EXPERIMENT: To find the temporary and permanent hardness of water sample by complexometric titration using standard EDTA solution

THEORY: Hardness of water is due to the presence of soluble salts of Ca and Mg. It is an important parameter to judge the quality of water. Determination of hardness of water by EDTA titration is a very accurate method based on the fact that when Eriochrome black-T (EBT; blue dye) is added to the hard water (at about pH 10), it gives a wine red colored unstable complex with Ca^{2+}/Mg^{2+} ions.

Temporary hardness in a water sample is caused by bicarbonates of hardness producing ions (Ca^{2+} and Mg^{2+}). This can be removed by prolonged boiling due to decomposition of bicarbonates with the evolution of CO_2 and simultaneous precipitation of the respective carbonates. When EDTA (ethylene diammine tetraacetic acid) solution is added to the hard water (with permanent or temporary hardness), the unstable wine red complex of Ca^{2+}/Mg^{2+} - Eriochrome black-T breaks and stable complex of Ca^{2+}/Mg^{2+} with EDTA is formed resulting in change of color of the solution from wine red to blue at the end point.
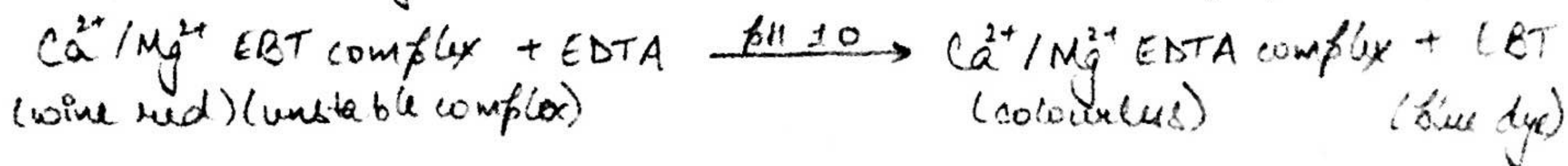
PROCEDURE:

Preparation of Standard Hard water: Dissolve 1 gm of pure dry $CaCO_3$ in minimum quantity of dilute HCl. Evaporate the solution to dryness on a water bath to remove excess of acid. Dilute the contents with distilled water to make 1L. Each ml of this solution contains 1 mg of $CaCO_3$, i.e. hardness of this solution
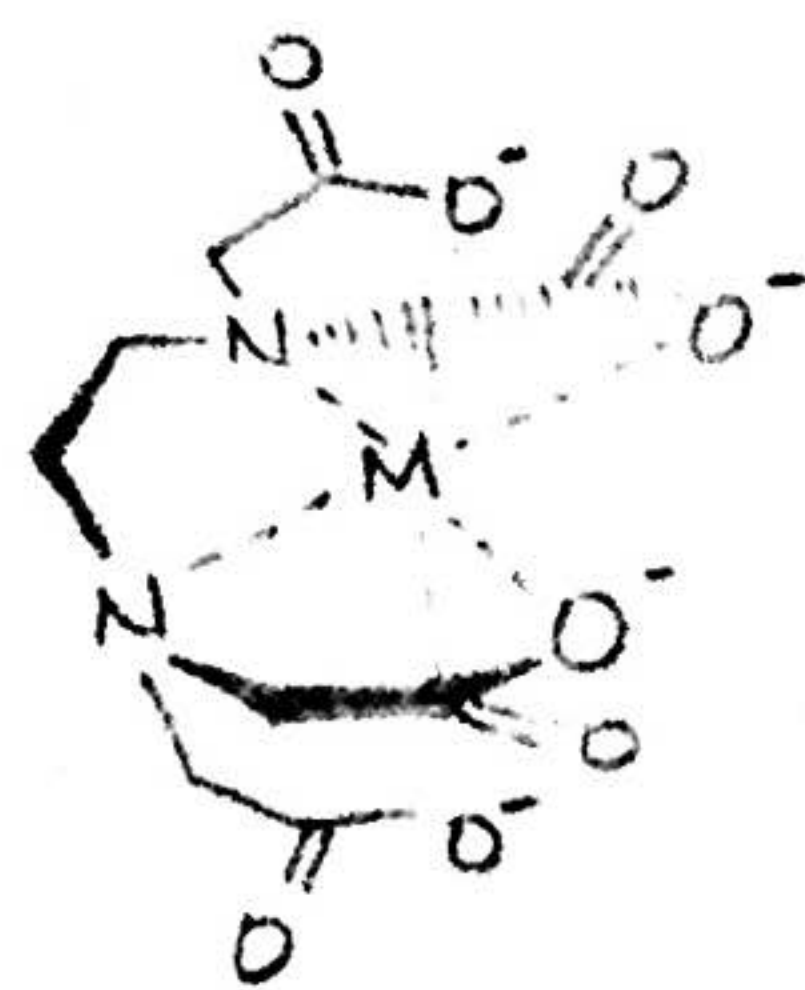
Khushi   Teacher's Signature : _____

Expt. No. 2

Date : 6/20/20

EXPERIMENT : To find the temporary and permanent hardness of water sample by complexometric titration using standard EDTA solution.

