

Subject Name: Engineering Chemistry

Unit No:1 Unit Name: WATER

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Lecture No: 2

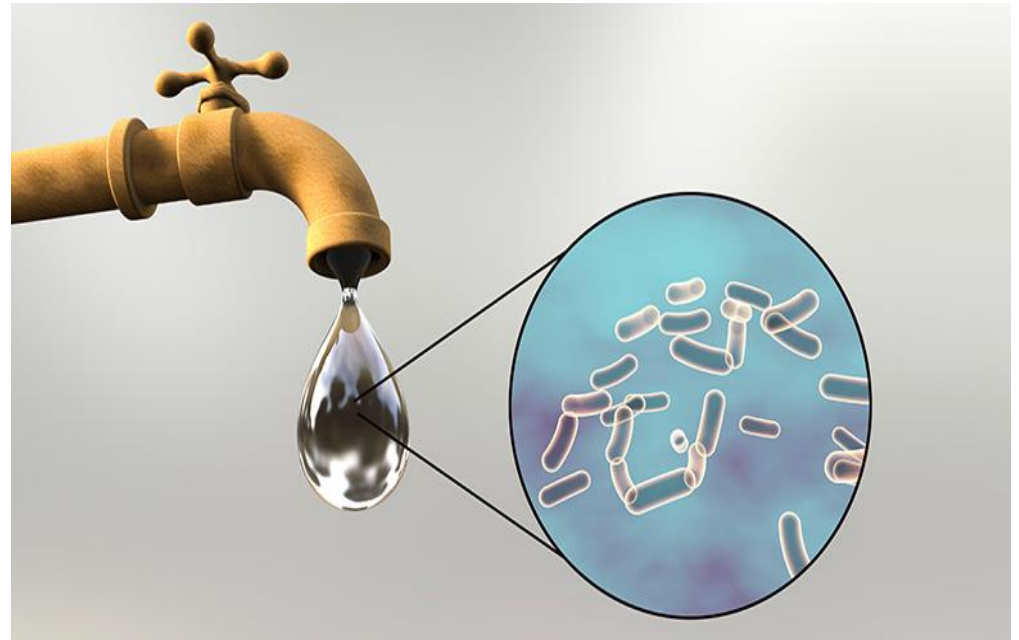
Hardness of water and numericals



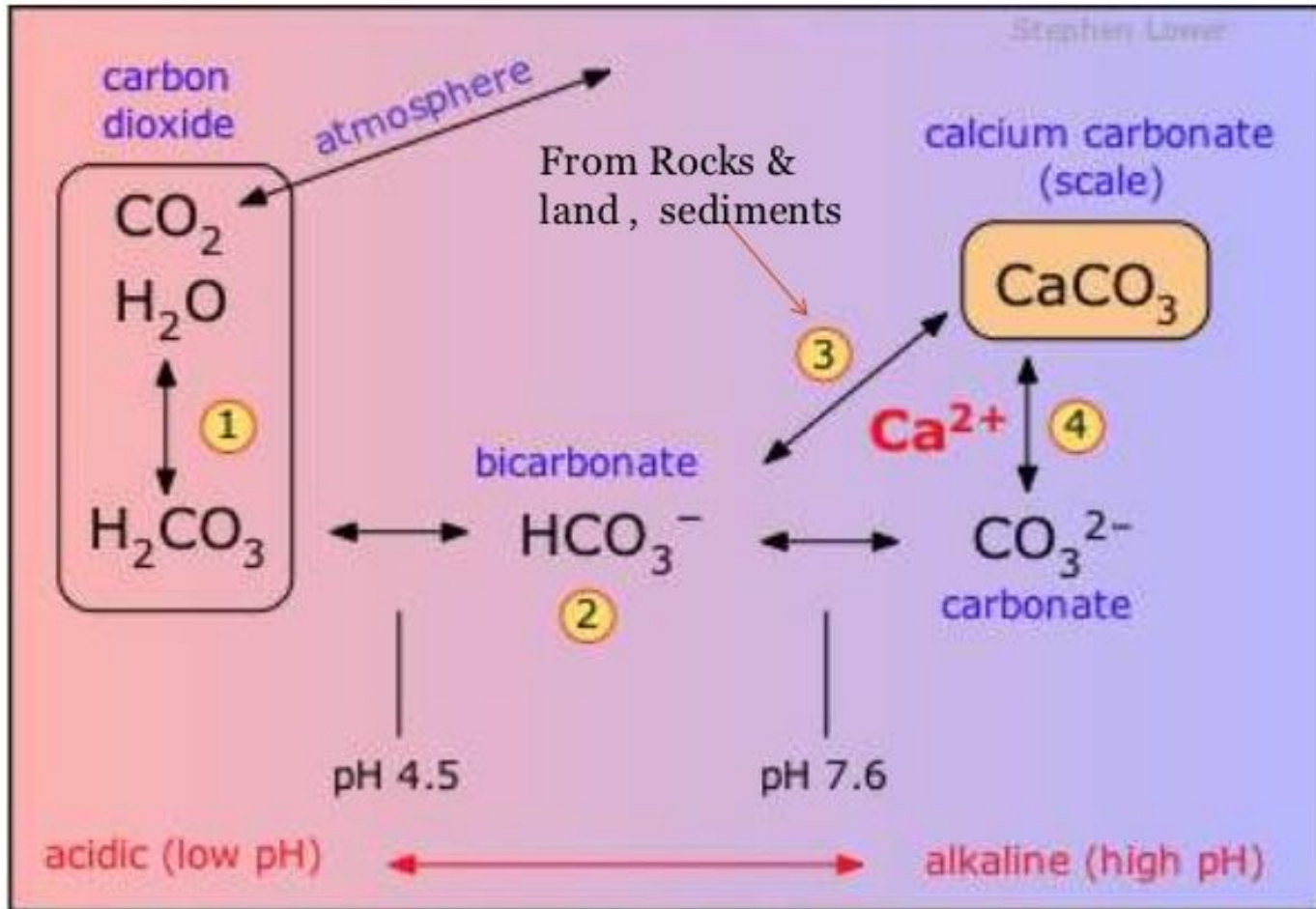
Water

There are mainly three types of water:

1. Physical
2. Chemical
3. Biological



Origin of Hardness: Mechanism



Water-Impurities

Physical Impurities

These include colour, turbidity, taste, odour, etc.

Colour in water is due to metallic substance like salt of iron, manganese, algae, etc.

Turbidity is due to colloidal matter. Different taste is due to presence of metallic ions like iron, aluminium, manganese, etc.

Odour in water is undesirable for domestic as well as industrial purposes.

Disagreeable odour is due to the presence of living organisms, decaying vegetation including algae, bacteria and fungi

Physical Impurity



