College of science

Department of chemistry

Course code: CHEM 353

Fourth practical experiment:

conductometric titration of a strong acid (Hydrochloric acid (HCl)) with a strong base (Sodium hydroxide (NaOH))

The work and contribution of this practical report is done by the following students:

1-Faisal Mansour (442105660)

2-TALAL ALOSAIMI (437103019)

Under the supervision of the teaching assistant: Abdulaziz Alsalman

*Introduction

-We can principally define conductivity to be “The ability of a solution to generate electrical current”, and not to perplex that with “Conduction” whose comparable definition has to do with solid substances or metals in general. On contrary, resistivity is defined as “The ability to impede the flow of an electrical current”. The inversely proportional relationship between the conductivity, which is symbolized as “L”, and the resistivity, which is symbolized as “R”, can be mathematically expressed as follows…

*L=1/R

-For instance, if we were given such resistivity of 10 (Ω), then by the application of the previously mentioned equation above, we should bring about a conductivity of 10^{-1} (Ω^{-1}) as a result approximately. Moreover, the unit for conductivity (L) is “Ω^{-1}”, which is actually equivalent to its SI unit, that is “S” (Siemens), meaning that [S= Ω^{-1}]. Thereupon, the conductivity has two equivalently distinct units of measurement while the unit of measurement for the resistivity (R) is simply “Ω” (Ohm). Additionally, the unit “µS” (MicroSiemens) is utilized for the conductivity of diluted solutions. Likewise, within the case of “Conduction” for solid substances, its unit of measurement is “S/m” (Siemens per meter).

-Conductivity is widely used for estimating the overall ion content (Concentration) in various sample of practical interest. Ion concentration can be determined by the means of **conductometric titration.** Although this can be the beneficial condition, such factors, five to be precise, can affect the conductivity such as the increase in temperature of a solution leads to the increase in conductivity of this solution. Furthermore, the concentration plays a role in which its increase within a solution would present an increase for the conductivity of this solution. Charges for atoms, that is, in a state of being ions affect the conductivity too in which a larger charge accounts for a greater conductivity whether this charge is a cation, which is a positively charged ion, such as (Na^{+}), (Ca^{2+}), or (Al^{3+}) for which (Al^{3+}>Ca^{2+}>Na^{+}), or if it’s an anion, which is a negatively charged ion, such as (NO_2^{-}), or (SO_4^{2-}) for which (SO_4^{2-}>NO_2^{-}). The type of a solvent as well is incumbent for the conductivity of a solution as using water (H_2O) as a solvent for conductivity can be distinctive to that of using ethanol (CH_3CH_2OH) as a solvent also for the same purpose. Last but not least, the conductivity of a solution is affected by the atomic size of a cation or an anion that have the same charges in which in terms of cations having the same charge magnitude, a more, and not less, miniscule atomic size of a cation would allow for the ease of movement for positively charged particles (Due to their free, rapid, and facilitated mobility) such as (H^+>Li^+>Na^+). In the same way, anions also having the same charge magnitude follow an akin principle to that of the cations like (F^->Cl^->Br^->I^-).

-In addition, advantages of conductivity feature determining the solubility constant "K_{sp}" as well as determining the dissociation constant "K_D". However, the flaws are made present within the conductivity as a property in which it isn't selective, that is, it is non-selective along with being profoundly affected by temperature as being one of its modifying factors as previously mentioned.

Aim of the experiment

-To determine the molar concentration of hydrochloric acid (HCl) using conductometric titrations.

Laboratory substances/materials/tools that'll be used

1) Three different solutions of known conductivity for examining and calibrating the conductive meter efficiency

2) Sodium hydroxide (NaOH)=>As a solid pellet initially from which we would then prepare a solution of it

3)A volumetric flask of 100 (mL) to be filled up by the strong base (Sodium hydroxide (NaOH))

4)Burette for the strong base (Sodium hydroxide (NaOH))

5)A hydrochloric acid solution of unknown concentration

6)A beaker of 100 (mL) volume to be filled up by hydrochloric acid (HCl)