APPARATUS: Pipette, burette, beakers, conical flask, funnel, burette stand and clamp.

CHEMICALS : Water samples, ethylenediaminetetraacetic acid (EDTA), Eriochrome Black-T (EBT) indicator, ammonium hydroxide - ammonium chloride buffer of pH 10.

CHEMICAL REACTIONS:

$$Ca^{2+}/Mg^{2+} + EBT \xrightarrow{pH\ 10} Ca^{2+}/Mg^{2+}\ EBT\ complex$$
$$\text{(blue dye)} \qquad\qquad \text{(wine red) (unstable complex)}$$

$$Ca^{2+}/Mg^{2+}\ EBT\ complex + EDTA \xrightarrow{pH\ 10} Ca^{2+}/Mg^{2+}\ EDTA\ complex + EBT$$
$$\text{(wine red)(unstable complex)} \qquad\qquad \text{(colourless)} \qquad \text{(blue dye)}$$

CHEMICAL STRUCTURES:

EDTA

Fig. 1

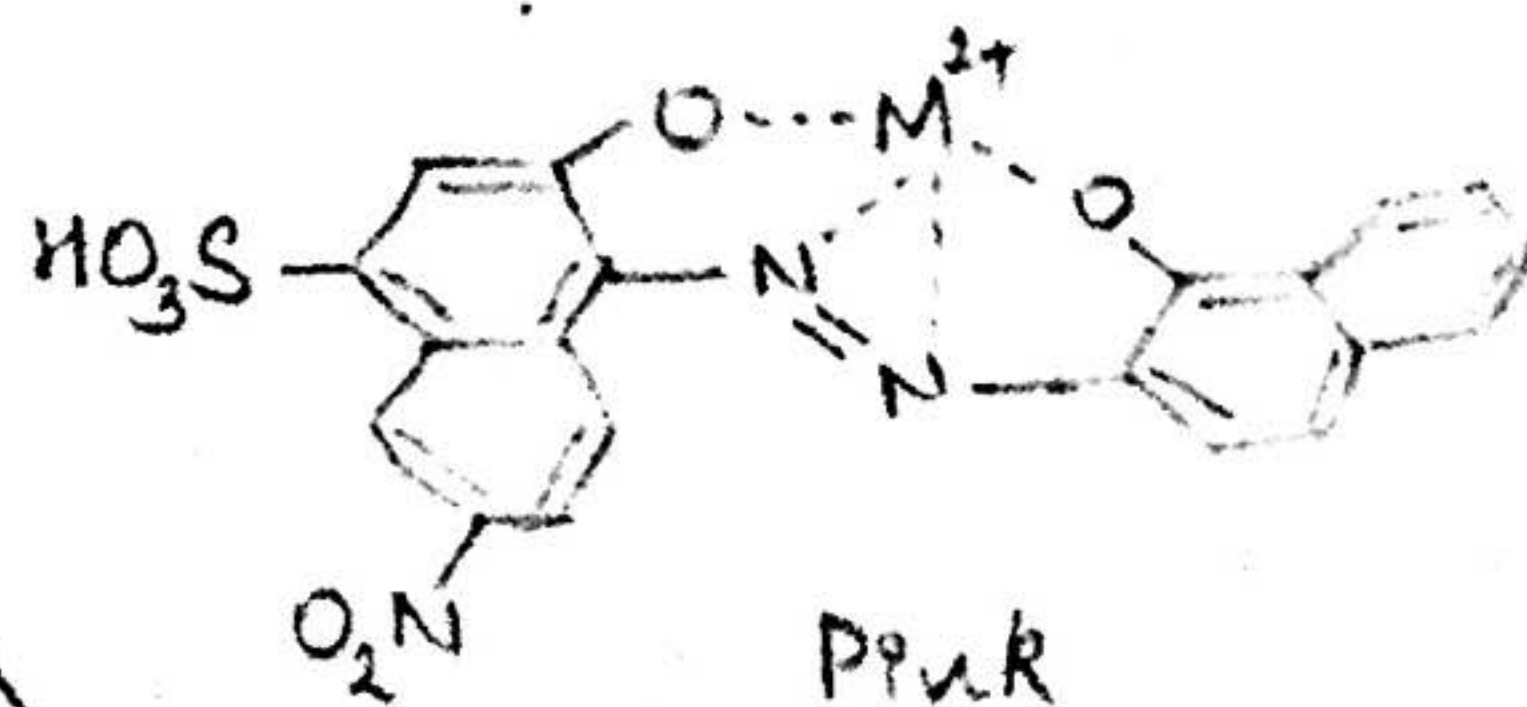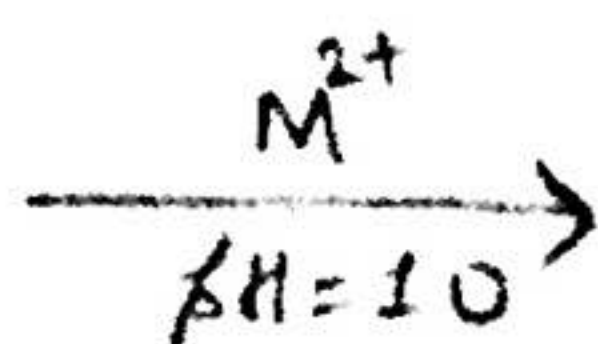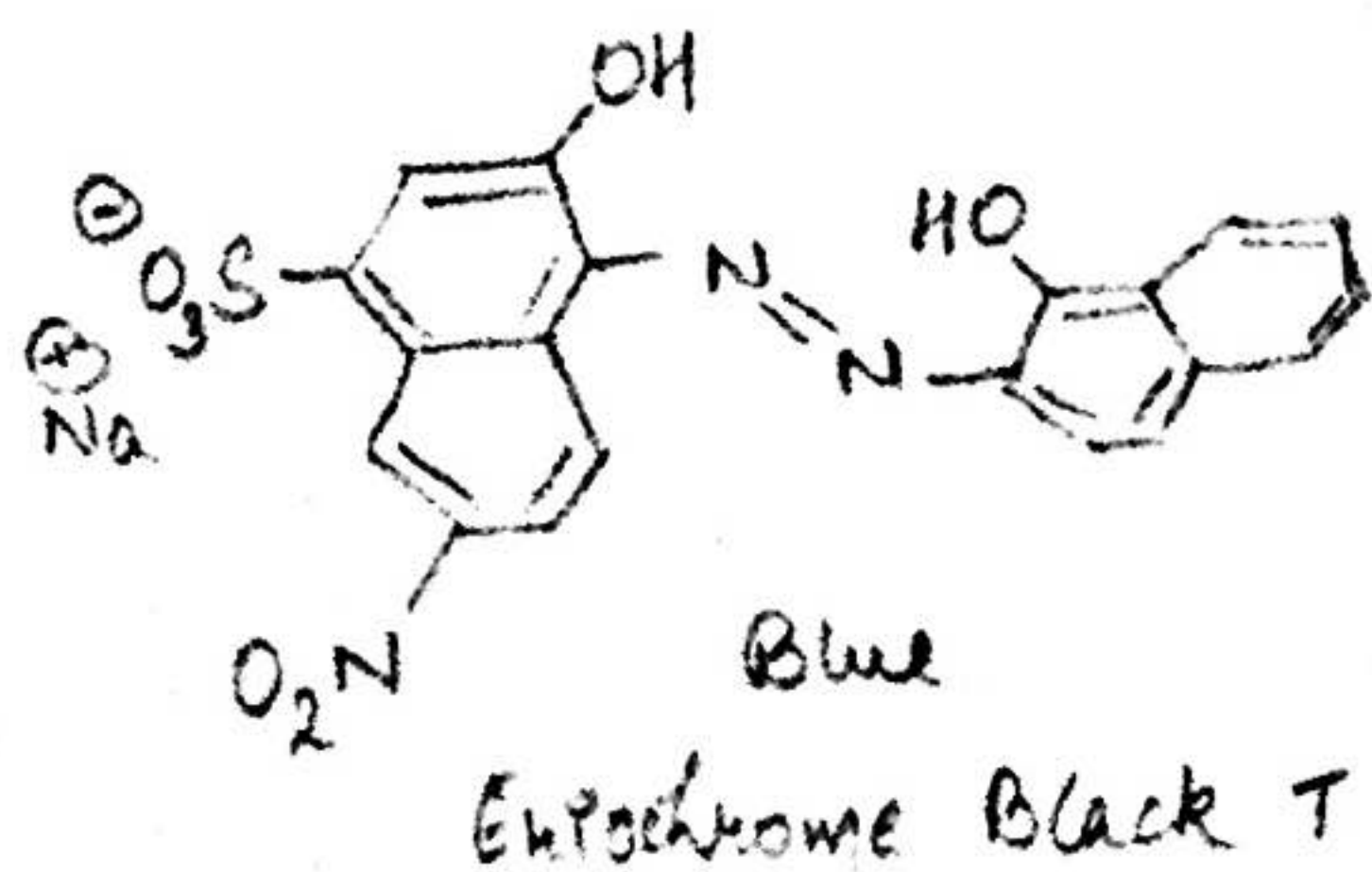

Metal - EDTA complex

Fig. 2

Eriochrome Black T $(M^{2+}=Ca^{2+}/Mg^{2+})$

Fig. 3

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≈ 1000 ppm $(0.01M)$. This solution is used to standardize the EDTA solution.