Test by colour, odour, taste

Water-Impurities

Chemical Impurities

These include inorganic and organic chemicals released from dyes, paints and varnishes, drugs, insecticides, pesticides, detergents, textile , etc.

Acidity in water is harmful. Surface water and ground water attain acidity from industrial waste like acid, mine, drainage, etc. Acidity is also caused by the presence of free CO₂.

Polluted water acquires CO₂ from the biological oxidation of organic matter. Dissolved O₂ in industrial water is not desirable. It includes corrosion reaction. Dissolved O₂ in water is essential to life of aquatic organism such as fishes.

Dissolved NH₃ in water arises from the decomposition of nitrogenous organic matter.

Chemical Impurity



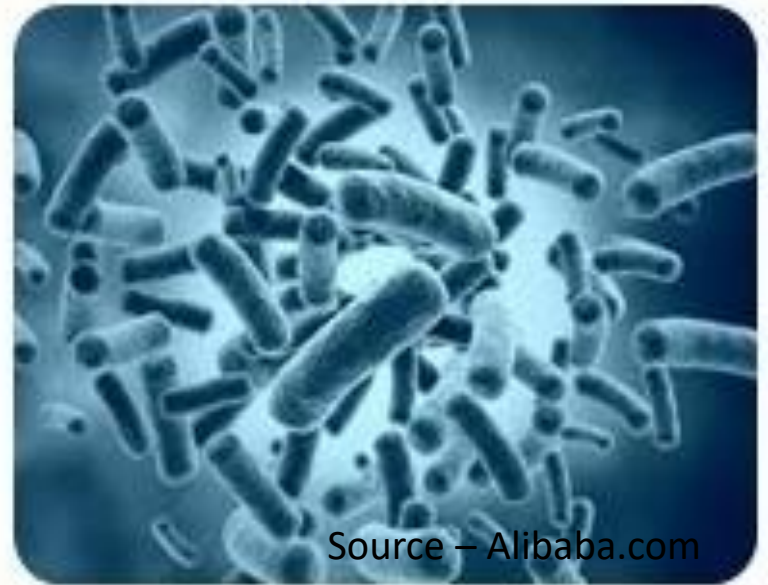
Water-Impurities

Biological Impurities

These are algae, pathogenic bacteria, fungi, viruses, parasites, etc.

