

HARDNESS OF WATER

Hard water is the water that does not readily form lather with soap.

Soft water is the water that readily forms lather with soap.

Hardness in water is caused by dissolved chlorides, sulphates and hydrogen carbonates of magnesium and calcium.

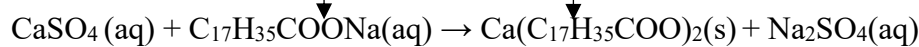
Action of soap on hard water

When soap is used in hard water, a white precipitate called scum forms.

Calcium sulphate + sodium stearate \rightarrow calcium stearate + sodium sulphate

(soap)

(scum)



Types of hardness of water

There are two types of hardness of water:

1. Temporary hardness

This type of hardness is caused by the presence of dissolved magnesium hydrogen carbonate or calcium hydrogen carbonate in water and can be removed by boiling.

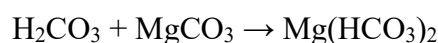
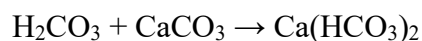
2. Permanent hardness.

This type of hardness is caused by the presence of dissolved chlorides and sulphates of magnesium and calcium. These cannot be removed by boiling the water.

How Water Becomes Hard

(a) Temporary hard water

- When rain water falls, it dissolves the carbon dioxide in the air to form carbonic acid.
 $\text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g}) \rightleftharpoons \text{H}_2\text{CO}_3(\text{aq})$
- When this water reaches the earth's surface, it passes through soil or rocks containing limestone (calcium carbonate), dolomite or magnesium carbonate.
- The carbonic acid in the rain water reacts with the calcium carbonate or magnesium carbonate to form calcium hydrogen carbonate or magnesium hydrogen carbonate.



(b) Permanent hard water

- Permanent hard water occurs when water flows through rocks rich in calcium sulphate (gypsum), magnesium sulphate or chloride.
- These salts are highly soluble in water and remain dissolved even after boiling.
- They are thermally stable, so boiling the water will not break them down.

Methods of removing hardness of water.

a. Methods of removing temporary hardness of water.

Temporary hardness of water can be removed by the following methods:

1. Boiling

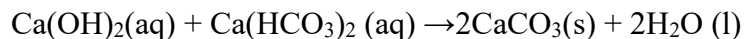
Boiling decomposes calcium hydrogen carbonate and magnesium hydrogen carbonate to form insoluble calcium carbonate and magnesium carbonate respectively. The insoluble carbonates are filtered off leaving soft water.



2. Addition of calcium hydroxide (lime water).

Calculated quantity of calcium hydroxide is used to remove temporary hardness of water.

It precipitates insoluble calcium carbonate hence removing the calcium ions that cause hardness.



3. Addition of aqueous ammonia.

This precipitates out calcium or magnesium carbonate and are filtered from the water.



b. Methods of removing both temporary and permanent hardness

1. Distillation.

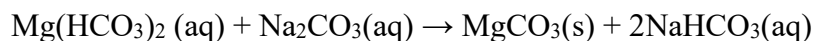
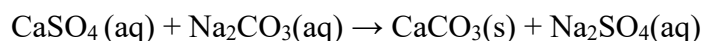
Distillation of water removes both types of hardness of water. Water is boiled to form vapour, vapour is condensed to form pure and soft water.

Solid impurities are left in the distillation flask.

This is the most expensive method.

2. Addition of washing soda (Na₂CO₃)

This precipitates insoluble calcium carbonate or magnesium carbonate which can be filtered off.

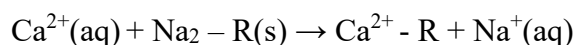


3. Use of ion exchangers

The hard water is passed through a container filled with small beads containing ion exchange resin.

Resin contains sodium ions that are weakly attached to it.

When hard water is passed through an ion exchanger, calcium or magnesium ions replace sodium ions and attach themselves on the resin.



Calcium or magnesium ions are therefore left behind in the resin while soft water and sodium ions flows out the container.

When all the sodium ions have been removed from the resin, it can be regenerated by adding a concentrated solution of sodium chloride into the exchanger.

Advantages and disadvantages of hard water

Advantages of hard water	Disadvantages of hard water
<ul style="list-style-type: none">It has a good taste	<ul style="list-style-type: none">Wastes soap – some of the soap is used to produce scum – more soap is required for washing.
<ul style="list-style-type: none">Provides calcium required for strong bones and teeth.	<ul style="list-style-type: none">It leads to the formation of furs in kettles and boilers (boiler scale). This can lead to wastage of fuel because fur is a bad conductor of heat.
<ul style="list-style-type: none">Prevents lead poisoning – coats lead pipe with a thin layers of lead (II) sulphate and carbonate.	<ul style="list-style-type: none">Causes dirty marks (stains) on clothes and in baths.
<ul style="list-style-type: none">Helps in the formation of shells in some organisms eg. Snail and egg shells.	<ul style="list-style-type: none">Reduces the lifespan of the household appliances.

Exercise

1. Explain how hard water can be made soft using an ion-exchange column.

OR

Ion exchange columns can be used to soften hard water. Describe how ion exchange column softens water.

2. An ion exchange column is used for a few weeks. Sodium chloride solution now needs to be passed through the ion exchange column. Suggest why.

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