Experiment 1:Estimation of total hardness of water by EDTA complexometric method

Significance of the experiment: Water from many natural sources contain a variety of dissolved salts which comprise ions such as Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-.[1]According to U.S. geological survey any water that has less than 60 mg/L of $CaCO_3$ mass equivalents (*i.e.* less concentrations of Ca^{2+} and Mg^{2+} ions) is considered soft water.[2]Higher concentrations of Ca^{2+} and Mg^{2+} ions in water render hardness and such water is referred to as hard water. Hard water may lead to (a) inefficient and dysfunctional boilers due to formation of scales; (b) excessive consumption of soap that arises due to the reaction of sodium soap with multivalent metal cationsinturn leading tothe formation of precipitate and the loss of its surfactant property. To increase the energy efficiency in industries[3] and to minimize wastage of soap for cleaning purposes it is essential to use soft water, which therefore means there is a need for a method to identify which is hard and which is soft water? And to estimate how hard the tested water is? This experiment is all about one such easy methods.

Aim : To determine the total hardness of given water sample using standard Na_2EDTA solution.

Principle: Hardness of water is due to the presence of calcium and magnesium salts in water. Ethylene diaminetetraaceticacid (EDTA) forms complexes with a large number of cations including Ca^{2+} and Mg^{2+} ions. Accordingly, it is possible to determine the total hardness of water using EDTA reagent.The EDTA molecule (H_4Y) has two easily replaceable hydrogen atoms and resulting ion after ionization may be represented as H_2Y^{2-}. It forms complexes with metal ions as follows.

$$M^{2+} + H_2Y^{2-} \longrightarrow MY^{2-} + 2H^+ \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where M^{2+} is Ca^{2+} and Mg^{2+} present in water. Reaction (1) can be carried out quantitatively at a pH of 10 using Eriochrome Black T indicator. Since the reaction involves the liberation of H^+ ions, a buffer mixture has to be used to maintain pH of 10. The buffer mixture used in the titration is NH_3-NH_4Cl. The hardness of water is usually expressed in terms of ppm (parts per million) of $CaCO_3$. Since EDTA (free acid) is sparingly soluble, its disodium salt, Na_2H_2Y is used for preparing the reagent.

Procedure:

Part A: Preparation of standard solution of disodium salt of Na_2EDTA

Weigh Na_2EDTA salt accurately and transfer to a 250 mL volumetric flask through a funnel. Add around 5 mL of ammonia (NH_3) solution. Dissolve the crystals in ion exchange water, dilute up to the mark and mix well. Calculate the molarity of Na_2EDTA solution.

Part B:Determination of total hardness of given water sample

Pipette out 25 mL of the given water sample into a clean conical flask. Add 3 mL of NH_3-NH_4Cl buffer and a pinch of EBT indicator. Titrate against Na_2EDTA solution till the color changes sharply from wine red to clear blue. Perform the titration slowly towards the end point and repeat the experiment for agreeing values.

Result: The total hardness of given water sample is= ----------ppm of $CaCO_3$.

Links to the external sources of information about the topic:

1. http://en.wikipedia.org/wiki/Hard_water
2. http://www.hardwater.org/
3. http://www.water-research.net/index.php/water-treatment/tools/hard-water-hardness

Experiment 1: Observation and Calculations

Part A: Preparation of standard solution of disodium salt of EDTA (Na_2EDTA).

1. Weight of bottle + Na_2EDTA salt = W_2= ---------- g

2. Weight of empty bottle = W_1 = ----------g

3. Weight of Na_2EDTA salt = W_2-W_1= ---------- g

$$Molarity\ of Na2EDTA = \frac{Weight\ of\ the\ salt\ (W2 - W1)\ \text{X}\ 4}{Molar\ mass of Na2EDTA\ (372.24g)} \qquad \text{---- (`Z')}$$

Part B: Determination of total hardness of given water sample

Burette Reading	**Trial I**	**Trial II**	**Trial III**
Final Reading			
Initial Reading			
Volume of Na_2EDTA run down (mL)			

Volume of Na_2EDTA consumed = ---------- mL (a)

1000 mL of 1M Na_2EDTA = 100 g of $CaCO_3$ (molar mass of $CaCO_3$ = 100 g)

`a' mL of `Z'M Na_2EDTA = $\frac{100\ X\ Z\ X\ a}{1000\ X\ 1}$ = ---------- g of $CaCO_3$ (b)

Amount of $CaCO_3$ in 25 mL of hard water solution = ---------- g (b)

Total hardness of the given water sample= $\frac{b\ X\ 10{,}00{,}000}{25}$= ---- ppm of $CaCO_3$

Result: The total hardness of given water sample is = ----------ppm of $CaCO_3$