The source of these contaminations is discharge of domestic and sewage waste, etc.

Bacteriological Impuriy



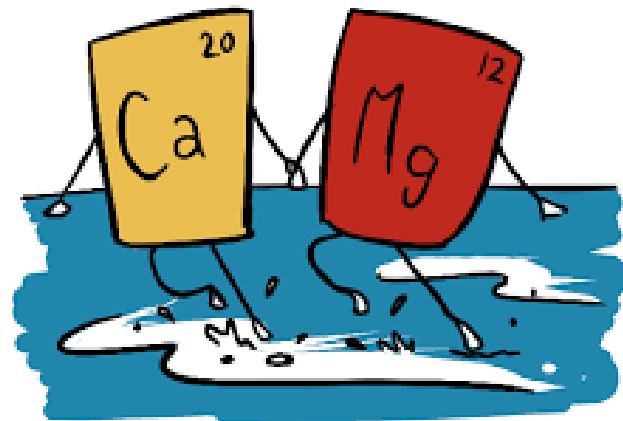
Source – Alibaba.com

Dissolved Compounds-Hardness

1. Calcium Bicarbonate
2. Magnesium Bicarbonate
3. Calcium Sulphate
4. Magnesium Sulphate

Less Common

- Calcium Chlorides and Nitrates
- Magnesium Chlorides and Nitrates
- Iron and Manganese salts
- Aluminium Compounds



Hardness

Hardness: “ The property of water to form an insoluble curd with soap instead of lather. In other words it is the soap destroying property due to the presence of Bicarbonates, Sulphates and Chlorides of Calcium and Magnesium.”

Hardness of water is expressed / measured in terms of milli equivalent / litre

□ 1 milli-equivalent = 50 mgs. of CaCO_3 / litre



Soft water----- = 1 m.Eq. / litre

Moderately hard water--- = 1-3 m.Eq. / litre

Hard water----- = 3-6 m.Eq. / litre

Very hard water---- = 6 and > 6 m.Eq. / litre



Types of Hardness

Carbonate Hardness Or Temporary Hardness

**Calcium and Magnesium-
carbonates and Bi-carbonates**

Non-Carbonate Hardness Or Permanent Hardness

**Calcium sulfate
Magnesium sulfate
Calcium Chloride
Magnesium Chloride**

TEMPORARY HARDNESS:

It is due to the presence of Bicarbonates of Calcium & Magnesium and can be removed by boiling.

PERMANENT HARDNESS:

It is due to the presence of Sulphates, Nitrates and Chlorides of Calcium & Magnesium.



A. FOR TEMPORARY HARDNESS:

- 1. Boiling**
- 2. Addition of Lime**

B. FOR PERMANENT HARDNESS:

- 1. Addition of Lime**
- 2. Addition of Sodium Carbonate**
- 3. Base Exchange method / Permutit Process**



How to define hardness of water?

