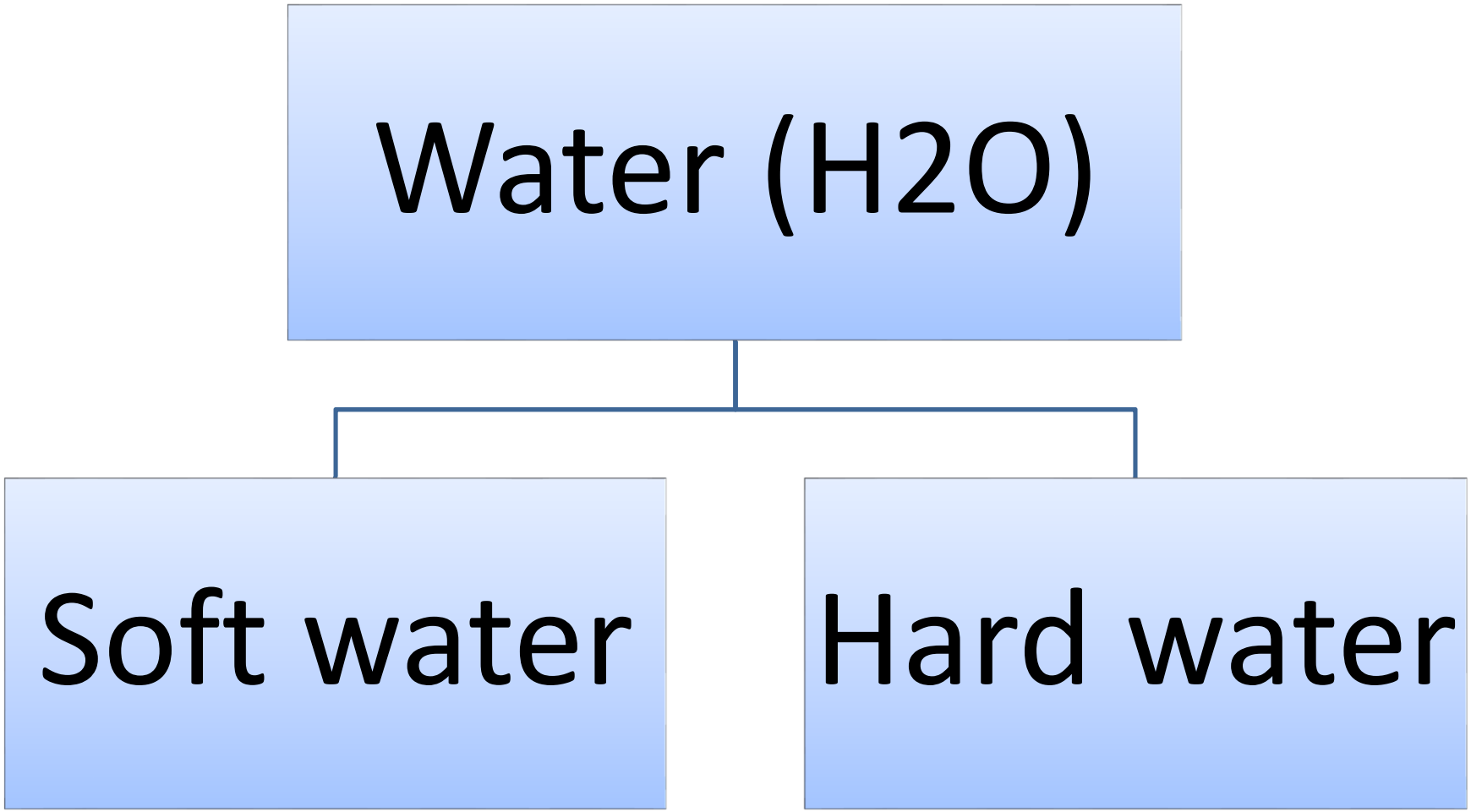
Hardness of water

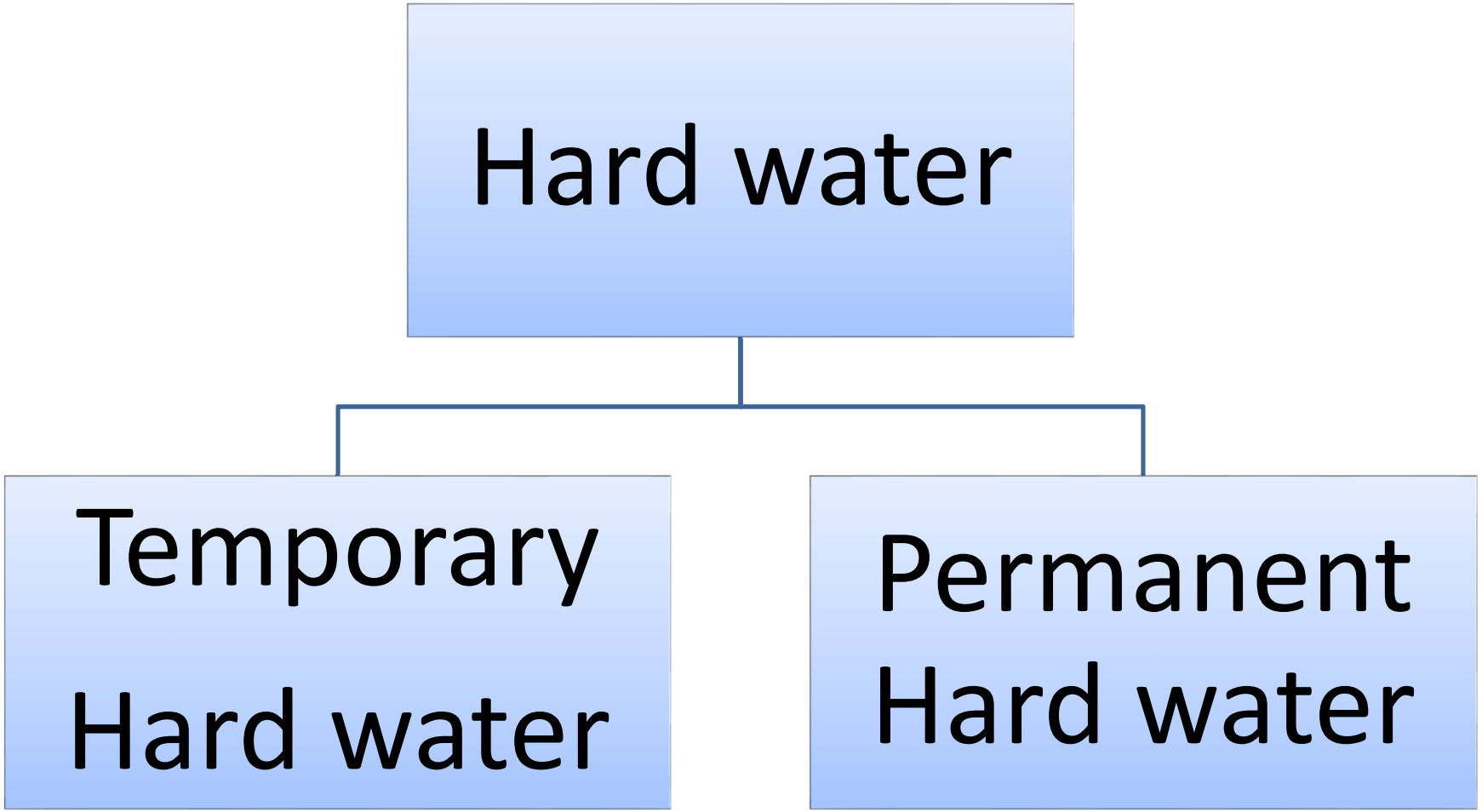

Water (H2O)
Soft water
Hard water

Soft water

- Water consists of low concentration of calcium and magnesium salts.
- It gives foam with soap
- Examples:
  - Tap water.
  - Drinking water.

Hard water

- Hard water is due to the presence of high concentration of calcium and magnesium salts that are dissolved in water.
- It doesn't form foam with soap.
- Examples:
  - Sea water.


Hard water
Temporary Hard water
Permanent Hard water

Temporary Hardness

- **Temporary Hardness** is due to the presence of Ca^{2+}, Mg^{2+} in the form of the bicarbonate ion HCO_3^-, being present in the water.
- This type of hardness can be treated by boiling the water to expel the CO_2, as indicated by the following equation:
- $Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3 + H_2O + CO_2$
- $Mg^{2+} + 2HCO_3^- \rightarrow MgCO_3 + H_2O + CO_2$

- Bicarbonate hardness is classified as temporary hardness

Permanent Hardness

- **Permanent hardness** is due to the presence of the ions Ca^{2+}, Mg^{+2} in the form of $Cl^{-}$and SO_4^{2-}. This type of hardness cannot be eliminated by boiling.
- The water with this type of hardness is said to be *permanently hard*
- As it can't be treated easily ,so it's treated by chemical treatment such as: ion exchange resin.

Problems of hard water

- Originally, water hardness was defined as the measure of the capacity of the water to precipitate soap
- It forms scales in the boiler that may cause:
  1. Decreasing in heat exchange efficiency.
  2. Corrosion takes place.
  3. Explosion.

