## HARDNESS OF WATER

## Experiment 1 <br> Determination of temporary hardness of tap water

Determination of temporary hardness of water is based on the titration of the water sample with a solution of hydrochloric acid of a known concentration in the presence of the indicator. During titration calcium and magnesium bicarbonates react with hydrochloric acid according to the reactions:

$$
\begin{aligned}
& \mathrm{Ca}\left(\mathrm{HCO}_{3}\right)_{2}+2 \mathrm{HCl}=\mathrm{CaCl}_{2}+2 \mathrm{H}_{2} \mathrm{O}+2 \mathrm{CO}_{2} \\
& \mathrm{Mg}\left(\mathrm{HCO}_{3}\right)_{2}+2 \mathrm{HCl}=\mathrm{MgCl}_{2}+2 \mathrm{H}_{2} \mathrm{O}+2 \mathrm{CO}_{2}
\end{aligned}
$$

Change of the indicator's color points to the end of the titration.
Laboratory equipment:
Chemicals:

- conical flasks, $\quad-0.1 \mathrm{M} \mathrm{HCl}$,
- burette, - indicator (methyl orange)
- pipette

Measure $100 \mathrm{~cm}^{3}$ tap water using measuring cylinder. Pour it into a conical flask, add 2 drops of methyl orange. Fill the burette with 0.1 N HCl to the volume marked " 0 ", and titrate water dropwise from a burette until the solution of the color change from yellow to pink. Read the burette volume of HCl used. Repeat titration. For the calculation take the average of the results. take into account that $1 \mathrm{~cm}^{3}$ of 0.1 N HCl corresponds to 2.8 mg of CaO .

## Experiment 2 <br> Determination of total hardness of water with disodium edetate

Determination of total hardness is based on the titration of the water sample containing ammonium buffer ( $\mathrm{pH} \sim 10$ ) solution of disodium EDTA to a known concentration as an indicator of Eriochrome black. In this environment, calcium and magnesium ions, which are responsible for water hardness, react with disodium edetate according to the reaction:


Laboratory equipment:

- conical flasks,
- burette, - indicator (Eriochrome black),
- pipette - ammonium buffer

In order to be sure observing the end of the titration, it is advisable to use comparative solution: the analyzed water containing the same amount of buffer and indicator. Measure $100 \mathrm{~cm}^{3}$ tap water using using measuring cylinder to 2 conical flasks, add $1 \mathrm{~cm}^{3}$ of the ammonium buffer with pipette and 5 drops of Eriochrome black indicator. Both flask set next to each other on a white sheet. The first solution is to be treated as a pattern of color, while the second titrate with 0.02 M EDTA solution until the color changes from red to blue. Read the burette volume of EDTA solution consumed. Repeated titration. For the calculation take the average of the results.

## Experiment 3

## Determination of hardness of water softened in ion-exchange column

Laboratory equipment:

- conical flasks,
- burette,
- pipettes

Chemicals:

- 0.1 M HCl ,
- 0.02 M EDTA
- indicators (methyl orange, Eriochrome black)
- ammonium buffer

Prepare two samples of the $100 \mathrm{~cm}^{3}$ of softened in ion-exchange column. One titrate as in Experiment 1, the second as in Experiment 2.

## Experiment 4

Determination of temporary and overall hardness of boiled water

Laboratory equipment:

- conical flasks,
- burette,
- pipettes - indicators (methyl orange, Eriochrome black)
- ammonium buffer

Prepare two samples of the $100 \mathrm{~cm}^{3}$ of boiled water. One titrate as in Experiment 1, the second as in Experiment 2.

## Disscusion of the results

1. Basing on titration results calculate transient hardness according to formula (1) and the overall hardness according to the formula (2). The results collectin the table on the report sheet. On the basis of the total hardness qualify tap water, ion-exchange column softened and softened by heat to a grade.

$$
\begin{gather*}
\mathrm{Tw}_{\text {przem }}=\mathrm{v}_{\mathrm{kw}} \cdot 2,8\left[{ }^{\mathrm{o}} \mathrm{n}\right]  \tag{1}\\
\mathrm{Tw}  \tag{2}\\
\mathrm{og} \\
=\frac{\mathrm{v}_{\text {EDTA }} \cdot 0,2 \cdot 1000}{\mathrm{v}_{\mathrm{w}}}\left[{ }^{\mathrm{o}} \mathrm{n}\right]
\end{gather*}
$$

$v_{\mathrm{kw}}$ - The volume of acid consumed for titration of the water sample $\left[\mathrm{cm}^{3}\right]$
$v_{w}$ - The volume of water taken for the titration $\left[\mathrm{cm}^{3}\right]$
$v_{\text {EDTA }}$ - Disodium edetate volume consumed for water titration $\left[\mathrm{cm}^{3}\right.$ ]
0.2 - Conversion factor - disodium edetate 1 cm 3 solution corresponds to 0.2 on.

Classify the water due to its hardness according to Table 1.
Table 1.Classification of water due to its hardness

| hardness of water <br> $\left[{ }^{\circ} \mathbf{n}\right]$ | class of water |
| :---: | :---: |
| $0 \div 4$ | very soft |
| $4 \div 8$ | soft |
| $8 \div 20$ | hard |
| over 20 | very hard |


| 20.......... | Name, surname: | Assistant <br> signature |
| :--- | :--- | :--- |
|  | Subject: HARDNESS OF WATER |  |

Results of titration

| type of water | $\mathbf{v}_{\mathbf{k w}}$ <br> $\left[\mathbf{c m}^{\mathbf{3}}\right]$ | temporary <br> hardness <br> $\left[{ }^{\mathbf{0}} \mathbf{n}\right]$ | $\mathbf{v}_{\text {EDTA }}$ <br> $\left[\mathbf{c m}^{3}\right]$ | overall <br> hardness <br> $\left[{ }^{\circ} \mathbf{n}\right]$ | class of <br> water |
| :--- | :---: | :---: | :---: | :---: | :---: |
| tap water |  |  |  |  |  |
| boiled water |  |  |  |  |  |
| water softened in ion- <br> exchange column |  |  |  |  |  |

Conclusions:

