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BASIC CONCEPTS OF ACID-BASE TITRATION AND IT'S APPLICATIONS

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ABSTRACT

Acid-base titration is quantitative addition of concentration of acid and base. The compounds having organic and inorganic properties can be determined by titration based on their basicity and acidity. We have reported titration based on sample using, HA (acid) + OH- (base) ⇌ A- + H2O (Dissocation reaction). To recognize the end point of titration, colour indicators are still frequently used. The pH value of the acid base titration solution is choose appropriate indicator by calculating end-point. The titration method involving NaOH was developed to examine the acid base properties of complex substances. A graph is plot by pH of acidic solution of the amount of added base is a titration curve. From this end-point or equivalence point is determined.

INTRODUCTION

Acid base titration is the method of quantitative analysis for determination of concentration of acid or base by neutralizing it with the solution which is the standard solution of acid or base which is having the known concentration. It can be also define as experimental technique for acquiring the information about the solution containing acid or a base. Many of the compounds which can be both organic or inorganic can determined by the titration based on their basic or acidic property. In this the acid is titrated with the base and the base is titrated with the acid. By addition of the indicator the end point is detected. It involves the week or strong base and acid, it is used to figure out the concentration of acid or base weather the unknown base or acid is strong or weak. In the acid base titration various types of indicators are used, the mainly indicator used in acid base titration are methyl orange phenolphthalein, malachite green. Mostly the methyl orange and phenolphthalein are used in the acid base titration. The indicators are the substances with change the color at a certain pH. The indicators are mostly organic in nature, mostly the indicators like phenolphthalein is used in the acid base titration because it is show the more easy color change then that of the other indicator and is mostly used in the strong acid and strong base titration. Methyl orange is used in strong acid and weak based titration because methyl orange will change sharply at the equivalence point In weak acid weak base titration neither the phenolphthalein not the methyl orange is suitable. No indicator is used in weak acid and weak base titration because it required a vertical position of the curve over 2 pH unit. In the week acid strong base titration mostly the indicator use is phenolphthalein and the color change sharply at equivalent point and would be a good choice. This acid base curve involves the neutralization of the acid and base so this titration is also known as neutralization titration. [1,2,3]

OBJECTIVES

• To study various chemical reactions of acid and base by using titration method i.e. Acid base titration.

• To calculate the endpoint or the equivalence point between acid and base in acid base titration.

• The main aim is to describe chemical equilibrium and equation of constants in acid base titration using various values.

• pKa and pKb of unknown concentration of acid and base is described to carry out the required reaction of used acid and base by titration method.

KEY TERMS:

1. **Titration –** A process where a solution of known strength is added to a certain volume of a treated sample containing an indicator.
2. **Titrant –** A solution of known strength of concentration used in the titration.
3. **Titrand –** The titrand is any solution to which the titrant is added and which contains the ion or species being determined.
4. **Titration curve –** A plot of pH Vs millilitres of titrant showing the manner in which pH changes Vs millilitres of titrant during an acid-base titration.
5. **Equivalence point –** The point at which just an adequate reagent is added to react completely with a substance.

TYPES OF ACID-BASE TITRATION:

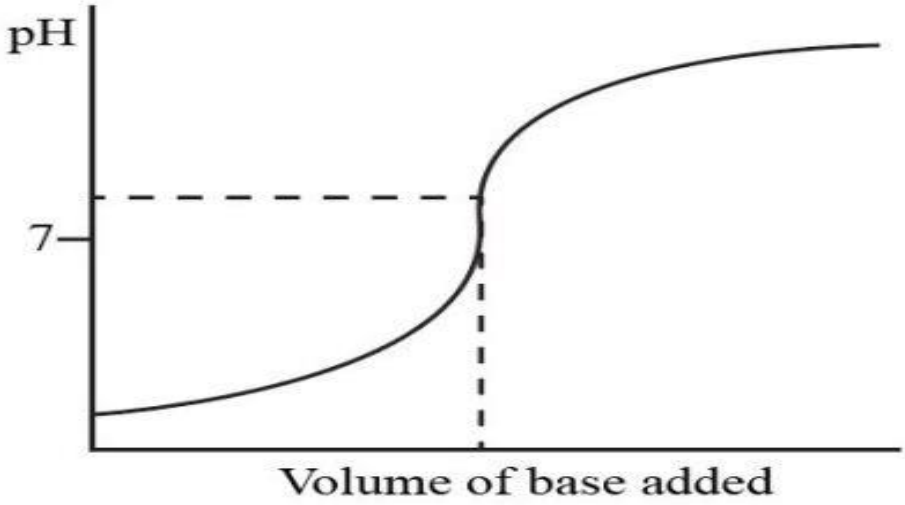
The types and examples of strong/weak acids and bases.

Sr.No	Types	Examples
1.	Strong acid-strong base	Hydrochloric acid and sodium hydroxide
2.	Weak acid-strong base	Ethanoic acid and sodium hydroxide
3.	Strong acid-weak base	Hydrochloric acid and ammonia
4.	Weak acid-weak base	Ethanoic and ammonia

TITRATION CURVE & EQUIVALENCE POINT:

In a titration, the equivalence point is the point at which exactly the same number of moles of hydroxide ions have been added as there are moles of hydrogen ions. In a titration, if the base is added from the burette and the acid has been accurately measured into a flask. The shape of each titration curve is typical for the type of acid-base titration. The pH does not change in a regular manner as the acid is added.

