourea (solid), 10% $(\text{NH}_4)_2\text{HPO}_4$ solution, NaOH (solid), titanium yellow, NH_4Cl (solid), $\text{Na}_2\text{S}_2\text{O}_3$ (c = 0.1 mol/l), 5% Na_2CO_3 solution

- AIDS:** spot plate, dropper, filter paper, Pt wire

- PROCEDURE:** We apply the sample on the spot test plate and we add the selected agent. According to the formation of the precipitate and its colouring, we determine the particular cation (see the table). If no precipitate creates, we apply another sample into another pit and add other agent to determine the cation. We carry out the analysis for all the samples. Finally, we write down the results of observations into the table.

Ag^+

Agent	reaction	note
HCl (2 mol/l)	$\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}$	white precipitate, grows purple or grey on light
	$\text{AgCl} + 2\text{NH}_3 \rightarrow [\text{Ag}(\text{NH}_3)_2]\text{Cl}$	soluble in NH_3 in complex $[\text{Ag}(\text{NH}_3)_2]\text{Cl}$
K_2CrO_4 (5%)	$2\text{Ag}^+ + \text{CrO}_4^{2-} \rightarrow \text{Ag}_2\text{CrO}_4$	reddish brown precipitate

Pb^{2+}

Agent	reaction	note
HCl (2 mol/l)	$\text{Pb}^{2+} + 2\text{Cl}^- \rightarrow \text{PbCl}_2$	white precipitate soluble in hot water
K_2CrO_4 (5%)	$\text{Pb}^{2+} + \text{CrO}_4^{2-} \rightarrow \text{PbCrO}_4$	yellow precipitate
KI (5%)	$\text{Pb}^{2+} + \text{I}^- \rightarrow \text{PbI}_2$	canary yellow precipitate, soluble in hot water, after cooling golden flaky crystals of "golden rain" fall out

Cu²⁺

Agent	reaction	note
K ₄ [Fe(CN) ₆] (5%)	$\text{Cu}^{2+} + [\text{Fe}(\text{CN})_6]^{4-} \rightarrow \text{Cu}_2[\text{Fe}(\text{CN})_6]$	„Hatchett“ brown
NH ₃	$\text{Cu}^{2+} + 2 \text{OH}^- \rightarrow \text{Cu}(\text{OH})_2$ $\text{Cu}(\text{OH})_2 + 4 \text{NH}_3 \rightarrow \text{Cu}(\text{NH}_3)_4(\text{OH})_2$	bluish precipitate, in excess soluble in the blue complex [Cu(NH ₃) ₄](OH) ₂
Pt wire	Flame test - solid sample	blue-green flame

Bi³⁺

Agent	reaction	note
KI	$\text{Bi}^{3+} + \text{I}^- \rightarrow \text{BiI}_3$ $\text{BiI}_3 + \text{I}^- \rightarrow [\text{BiI}_4]^-$	brownish red precipitate, in an excess soluble to yellow-orange complex [BiI ₄] ⁻
thiourea - solid	$\text{Bi}^{3+} + \text{CS}(\text{NH}_2)_2 \rightarrow \text{complex compound}$	intense yellow to orange colouring

Fe³⁺

Agent	reaction	note
K ₄ [Fe(CN) ₆] (5%)	$4 \text{Fe}^{3+} + [\text{Fe}(\text{CN})_6]^{4-} \rightarrow \text{Fe}_4[\text{Fe}(\text{CN})_6]_3$	precipitate of "Prussian (Berlin)" blue
KSCN (5%)	$2 \text{Fe}^{3+} + 6 \text{SCN}^- \rightarrow \text{Fe}[\text{Fe}(\text{SCN})_6]$	blood-red precipitate
Na ₂ S ₂ O ₃ (0,1 mol/l)	$\text{FeCl}_3 + 2 \text{Na}_2\text{S}_2\text{O}_3 \rightarrow 2\text{FeCl}_2 + 2 \text{NaCl} + \text{Na}_2\text{S}_4\text{O}_6$	brown-violet color, which is immediately decolorized

