Object: ***To determine the hardness of the tap water using ~ M/100 EDTA solution as an intermediate solution. Molecular weight of $MgSO_4.7H_2O$ = 246.48. Molecular weight of $CaCO_3$ = 100.***

Reagents:

1) $MgSO_4.7H_2O$ salt
2) ~M/100 EDTA solution
3) EBT indicator
4) NH_3-NH_4Cl buffer solution
5) Sample/tap water

Apparatus:

1) Digital weighing machine
2) Volumetric flask
3) Pipette (10, 50ml)-1
4) Burette (25ml)-1
5) Conical flask(100/150ml-1
6) Beaker (100/150ml)-2

Theory: Natural water contains certain amount of dissolved salts of calcium and magnesium. Such water is known as hard water as it gives hardly any lather with soap and the quantity of such dissolved salts is the measure of the hardness of the water. Hardness is expressed as the equivalent of parts of $CaCO_3$ with respect to Ca^{2+} and Mg^{2+} salts in a specific part of water. Ca^{2+} and Mg^{2+} ions both form 1:1 complex with both EDTA and Eriochrome Black T (EBT) in the pH range 10 -11. The pH of the solution can be kept constant around pH~10.5 using NH_3-NH_4Cl buffer solution. Colorless Ca-EDTA complex is more stable than the colorless Mg-EDTA complex and the both colorless metal-EDTA complexes are more stable than the wine red color Mg-EBT complex. The color of the free indicator (EBT) anion is blue in the same pH range. As the titration with EDTA proceeds, first EDTA preferentially makes complex with Ca^{2+} followed by Mg^{2+} ion. After the complete reaction with free metal ions, EDTA displaces indicator anion from Mg-EBT complex with the formation of more stable Mg-EDTA complex and the color of the titrating mixture changes from wine red color to pure blue color at the equivalence point.

Procedure:

1) Weigh around 0.25g of $MgSO_4.7H_2O$ salt (note down the exact weight)h.
2) Transfer $MgSO_4.7H_2O$ in 100ml volumetric flask with the help of a funnel. Dissolve the $MgSO_4.7H_2O$ salt and then make up the volume of the volumetric flask.
3) Take 10ml of this standard $MgSO_4.7H_2O$ solution in a 100/150ml conical flask with pipette and add 2ml NH_3-NH_4Cl buffer solution and one pinch EBT indicator

   and mix thoroughly. The color of the solution will be wine red. Titrate this mixture against the supplied ~ M/100 EDTA solution (taken in the burette) until the wine red color turns to pure blue. Repeat the titration as long as the two concordant readings are observed.
4) Take 50ml tap water in a 100/150ml conical flask with pipette and add 2ml NH_3-NH_4Cl buffer solution and one pinch EBT indicator and mix thoroughly. The

   color of the solution will be wine red. Titrate this mixture against the supplied ~ M/100 EDTA solution (taken in the burette) until the wine red color turns to pure blue. Repeat the titration as long as the two concordant readings are observed.

Observation and Calculation:

Weight of the $MgSO_4.7H_2O$ salt transferred W =……g

So, strength of 100ml $MgSO_4.7H_2O$ solution (M_1)= [W ×1000]/[246.48 × 100] (M)

Table 1: Standardization of the supplied ~ M/100 EDTA solution against 10 ml standard $MgSO_4.7H_2O$ solution of strength …………M using EBT indicator

No. of observations	Initial burette readings of EDTA (ml)	Final burette readings of EDTA (ml)	Volume of EDTA used (ml)	Concordant volume of EDTA (ml)
1				
2				
3				

$$M_1 \times V_1 = M_2 \times V_2$$

where M_1 = the molar strength of the standard aq. $MgSO_4.7H_2O$ solution M_2 = the molar strength of the supplied aq. EDTA solution V_1 = the volume of the standard aq. $MgSO_4.7H_2O$ solution = 10 ml V_2 = the volume of the supplied aq. EDTA solution

So, the strength of the supplied aq. EDTA solution (M_2) = $M_1 \times V_1 / V_2$ (M)

Table 2: Titration of the 50 ml tap water against standard ~ M/100 EDTA solution of strength ………….M using EBT indicator

No. of observations	Initial burette readings of EDTA (ml)	Final burette readings of EDTA (ml)	Volume of EDTA used (ml)	Concordant volume of EDTA (ml)
1				
2				
3				

$$M_3 \times V_3 = M_2 \times V_2^{/}$$

where M_3 = the molar strength of the unknown aq. $MgSO_4.7H_2O$ solution
M_2 = the molar strength of the supplied aq. EDTA solution
V_3 = the volume of the unknown aq. $MgSO_4.7H_2O$ solution = 50
ml $V_2^{/}$ = the volume of the supplied aq. EDTA solution

So, the total strength of the Ca^{2+} and Mg^{2+} salts (M_3) = $M_2 \times V_2^{/} / V_3$ (M)

Therefore, the hardness of the water
= ($M_2 \times V_2^{/}$ × Molecular weight of $CaCO_3$) / V_3 (in g/L)
= ($M_2 \times V_2^{/}$ × Molecular weight of $CaCO_3$ × 1000) / V_3 (in mg/L)
= ($M_2 \times V_2^{/}$ × Molecular weight of $CaCO_3$ × 1000) / V_3 (parts per million, ppm)

Results: The hardness of the tap water was found to be xxx ppm.