Lesson 3. Control work № 3. Laboratory work № 3. Determination of Total Water Hardness

THE SELF-PREPARATION PROGRAM

1. Type of Volumetric glassware and its characteristics.
2. Using Volumetric Equipment.
3. Techniques for calibrating glassware.
4. Protolytometry or acid–base titration (a neutralization method): the basic concepts, titrants, indicators, rule for indicator choice, defined substances. Titration Errors with Acid/Base Indicators, Titration of Polyprotic Acids.
5. Rules of application of direct, indirect, return and reversive titration in different type of titrations.
6. The calculations of titration curves.
7. The Composition of Solutions During different type of Titrations.
8. Titration in non-aqueous solvents. Different type of solvent. Levelling effect. Indicators of protolytometry method in non-aqueous solutions. titrants, defined substances.
9. Complexation titrimetry and its classification. Complexing reactions, which use in titrimetry, requirements to them.
10. Mercurimetry: an essence, titrant, Stanardization of titrant, the indicator, titration conditions, practical application
11. Complexonometry: an essence, titrant, Stanardization of titrant, the indicator, titration conditions, practical application
12. Direct, back, displacement chelatometry. Application conditions.
13. Classification of precipitation titration.
14. Advantages, lacks, conditions of application of different methods of precipitation titration. Requirements to reactions in a method precipitation titration.
15. Titration Curves: the analysis, influence of solution concentration, solubilities of compounds and temperature on size inflection points.
16. Argentometry (Gay-Lussac method, method to point enlightenment, Mohr method, Fajans–Fisher–Khodacov method, Volhard method): an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application
17. Mercurometry: an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application
18. Calculation of molar concentration of solution according data of titration.
19. Calculation of solution titer (T) and amount of substance (m)

Laboratory work № 3. Part I. Determination of water hardness.

Water hardness is caused by dissolved calcium and magnesium salts. It is expressed by millimoles of Ca^{2+} and Mg^{2+} ions in a liter (mmol/l). The water is soft, if there is less than 4 mmol/l of Ca^{2+} and Mg^{2+} ions, it is moderately hard in case of 4-8 mmol/l, hard in case of 8-12 mmol/l, and very hard in case of more than 12 mmol/l. Water hardness can be either temporary (carbonate hardness, TH) or permanent (non-carbonate hardness, PH). Temporary hardness is caused by calcium and magnesium hydrocarbonates $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ dissolved in water, while permanent

hardness is maintained by sulfates, chlorides, silicates, phosphates, and nitrates of calcium and magnesium. Temporary and permanent water hardness form total water hardness (GH).

An amount of calcium and magnesium hydrocarbonates in water can be determined titrating by hydrochloric acid:

$$Ca(HCO_3)_2 + 2HCl \rightarrow CaCl_2 + CO_2 \uparrow + 2H_2O$$

$$Mg(HCO_3)_2 + 2HCl \rightarrow MgCl_2 + CO_2 \uparrow + 2H_2O$$

Task: To titrate by pretitrated HCl solution the unknown water and, for comparison, distilled water. According to data of the titration, to estimate water temporary hardness (TH), in mmol/l. To prepare the report of the analysis.

Procedure:

Prepare the vessels for titration: a burette, a pipette, a volumetric flask of 100 ml, and 3 Erlenmeyer flasks. Place 100 ml of the unknown water measured by pipette or volumetric flask to 2 Erlenmeyer flasks. Add 2-3 drops of methyl orange to each flask. Titrate by HCl solution of known concentration. Estimate average amount **a** (ml) of HCl used. For comparing place 100 ml of distilled water to an Erlenmeyer flask, add 2-3 drops of methyl orange and titrate by the same HCl solution. The amount of HCl used for this titration is **b** (ml). The volume of HC1, which has reacted Ca2+ and Mg2+ ions, is the following:

$$V_r = a - b \quad (ml)$$

$$TH = \frac{V_r \cdot n_r \cdot 10}{2} = V_r \cdot n_r \cdot 5 \qquad (mmol/l)$$

DETERMINATION OF WATER TOTAL HARDNESS

Task: To titrate by Trilon B the unknown water in alkaline medium obtained using ammonia buffer. According to data of the titration, to estimate water total hardness (GH). To calculate water permanent hardness (PH). To prepare the report of the analysis.

Procedure: Prepare the vessels for titration. Transfer 100 ml aliquots of the unknown water to 3 Erlenmeyer flasks. Add 5 ml of ammonia buffer ($NH_4OH + NH_4C1$) and a bit (size of a safety match's head) of the solid indicator Eriochrome Black T to each flask. Thoroughly mixed content of the flask gets red color. Titrate by Trilon B solution of known concentration. Titration is completed, when one drop of Trilon B solution changes the color of the solution from purple red to green blue, and the addition of one more drop for the control does not change the color any more.

According to the data of the titration, calculate water total hardness (GH):

$$GH = \frac{n_{tr.} \cdot V_{tr.} \cdot 1000}{2 \cdot V_{H_2O}}, \qquad (mmol/l)$$

The permanent water hardness (PH) is obtained when the temporary hardness (TH) is subtracted from the total one (GH):

$$PH = GH - TH, \quad (mmol/1)$$

Conclusion:

The results you present to teacher.