Experiment	Date: 28/01/2020
Problem definition	Estimation of sulphate in drinking water by conductivity method People using water with high levels of sulfate are vulnerable to dehydration and diarrhea. Kids are more sensitive to sulfate than adults.
Methodology	Conductivity of the soluble sulphate solution will change when it is precipitated by BaCl₂. Conductivity will reach minima when all sulphate ions are precipitated, and from which, the total amount of sulphate ion present in the water can be determined.
Solution	Amount of BaCl₂ required to remove the dissolved sulphate can be estimated.
Student learning outcomes	Students will learn to a) perform conductometric method b) remove sulphate ion from irrigate water

Principle:

Electrolyte solutions conduct electricity due to the presence of ions in solution. In case of precipitation titration between $BaCl_2$ and Na_2SO_4, the conductance decreases slowly due to the replacement of Cl^- ion by SO_4^{2-} ion upto the equivalence point. After the equivalence point, the conductance increases rapidly due to the excess addition of $BaCl_2$ which remains in solution as Ba^{2+} and Cl^-. This makes detection of neutralization point easy from the conductance trend plotted as a graph. This is the principle used in the estimation of SO_4^{2-} from contaminated water sample.

Requirements:

Reagents and solutions: $BaCl_2$ (0.1 N), Na_2SO_4 (0.02 N), unknown sulphate solution and distilled water.

Apparatus: Conductivity Bridge, Conductivity cell, Burette, Pipette, Volumetric flasks, Glass rod, Beaker (100 mL).

Procedure:

Calibration of Conductivity meter: Place a freshly prepared 0.1 N KCl solution (given in bottle) in a 100 mL beaker. Dip the conductivity cell in this solution and connect to the Conductivity meter. Press "CAL" button and complete the internal calibration of the instrument.

Standardization of BaCl₂ (Titration – 1):

Pipette out 20 mL of 0.02 N Na_2SO_4 solution (from Bottle A) in a 100 mL beaker and add 10 mL of distilled water to it to make the conductivity cell dip completely in the solution. Addition of water will not affect the conductivity since the number of ions in the solution remains unaltered. Dip the conductivity cell into the solution in the beaker and connect to the conductivity meter. Fill the burette with ~0.1 N $BaCl_2$ solution (from Bottle B). Record the conductivity of the sulphate solution without adding any $BaCl_2$ from the burette (0th reading). Add 1 mL $BaCl_2$ of known concentration into the beaker, stir with glass rod and note down the conductance. Continue the addition of $BaCl_2$ (1 mL each time) and note the conductance after each addition. Continue the titration beyond the equivalence point for about 5 mL. The conductance will either decrease slightly or remain constant until complete precipitation of $BaSO_4$, and then starts increasing on continuing the addition of $BaCl_2$. A graph is now drawn by plotting conductance vs volume of $BaCl_2$ added. Intersection point from the plot gives the volume of $BaCl_2$ required for precipitating the sulphate present in the known sample.

Estimation of unknown sulphate in the given solution (Titration – 2):

Make up the unknown sulphate solution given in a 100 mL standard flask upto the mark using distilled water resulting in a solution containing 0.96 mg/mL of sulphate ions (Eq. wt. of SO_4^{2-} = 48.03). Pipette out 20 mL of this solution into a 100 mL beaker and add 10 mL distilled water to it. Dip the conductivity cell and repeat the above procedure with the unknown sulphate solution to determine the amount of $BaCl_2$ required for precipitating the unknown sulphate in the sample. From the two titrations carried out, calculate the amount of sulphate present in the effluent sample.