Scales due to hard water

Scales due to hard water

Boiler scale on water side

Determination of Total hardness

- The ions involved in water hardness, i.e. $Ca^{2+}(aq)$ and $Mg^{2+}(aq)$, can be determined by titration with a chelating agent ethylenediaminetetraacetic acid (EDTA), usually in the form of disodium salt (H_2Y_2-). The titration reaction is:

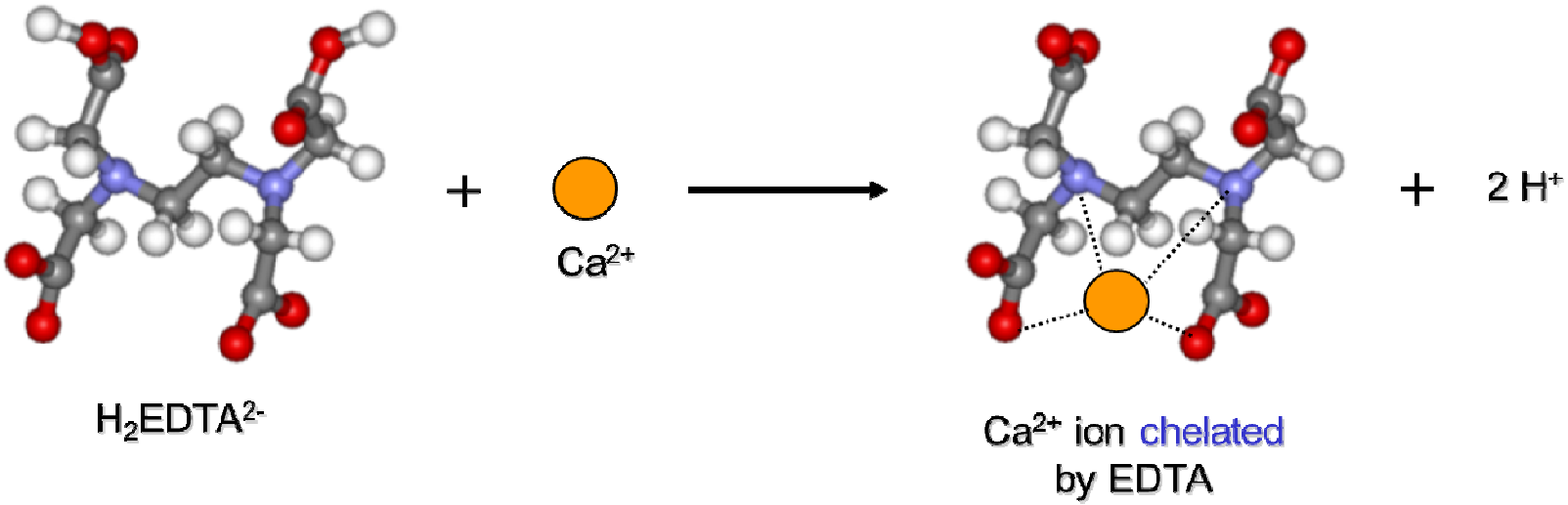
During titration:

$$H_2Y^{2-}(aq) + Ca^{2+}(aq) \rightarrow CaY^{2-}(aq) + 2\,H^{+}(aq)$$
$$H_2Y^{2-}(aq) + Mg^{2+}(aq) \rightarrow MgY^{2-}(aq) + 2\,H^{+}(aq)$$

At end point

$$H_2Y^{2-}(aq) + \underset{\text{Wine-red}}{MgIn^{-}(aq)} \rightarrow MgY^{2-}(aq) + \underset{\text{sky-blue}}{HIn^{2-}(aq)} + H^{+}$$

Determination of Total hardness



Determination of Total hardness

- When both Ca and Mg are both determined, this experiment is called total hardness.
- **Chelating agent:** EDTA which is capable to react with Ca and Mg ions that present in sample solution.
- **Hardness solution(I), (II):** (NH_4OH+NH_4Cl) and (KOH) used as buffer solution that keeps the pH = 10.
- **Sample solution:** Tap water.
- **Indicators:** ManVer which has the ability to select both (Ca, Mg) ions and the calVer has the ability to select Ca ion only.

Determination of total hardness

Procedures:

- Get 10 ml of tap water as a sample solution in a conical flask.
- Add 1 ml of hardness solution (I) to the sample.
- Add 2 drops of indicator (manVer) to the sample solution.
- Fill the burette with standard solution of EDTA (0.01M).
- Titrate EDTA against the sample until the color of the indicator changes from red to blue.
- Repeat these steps 3 times.
- Calculate the average value of the three volumes.

Determination of total hardness

Reading	V_1 (ml)	V_2 (ml)	V_3 (ml)	$V_{average}$ (ml)
Volume	.....	.....	.....	.....

$$V_{average} = (V_1 + V_2 + V_3) / 3$$

Concentration of (Ca + Mg) = $V_{av.}$ *100 = ... mg/l

Determination of calcium hardness

Procedures:

- Get 10 ml of tap water as a sample solution in a conical flask.
- Add 1 ml of KOH as hardness solution to the sample.
- Add 2 drops of indicator (calVer) to the sample solution.
- Fill the burette with standard solution of EDTA (0.01M).
- Titrate EDTA against the sample until the color of the indicator changes from red to blue.
- Repeat these steps 3 times.
- Calculate the average value of the three volumes.

Determination of calcium hardness

Reading	V_1 (ml)	V_2 (ml)	V_3 (ml)	$V_{average}$ (ml)
Volume	.....	.....	.....	.....

$$V_{average} = (V_1 + V_2 + V_3) / 3$$

Concentration of (Ca) = $V_{av.}$ *100 = ... mg/l

Thank you