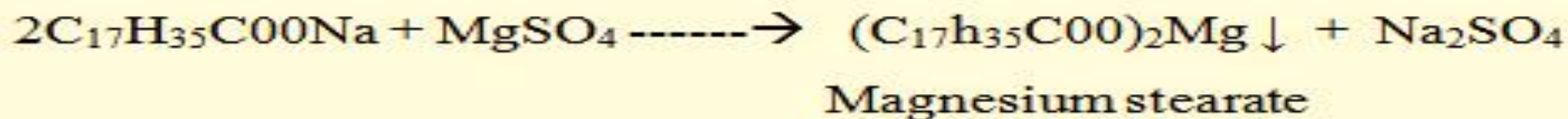
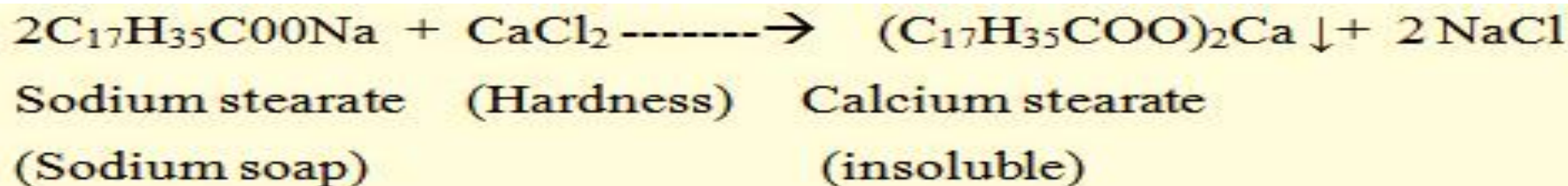
Hardness in water is that characteristic, which prevents the lathering of soap. This is due to presence in water of certain salts of calcium, magnesium and other heavy metals dissolved in it.

A sample of hard water, when treated with soap (sodium or potassium salt of higher fatty acid like oleic, palmitic or stearic) does not produce lather, but on the other hand forms a white scum or precipitate.

This precipitate is formed, due to the formation of insoluble soaps of calcium and magnesium. Typical reactions of soap (sodium stearate) with calcium chloride and magnesium sulphate are depicted .



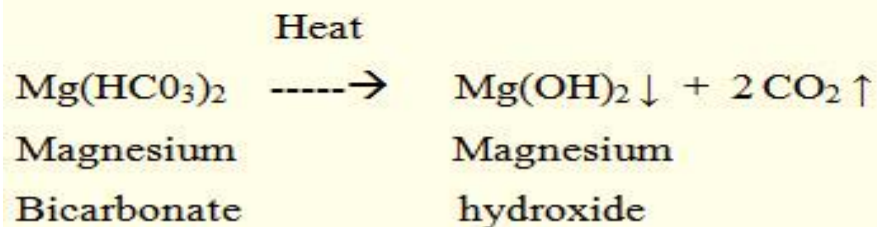
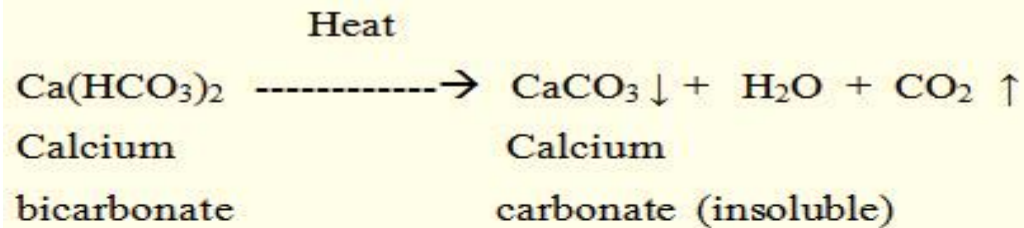
Hardness equations



Water which does not produce lather with soap solution readily but forms a white curd is called **Hard water**.