7)Conductive meter

8)Distilled water

*Practical work methodology

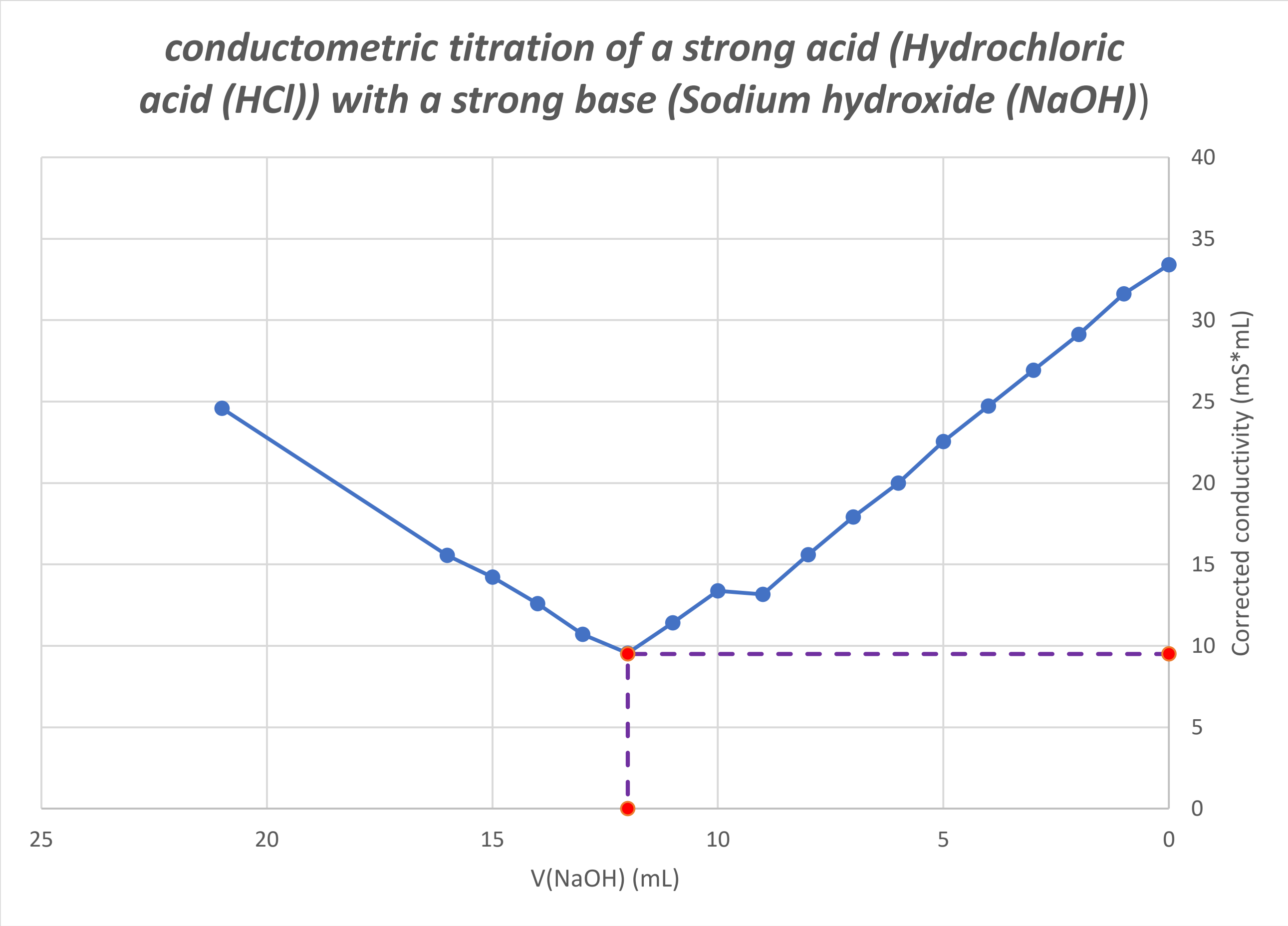
- We start by preparing a solution of sodium hydroxide (NaOH) that exactly requires a mass of 2 (g) of (NaOH) pellets for a concentration of 0.5 (M) in a 100 (mL) volumetric flask, meaning that, 0.5 (M)=100 (mL) in order to be put into a burette when proceeding. Once this approach is done, we then fill up a burette on a bench with the sodium hydroxide (NaOH) solution along with where we can find upon the same bench within the laboratory a conductive meter that needs as a must to be neatly washed and rinsed by distilled water with the goal for it to duly function and yield successful, precise results in addition to its need to be examined by the avail of the three differential solutions of known conductivity that can be found on the top on the same bench in order to calibrate it by this method. When this objective is nicely completed, a beaker of 100 (mL) volume is to be used and cleanly washed for the intention of filling it with 10 (mL) of hydrochloric acid, and which is then to be diluted by filling in again and pouring in 40 (mL) of distilled water to the same 100 (mL) beaker. Once this step is accomplished, we then take the read from the conductive meter after measuring the diluted solution of the hydrochloric acid (HCl) by the 40 (mL) distilled water before adding any of the sodium hydroxide (NaOH) solution from the burette, that is, at V(NaOH)=0 (mL). we then progress by conductively and exactly titrating 1 (mL) within each time from the sodium hydroxide (NaOH) solution from the burette into the diluted hydrochloric acid (HCl) solution that is in the 100 (mL) beaker where here we can noticeably perceive that the reads on the conductive meter are progressively increasing till we reach our only equivalence point, which will take the appearance of a letter "V" shape when the data are graphically illustrated, since this is a conductometric titration between a strong acid, which is the hydrochloric acid (HCl), and a strong base, which is sodium hydroxide (NaOH). The reads of the conductive meter would be gradually increasing immediately then from the reached equivalence point. Additionally. It's crucial to notice that the conductive meter can take reads in units of "mS" (MilliSiemens) or "µS" (MicroSiemens), which can definitely affect the graphically plotted data in terms of representation as well as when computing the unknown concentration of hydrochloric acid as our point of interest within this experiment. We then attempt to calculate the unknown concentration of hydrogen chloride (HCl) after carrying out the experiment's data practically based upon our recorded information and our graphically indicated conductometric titration curve.