Al³⁺

Agent	reaction	note
Na ₂ S ₂ O ₃ (0,1 mol/l)	$2 \text{Al}^{3+} + 3 \text{S}_2\text{O}_3^{2-} + 3 \text{H}_2\text{O} \rightarrow 2\text{Al}(\text{OH})_3 + 3\text{S} + 3 \text{SO}_2$	white precipitate of Al (OH) ₃ , SO ₂ escapes – odour, must be heated

Mg²⁺

Agent	reaction	note
NH ₃	$\text{Mg}^{2+} + 2 \text{NH}_3 + 2 \text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2 + 2 \text{NH}_4^+$	white precipitate of Mg (OH) ₂ - creating salts dissolve the precipitate
Na ₂ CO ₃ (5%)	$\text{Mg}^{2+} + \text{CO}_3^{2-} \rightarrow \text{MgCO}_3$	white precipitate
(NH ₄) ₂ HPO ₄ (10%)	$\text{Mg}^{2+} + \text{NH}_4^+ + \text{PO}_4^{3-} + 6 \text{H}_2\text{O} \rightarrow \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$	white crystalline precipitate
Titanium yellow	Filtr paper + titanium yellow → dry it + a drop of a sample + several drops of NaOH → red spot	intensive red colour



Ba²⁺

Agent	note	note
H ₂ SO ₄ (2 mol/l)	$\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4$	white precipitate
K ₂ CrO ₄ (5%)	$\text{Ba}^{2+} + \text{CrO}_4^{2-} \rightarrow \text{BaCrO}_4$	yellow precipitate which is soluble in diluted. HCl
Pt wire	Flame test - solid sample	green flame

Ca²⁺

Agent	note	note
(NH ₄) ₂ C ₂ O ₄ (2 mol/l)	$\text{Ca}^{2+} + \text{C}_2\text{O}_4^{2-} \rightarrow \text{Ca C}_2\text{O}_4$ heat it	white precipitate in NH ₃ medium
H ₂ C ₂ O ₄ (5%)	$\text{Ca}^{2+} + \text{C}_2\text{O}_4^{2-} \rightarrow \text{Ca C}_2\text{O}_4$	white precipitate
Pt wire	Flame test - solid sample	brick-red flame

NH₄⁺

Agent	note	note
NaOH (solid)	$\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$	moist pH paper turns blue

■ **CONCLUSION: Fill in the table.**

STUDENT'S SHEET No. 19

PROOF REACTIONS OF CATIONS

1. VOCABULARY

Match the Czech words with their English equivalents:

cation	roztok	1....
moist	činidlo	2....
solution	thiomočovina	3....
agent	titanová žluť	4....
thiourea	rovnice	5....
titanium yellow	zelenomodrý plamen	6....
equation	Pt drátek	7....
green- blue flame	kyselina šťavelová	8....
Pt wire	kation	9....
oxalic acid	vlhký	10....

2. **Choose the correct word or spelling:**

a) **Solid form in a solution is:**

- precipite
- precipate
- precipitate

- diluted acids
- dilluted acids
- dilutted acids

b) **pH paper must be used:**

- most
- moist
- mosti

d) **The colour of a precipitate is not stable, it is**

- declors
- coloured
- decolorized

c) **In cation proof reactions we often use:**

3. **Put the words into the right order:**

1. If/ another / precipitate /resulted, we /apply /no /is/ sample.
2. We/ the /spot /sample /on /apply/ a / plate/test.
3. will /Dividing /mixtures/ discussed/ in/ of/ be/ chemistry/ analytical.

4. **Mark the following cations with the right oxidation number 1+, 2+, 3+:**

Ca, Ag, Cu, Al, Mg, Na, K, Ba, Bi, K, Ni, Fe, NH₄



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

5. **Fill in the missing letters:**

M-ist -H pa-er tu--s bl-e.

Use t-e te-t tub- or a d- ippl-te.

Add mor- ox-lic ac-d s-luti-n.

P-epa-e ca-ion test in a fl-me.