

Determination of the amount of hardness in water using soap solution

Introduction

Soft water readily forms **lather** with soap, but it is more difficult to form lather with hard water. Hard water contains dissolved calcium or magnesium compounds. This can 'fur up' kettles, boilers and pipes, which wastes energy and can be dangerous if the flow of water is impeded. The calcium ions and magnesium ions in hard water react with the soap to form scum, so more soap is needed to form a lather.

Temporary hard water contains calcium and magnesium hydrogencarbonate. Temporary hard water becomes soft on boiling (forming limescale). Permanent hard water does not become soft when it is boiled.

Apparatus

100cm³ conical flask and stopper
dropping pipette
50cm³ measuring cylinder
water samples - **A, B, C, D**, boiled **A**, boiled **B**, boiled **C**, boiled **D**
stopwatch
soap solution

Method

1. Measure 50cm³ of water sample **A** into a conical flask.
2. Add 1 cm³ of soap solution, insert the stopper and shake vigorously for 5 seconds.
3. Repeat step 2 until a lather forms that lasts for 30 seconds. Record the total volume of soap solution added.
4. Repeat steps 1-3 with 50cm³ samples of all other types of water.

Analysis

1. Draw a bar chart of volume of soap solution against water sample.
2. Use your results to identify which samples are: soft water, temporary hard water and permanent hard water.

Risk Assessment

Hazard	Risk	Control measure
Soap solution made up in alcohol is an irritant	Soap splashing into eyes when using dropping pipette	Wear safety goggles

Teacher / Technician notes

Wanklyn's or Clarke's soap solution can be used.

Suggested hard water concentration (and approximate volume of soap solution required)

- **A - Soft Water**
 - Unboiled de-ionised water (1 cm³)
 - Boiled de-ionised water (1 cm³)
- **B - Permanent Hard Water**
 - Unboiled 60% magnesium hard water, 40% calcium hard water (8 cm³)
 - Boiled 60% magnesium hard water, 40% calcium hard water (8 cm³)
- **C - Temporary Hard Water**
 - Unboiled 50% magnesium hard water, 50% calcium hard water (12 cm³)
 - Boiled de-ionised water (1 cm³)
- **D - Permanent hard water**
 - Unboiled calcium hard water (15 cm³)
 - Boiled calcium hard water (15 cm³)
- Hard water solutions
 - Magnesium hard water – 0.45g/dm³ magnesium sulfate
 - Calcium hard water – 0.45g/dm³ calcium sulfate

Sample **C** is used to represent boiled temporary hard water to demonstrate that hardness has been removed. Teachers may want to create a further sample that contains a mixture of permanent hard water and temporary hard water to extend the experiment for more able students.

- **E - Permanent hard water**
 - Unboiled calcium hard water (15 cm³)
 - Boiled 50% calcium hard water, 50% de-ionised water (8 cm³)

Results are best recorded in a tally chart to enable students to record each time 1 cm³ of soap is added to the solution.

Water sample	Tally chart of 1 cm ³ portions of soap solution added (cm ³)	Total volume of soap solution added (cm ³)

Working scientifically skills covered

1. Development of scientific thinking

Explain every day and technological applications of science; evaluate associated personal, social, economic and environmental implications and make decisions based on the evaluation of evidence and arguments.

2. Experimental skills and strategies

Plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena.

3. Analysis and Evaluation

Translate data from one form to another.

Interpret observations and other data including identifying patterns and trends, making inferences and drawing conclusions.

Evaluate data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.