Calculations and results

-In agreement with the antecedent entire information that was practically and experimentally fulfilled and produced effectively in addition to the avail of Microsoft excel, a scatter plot that has an increasingly varying Corrected conductivity in “mS*mL” (MilliSiemens millilitre) that represents the Y-axis, and has a gradually increasing by 1 (mL) exactly of volume in milliliters (mL) from the additions of the strong base (Sodium hydroxide;(NaOH)) solution in the burette that forms the X-axis can be established in the interest of representationally showing and indicating the data prior.

Practically implemented information for the volume of a strong base (Sodium hydroxide (NaOH)) in (mL) with each corresponding corrected conductivity in (mS*mL)

V(NaOH) (mL)	Corrected conductivity (mS*mL)
0	33.4
1	31.62
2	29.12
3	26.924
4	24.732
5	22.55
6	19.992
7	17.9094
8	15.602
9	13.157
10	13.368
11	11.407
12	9.548
13	10.71
14	12.5952
15	14.222
16	15.5628
21	24.5802



-The following chemical equation describes the reaction between hydrochloric acid (HCl) and sodium hydroxide (NaOH)…

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O$

-From the use of Microsoft excel graphical scatter plot, we can determine the unknown molar concentration of concentrated hydrogen chloride (HCl), that is, before the dilution process by the previously mentioned 40 (mL) of distilled water as well as for after the dilution process. This procedure can be done by utilizing the dilution equation for the concentrated hydrochloric acid (HCl) (Before the dilution process) and for after the dilution process (Diluted hydrochloric acid (HCl))

-We start by evaluating the unknown molar concentration for the diluted hydrogen chloride (HCl)… (After the dilution process) …

$$M\times V=M'\times V'$$

-Where…

-M=>Unknown molar concentration of the strong acid (hydrogen chloride (HCl)) solution

-V=>Volume of the strong acid (Hydrogen chloride (HCl)) that is to be 50 (mL) due to its initial concentrated volume of 10 (mL) and then diluted by the distilled water of 40 (mL)

-M'=>Molar concentration of the strong base solution (Sodium hydroxide (NaOH)), which is 0.5 (mol/L)

-V'=>Volume of the strong base (Sodium hydroxide (NaOH)) according to its correspondence within the graphical Microsoft excel scatter plot from the corrected conductivity in (mS*mL) as the Y-axis to the volume of sodium hydroxide (NaOH) in (mL)

$$\Leftrightarrow M=(M'\times V')/V$$

$$\Leftrightarrow M'=(0.5\times 12)/(50)$$

$$\Leftrightarrow M'=0.12(M)$$

-Now that we obtained the calculated diluted concentration of hydrochloric acid (HCl), we can then figure out the concentrated solution of hydrochloric acid (HCl) (Before the dilution process) by availing the dilution equation again…

(Before the dilution process) $M\times V=M'\times V'$ (after the dilution process)

-Where…

-M=>Unknown molar concentration of the concentrated (Before the dilution process) strong acid (hydrogen chloride (HCl)) solution

-V=>Volume of the concentrated (Before the dilution process) strong acid (Hydrogen chloride (HCl)) that is to be 10 (mL)

-M’=>Molar concentration of the diluted strong acid (hydrogen chloride (HCl)), which is to be 0.12 (mol/L) (After the dilution process)

-V’=>Volume of the diluted strong acid (Hydrogen chloride (HCl)), which is to be 50 (mL) (After the dilution process)

$$\Leftrightarrow M=(M' \times V')/V$$

$$\Leftrightarrow M'=(0.12 \times 50)/(10)$$

$$\Leftrightarrow M'=0.6(M)$$

*Conclusion

-What has been practically and experimentally executed is a conductometric titration of a strong acid, which is hydrochloric acid (HCl), with a strong base, which is sodium hydroxide (NaOH).

*References

-The last practical lecture of course CHEM 353.

The end of the practical experiment