Standardization of EDTA

1. Rinse the titration flask with distilled water and transfer 10ml of the standard hard water sample $(0.01M)$ into it using a pipette.
2. Add about 2-3ml of ammonia/ammonium chloride buffer solution and 2-3 drops of EBT. The color of sol^n becomes wine red
3. Titrate the hard water against the EDTA sol^n, till the wine red color turns blue. Note the burette reading $(V_0 ml)$.
4. Repeat the procedure until 3 concordant readings are obtained

Determination of total hardness of water sample

Rinse the titration flask with distilled water and transfer 10ml of the given water sample into it using a pipette. Follow steps 2-4 given above. Let the titre value corresponding to total hardness of sample be V_1.

Determination of permanent hardness

Measure 100ml of hard water sample into 500ml beaker, boil gently for 30-35 minutes. Filter the solution into a 100ml measuring flask. Make up the solution up to the mark with de-ionized water and mix thoroughly.
Rinse the titration flask with distilled water and transfer 10ml of this (boiled-water) sample into it using a pipette.
Follow the steps 2-4 as above. Let the titre value corresponding

INDICATOR: Eriochrome Black-T (EBT)

OBSERVATIONS:

(i) Standardization of EDTA solution

Volume of 0.01 M standard hard water taken for each titration = 10 mL

Sr. No.	Burette Reading (mL)		Volume of EDTA used (mL)
	Initial	Final	
1.	0.1	10.0	9.9
2.	0.1	10.0	9.9
3.	0.1	10.0	9.9

Mean Volume of EDTA used (V_0) = 9.9 mL

(ii) Determination of Total hardness

Volume of hard water sample (unknown) taken for each titration = 10 mL

Sr. No.	Burette Reading (mL)		Volume of EDTA used (mL)
	Initial	Final	
1.	0.1	7.8	7.7
2.	0.1	7.8	7.7
3.	0.1	7.8	7.7

Mean Volume of EDTA used (V_1) = 7.7 mL

(iii) Determination of Permanent hardness

Volume of boiled hard water sample taken for each titration = 10 mL

Sr. No.	Burette Reading (mL)		Volume of EDTA used (mL)
	Initial	Final	
1.	0.1	6.4	6.3
2.	0.1	6.4	6.3
3.	0.1	6.4	6.3

Mean Volume of EDTA used (V_2) = 6.3 mL

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to total hardness of water sample be V_2.

Determination of temporary hardness
Difference between the two values $(V_1 - V_2)$ corresponds to temporary hardness.

RESULTS : Total hardness = 770 ppm (mg/L)
          Permanent hardness = 630 ppm (mg/L)
          Temporary hardness = 140 ppm (mg/L)

PRECAUTIONS: 1. Wash the titration flask with distilled water each time, before transferring hard/sample water solution.
2. Continue the titration till the complete removal of wine-red tinge in the solution.

GENERAL CALCULATIONS:

(i) Determining the molarity of EDTA solution

Applying the molarity equation

(Standard Hard Water) (EDTA)

$$0.01 \times 10 = M_1 \times 9.9$$

Molarity of EDTA, $M_1 = \dfrac{(0.01 \times 10)}{9.9} = 0.01 \, M$

(ii) Determination of total hardness

Applying the molarity equation

(Hard Water) (EDTA)

$$M_2 \times 10 = M_1 \times V_1$$

Molarity of hard water, $M_2 = \dfrac{0.01 \times 7.7}{10} = 0.0077 M$

Hardness of water sample, Y = Molarity × Molecular weight of $CaCO_3$

$$= 0.0077 \times 100$$
$$= 0.77 \, gm/L$$
$$= 770 \, mg/L$$

Total Hardness = 770 ppm (mg/L)

(iii) Determination of permanent hardness

Applying the molarity equation

(Boiled Hard Water) (EDTA)

$$M_3 \times 10 = M_1 \times V_2$$

Molarity of hard water, $M_3 = \dfrac{0.01 \times 6.3}{10} = 0.0063 M$

Permanent hardness of water sample, Z = Molarity × Mol. wt. of $CaCO_3$

$$= 0.0063 \times 100$$
$$= 0.63 \, gm/L$$
$$= 630 \, mg/L$$

Permanent Hardness = 630 ppm

(iv) Temporary Hardness

Total Hardness − Permanent Hardness = 770 − 630 = 140 ppm (mg/L)

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