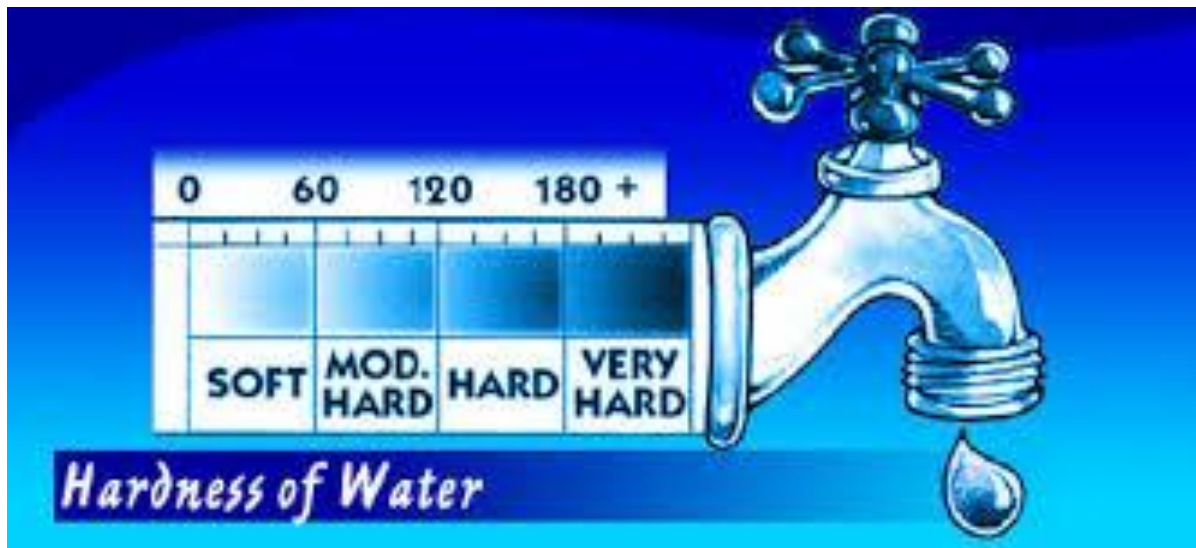
Other hand, water which lathers easily on shaking with soap solution is called **Soft water**.

Removing Temporary Hardness



Total Hardness

Total Hardness = [Temporary Hardness + Permanent Hardness]



Hardness Units

(1) **Parts per million (ppm)** is the parts of calcium carbonate equivalent per 10^6 parts of water, i.e., $1 \text{ ppm} = 1 \text{ part of CaCO}_3 \text{ eq. hardness in } 10^6 \text{ parts of water}$.

(2) **Milligrams per liter (mg/L)** are the number of milligrams of CaCO_3 equivalent hardness present per liter of water. Thus;
 $1 \text{ mg/L} = 1 \text{ mg of CaCO}_3 \text{ eq. hardness of 1 L of water}$

But 1 L of water weighs

$$= 1 \text{ kg} = 1,000 \text{ g} = 1,000 \times 1,000 \text{ mg} = 10^6 \text{ mg}.$$

$$\therefore 1 \text{ mg/L} = 1 \text{ mg of CaCO}_3 \text{ eq. per } 10^6 \text{ mg of water}.$$

$$= 1 \text{ part of CaCO}_3 \text{ eq. per } 10^6 \text{ parts of water} = 1 \text{ ppm}$$



Numerical

Problem : The water sample contains the following impurities in mg/L.

$\text{Mg}(\text{HCO}_3)_2 = 7.3$, $\text{MgCl}_2 = 9.5$, $\text{Ca}(\text{HCO}_3)_2 = 16.2$, $\text{CaSO}_4 = 13.6$

Calculate the temporary permanent and total hardness.

Solution:

Conversion into CaCO_3 equivalent:

Constituents	Quantity in mg/L	Multiplication factor	CaCO_3 equivalent
$\text{Mg}(\text{HCO}_3)_2$	7.3	100/146	05
MgCl_2	9.5	100/95	10
$\text{Ca}(\text{HCO}_3)_2$	16.2	100/162	10
CaSO_4	13.6	100/136	10

$$\begin{aligned}\text{Temporary Hardness} &= \text{Hardness due to } [\text{Mg}(\text{HCO}_3)_2 + \text{Ca}(\text{HCO}_3)_2] \\ &= 5 + 10 \\ &= 15 \text{ ppm}\end{aligned}$$

$$\begin{aligned}\text{Permanent Hardness} &= \text{Hardness due to } [\text{MgCl}_2 + \text{CaSO}_4] \\ &= 10 + 10 \\ &= 20 \text{ ppm}\end{aligned}$$

$$\begin{aligned}\text{Total Hardness} &= \text{Temporary Hardness} + \text{Permanent Hardness} \\ &= 15 + 20 \\ &= 35 \text{ ppm}\end{aligned}$$

Thus,

Temporary hardness = 15 ppm, Permanent hardness = 20 ppm, Total hardness = 35 ppm



Can you answer?

- **What is the concept of Hardness of Water?**
- **What are the salts responsible for hardness?**

Types of hardness

<https://www.youtube.com/watch?v=INAMfROxbZI>

Impurities in water

<https://www.youtube.com/watch?v=Pqtq8JoTvYg>



Thank You