Table 1: Conductometric Titrations

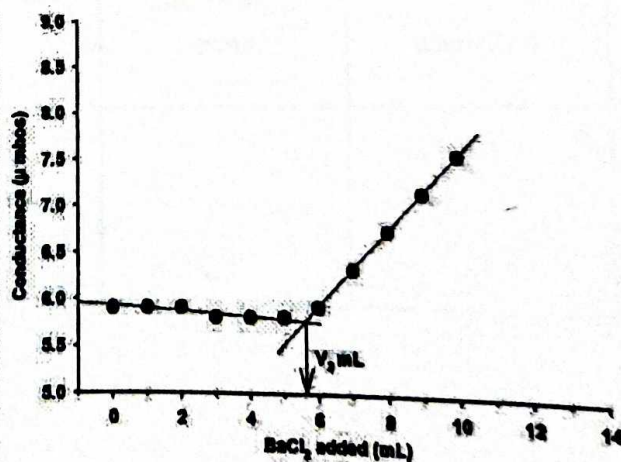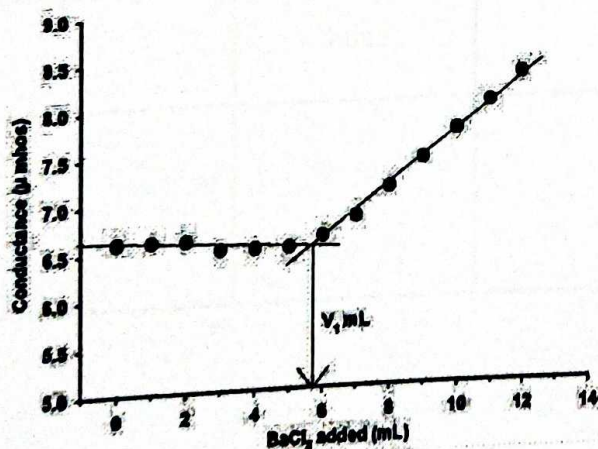| Titration-1: Standardization of BaCl₂		Titration-2: Estimation of sulphate content	
Burette: BaCl₂ solution (~0.1 N) Beaker: 20 mL of Na₂SO₄ (0.02 N) + 10 mL of distilled water Conductivity cell, Conductivity meter		Burette: std. BaCl₂ solution Beaker: 20 mL of unknown sulphate solution + 10 mL of distilled water Conductivity cell, Conductivity meter	
Volume of BaCl₂ added (mL)	Conductance (μ mhos)	Volume of BaCl₂ added (mL)	Conductance (μ mhos)
0.0	2.6	0.0	2.4
1.0	2.5	1.0	2.3
2.0	2.5	2.0	2.3
3.0	2.4	3.0	2.2
4.0	2.3	4.0	2.2
5.0	2.5	5.0	2.3
6.0	2.9	6.0	2.6
7.0	3.2	7.0	2.9
8.0	3.6	8.0	3.2
9.0	3.8	9.0	3.4
10.0	4.1	10.0	3.8
11.0	4.4	11.0	3.9
12.0	4.7	12.0	4.3

Fig 1: Model graphs – 1 and 2 for Conductometric estimation of known and unknown sulphate sample solutions, respectively.

Calculations:

A). Standardization of 0.1 N BaCl$_2$:

(N x V) of BaCl$_2$ solution = (N x V) of sodium sulphate

$$N \text{ of BaCl}_2 \text{ solution} = \frac{0.02 \text{ N} \times 20 \text{ mL}}{\text{Volume measured from Plot-1 (V}_1)}$$

$$= \frac{\cancel{0.02}}{0.095} \text{ N of BaCl}_2 \text{ solution}$$

$V_1 = 4.2$

$N = \dfrac{0.02 \times 20}{4.2} =$ 0.0952

B). Estimation of unknown sulphate:

(N x V) of irrigation water sample = (N x V) of BaCl$_2$ solution

$$N \text{ of irrigation water sample} = \frac{N \text{ of BaCl}_2 \times \text{Volume measured from Plot-2 (V}_2)}{20 \text{ mL}}$$

$$= \frac{\cancel{0.023}}{0.023} \text{ N of irrigation water sample}$$

$V_2 = 4.9$

$N = 0.023$

Amount of sulphate present in 1L = Normality of irrigation water sample x Eq. wt. of SO$_4^{2-}$ (48.03)

Amount of sulphate present in given sample solution = $\dfrac{\text{Strength of irrigation water sample} \times 48.03 \times 100}{1000}$

= __0.11__ grams in 100 mL

$\dfrac{0.023 \times 48.3 \times 10^3}{1000}$

$= 0.11$

Result: Amount of sulphate in given irrigation water sample = __0.11__ grams.

Evaluation of Result:

Sample number	Experimental value	Actual Value	Percentage of error	Marks awarded
				$\frac{10}{10}$

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Plot 1

x → 1 unit = 1 cm
y → ... units = 2 cm

Conc → BaCl₂

Conductance

Plot 2

x → 1 unit = 1 cm
y → 3 units = 2u...

Conc of BaCl₂

Conductance