

# Hard water challenge

Download the teacher notes,  
student workbook and technician notes  
that accompany this resource at  
[rsc.li/3Pqq6Jz](https://www.rsc.li/3Pqq6Jz).

# Learning objectives

By the end of this session, you will be able to:

- Explain the construction and use of a look-up chart.
- Follow instructions for carrying out a procedure to test hard water.
- Compare the effectiveness of different water filters.
- Describe the domestic and health issues associated with hard water.



# What is calcium?

**Calcium** is a metallic element that can be found in many rocks on the Earth's surface. It is often found as the compound calcium carbonate in rocks such as marble, limestone and chalk.





## What is hard water?

Acid rain slowly dissolves calcium carbonate in rocks to form 'hard water'.

Dissolved calcium (and magnesium) **ions** can cause problems such as limescale in kettles, washing machines and shower heads.

Hard water is better for your health due to its higher mineral levels than soft water.

Rainwater and distilled water are considered 'soft' because they contain no dissolved metal ions.



# Testing the hardness of water

The concentration of dissolved calcium ions (otherwise known as the 'hardness' of the water) can be determined by taking one kilogram of water (approximately one litre) and finding the mass of dissolved calcium ions in milligrams.

A 1 kg sample of water containing 0.100 g (100 mg) of calcium ions has a concentration of **100 parts per million (ppm)**.

A sample of water can be classified using the concentration of its dissolved ions:

Classification	Concentration / ppm
Soft	< 60
Moderately hard	60–120
Hard	120–180
Very hard	> 181



## Laboratory analyst

Meet Joseph, a laboratory analyst and higher degree apprentice, who works at Thames Water and carries out vital safety tests on drinking water for 15 million people.

**A FUTURE IN CHEMISTRY**  
**MAKING THE DIFFERENCE**

Laboratory analyst



# Hardness of water classification

Classification	Concentration / ppm
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## Activity 1

# Measuring calcium concentrations

▶ See student workbook



## Measuring calcium concentrations answers

- (a) 4.5% of people are colour blind (most being male with 8% of men being colour blind). You should be able to reflect on the method and relate this to the accuracy of your results.
- (b) You could have more confidence in your results if you had calculated an average result after many repetitions. You could calculate class averages to demonstrate this.
- (c) The best-fit line should show a linear relationship. Are there any outlying results? Do all the groups have similar charts?
- (d) Soft water lathers better with soap, which enables people to clean themselves more effectively and remove germs that may cause health issues such as infections. Soft water also reduces scale build-up in kettles and other appliances.



## Water filters

You can remove calcium ions from hard water to make the water soft.

An ion-exchange water softener exchanges calcium (and other ions such as magnesium) for sodium ions. As the concentration of calcium falls the likelihood of limescale damage falls too.



# Analytical chemists

Analytical chemists work hard to make sure that we have safe drinking water.

Meet Harsh and Michael, analytical chemists, who both work at Thames Water and have the critical job of analysing samples of water to keep drinking water and sewage systems safe and operational.

**A FUTURE IN CHEMISTRY**  
**MAKING THE DIFFERENCE**

Analytical chemist





## Activity 2

# Investigating ion-exchange filters

▶ See student workbook



## Investigating ion-exchange filters answers

- (a) Discuss some ways in which you can compare effectiveness.
- (b) For example, you could use the difference between the percentage changes in ppm of calcium ions after the water was filtered. The difference between filters could be expressed as a percentage. For example, filter A removes 20% more ions than filter B.
- (c) Your sketch might show the water filter being positioned so that it allows soft water to be used upstairs in the bathrooms and downstairs by the appliances in the kitchen. Mains water should be allowed to bypass the filter for drinking water so that people can drink hard water rather than soft water.





## Activity 3



# Using dipsticks to measure the hardness of water

▶ See student workbook

## Using dipsticks to measure the hardness of water answers

- (a) The answers will vary but consider whether the results from the dipstick tests were consistently accurate across the range of solutions tested.
- (b) These might be useful to test whether your home water softener is working, or to see whether your local water supply is hard or soft (you could then consider using water-softening products in your appliances). It is also important to monitor water hardness in aquariums, in hydroponics and in horticulture as mineral and pH levels can affect growth. The ions in hard water can also cause limescale and leave deposits that clog pipes, which makes it important for plumbers to maintain central heating systems.



# Acknowledgements

This resource was originally developed by Nottingham Trent University to support outreach work delivered as part of the Chemistry for All Project.

To find out more about the project, and get more resources to widen participation, visit our Outreach resources hub: [rsc.li/3CJX7M3](https://rsc.li/3CJX7M3).

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