

## Experiment: Hardness of Water

### Background information

Hard water is water that has high mineral content (in contrast with soft water). Hard water has high concentrations of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  ions. Hard water is not bad for your health but it can lead to problems in household appliances. For example washing machines may be damaged if used with hard water and without water softener over many years. Water gets hard on its way to your tap<sup>1</sup> if it gets into contact with particular rock in the ground, for example limestone<sup>2</sup>. At home the hardness of water is often shown by the non-formation of foam<sup>3</sup> when soap is mixed in a water sample<sup>4</sup>.

### Measurement<sup>5</sup>

- parts per million (ppm):  
usually defined as one milligram of calcium carbonate ( $\text{CaCO}_3$ ) per litre of water
- German degrees (Grad deutsche Härte, °dH):  
one German degree is defined as 17.85 milligrams of calcium carbonate per litre of water, or 17.85 ppm

### The experiment: Determination of hardness in water samples (Boutron-Boudet)

<b>reagents and equipment</b>	<ul style="list-style-type: none"> <li>○ 2 reference samples: hard water, soft water</li> <li>○ 2 water samples: tap water Kenzingen, tap water Denzlingen</li> <li>○ soap solution</li> <li>○ <u>graduated cylinder</u><sup>6</sup>, 4 <u>test tubes</u><sup>7</sup>, 4 <u>plugs</u><sup>8</sup>, pipette, ruler</li> </ul>
<b>Procedure</b>	<ol style="list-style-type: none"> <li>(1) Pour 5 mL of reference sample 'hard water' into a test tube, and 5 mL of reference sample 'soft water' into another test tube.</li> <li>(2) Using the pipette add soap solution to each of the test tubes. Start with 0.5 mL portions. Then go on to add soap solution drop by drop. Count the drops! After each addition put the plug on the test tube and shake it. Go on adding soap solution until a 2 cm <u>lasting</u><sup>9</sup> foam layer is formed.</li> <li>(3) Repeat this procedure with the 2 water samples.</li> </ol>
<b>observations and data</b>	[Use a separate sheet.]
<b>Interpretation</b>	<ul style="list-style-type: none"> <li>○ Calculate for each sample the overall volume of soap solution added.</li> <li>○ Use the table on the backside and determine the hardness of the different water samples in °dH and ppm.</li> <li>○ Assign a hardness range to the samples.</li> </ul>
<b>further tasks</b>	What's 'hard water' and what's 'heavy water'?

<sup>1</sup> Wasserhahn

<sup>2</sup> Kalkstein

<sup>3</sup> Schaum

<sup>4</sup> Probe

<sup>5</sup> Messung, Maßangabe

<sup>6</sup> Messzylinder

<sup>7</sup> Reagenzglas

<sup>8</sup> Stopfen

<sup>9</sup> bleibend

volume (soap solution added)	hardness in ° dH	hardness range
0.5 ml 1.0 ml 1.5 ml	2.5° 5.0° 7.5°	soft
2.0 ml 2.5 ml 3.0 ml	10.0° 12.5° 15.0°	moderately hard
3.5 ml 4.0 ml 4.5 ml	17.5° 20.0° 22.5°	hard
5.0 ml 5.5 ml 6.0 ml	25.0° 27.5° 30.0°	very hard

### Annotations:

#### **Aims:**

- o experiencing the English language as means of communication in a chemistry laboratory
- o introducing students to some chemistry related technical terms (with view to the visit to Croatia)
- o determining the hardness of two tap water samples after Boutron and Boudet

#### **Content:**

- o As said in the introduction on the worksheet the hardness of water is relative to the formation of foam when soap solution is added. Hence, the students determine how much soap solution can be added to a water sample until a foam layer of a certain height is formed. Roughly speaking one can say: If there is a lot of foam formed quickly with only little soap solution, the water is rather soft. To the contrary, if you need to add a lot of soap solution to produce at least some foam, the water is rather hard. The students make this basic observation when testing the two reference samples.
- o Now the students test two tap water samples of which the hardness range is to be determined. The experience gained in the first part of this laboratory will now be of value for the students when testing two unknown samples. According to the procedure description, they add soap solution to the samples and calculate the overall volume of soap solution. Two drops of soap solution equal 0.1 mL.

#### **Result:**

Tap Water Kenzingen:

- o After **3.1 mL** (= class average) of **soap solution** were added, a 2 cm lasting foam layer was formed.
- o This means that Kenzingen's tap water is **moderately hard to hard**.
- o  $\approx$  **15.5 – 16 ° dH**
- o 1 ° dH equals 17.85 ppm. → 15,75 ° dH equals **281.14 ppm**.

(An additional test with a test strip as used for fish tanks (roughly) confirmed the students' result.)

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#### **Sources:**

- o <http://www.seilnacht.com>.
- o <http://de.wikipedia.org>.
- o Gibb and Hawley: *Intermediate 2 - chemistry (success guides)*. Leckie Leckie. 2006.