Graph 1. Titration curve & Equivalent point.



CHOICE OF INDICATORS:

Acid-base indicators are substances which change colour at a certain pH. They locate equivalence point and also measure pH. They are organic in nature. Various indicators have different ionization constants and therefore they show a change in colour at different pH intervals. Acid-base indicators can be broadly classified into three groups.

- **The phthaleins and sulphophthaleins (eg; Phenolphthalein)**
- **Azo indicators (eg; Methyl orange)**
- **Triphenylmethane indicators (eg; Malachite green)**

The two common indicators used in acid-base titration is **Phenolphthalein** and **methyl orange**. In the four types of acid-base titrations, the base is being added to the acid in each case.

The Choice of indicators based on the type of titration is tabulated below.

Types of titration	Indicators
Strong acid-strong base	Phenolphthalein is usually preferred because of its more easily seen colour change.
Weak acid-strong base	Phenolphthalein is used and changes sharply at the equivalence point and would be a good choice.
Strong acid-weak base	Methyl orange will change sharply at the equivalence point.
Weak acid-weak base	Neither phenolphthalein, nor methyl orange is suitable. No indicator is suitable because it requires a vertical portion of the curve over two pH units.

METHODOLOGY:

In an acid-base reaction, the molecule of acid would react with the base to form an anion of the acid and water molecule:[4]

$$HA\ (acid) + OH^-\ (base) \rightleftharpoons A^- + H_2O$$

Therefore, the amount of mole of the acid is equal to the volume times the concentration ($A \cdot a$) and the base follows the same principle ($B \cdot b$). The reactionreaches its equivalence point when enough base is added therefore, $A \cdot a = B \cdot b$, and the solution ismonitored by measuring the pH after adding each drop of pH. The weak acid does not completely dissociate before reaching its equilibrium.[4,5,6,7]

Dissociation Reaction: $HA \rightleftharpoons H^+ + A^-$

Which means that the amount of moles of the acid present in this solution is equal to the amount of moles of hydrogen ion. Therefore, to keep track of the concentration of the substance, the amount of moles of each compound is divided by the total volume ($a+b$).[4,5,6,7]

The concentration of the compound:

$$[HA] = \frac{A \cdot a - B \cdot b}{a+b}$$

The titration model is created by using the dissociation constant formula:

$$Ka = \frac{[H+] \cdot [A-]}{[HA]}$$

EXAMPLES:

1) The chemical equation for the reaction of hydrochloric acid (HCl) and sodium hydroxide (NaOH) is shown below. An unknown concentration of 25.0 mL HCl solution was titrated with 32.0 mL of 0.15 M NaOH. What is the concentration of the solution of HCl?

$$HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H2O(l)$$

Step 1: Determine the relationship between the acid and the base component in the reaction by evaluating the balanced chemical reaction. From the chemical reaction, we can see that one equivalent of HCl reacts with one equivalent of NaOH. Therefore, n1 and n2 are each equal to 1.

Step2: Assign the acid as substance 1 and the base as substance 2 and record all information that you know about each. We are given the volume of acid V1 is 25.0 mL. We know from our balanced equation that n1 is 1. We are given the volume of base V2 is 32.0 mL and the concentration of base M2 is 0.15 M. We know from our balanced equation that n2 is 1.

Step 3: Use the equation M1×V1×n2=M2×V2×n1to find the unknown concentration of our solute. We rearrange the equation to get M1=M2×V2×n1 / V1×n2. We plug in all of the values we are given into the equation provided. M1=0.15M×32.0mL×1 / 25.0mL×1. This gives us M1=4.8M / 25.0. We solve for M1and get M1=0.19M

2) How much 3.5 M NaOH is required to neutralize 75 mL of 12 M HCI?

$$\mathbf{Ma = 12M \quad Va = 75ml \quad Mb = 3.5M \quad Vb = ?\ Ml}$$

$$\mathbf{Ma\ Va = Mb\ .\ Vb \rightarrow Vb = \frac{Ma\ .\ Va}{Mb}}$$

$$\mathbf{Vb = \frac{Ma\ .\ Va}{Mb} = \frac{(12M)\ (75ml)}{3.5M} = 257.1ml}$$

Application of Acid-Base Titration in Pharmaceutical Industries:

- In medicine, titration is a technique for restricting the conceivable unfavorable responses of the body to drugs. This is significant because everybody answers distinctively to drugs, contingent upon their age, comorbidity, weight, sensitivities, insusceptibility, and general natural chemistry.
- Purity analysis, in which acid-base titrations are frequently utilised. A genuine model can be referred to as purity control of medication ephedrine, which can be discovered in hack syrups.
- Content analysis, wherein redox (oxidation-reduction) responses are utilised to layout the purity of unrefined components, remembering restricting substances for oral meds instead of the finished result itself.
- Precipitation titrations bring about the arrangement of a strong item. One model is the antifungal medication clotrimazole.
- The pH-detail titration is used to decide the acidity of medications, check the purity of compounds made, and research the speed and attributes of applicable synthetic responses.

CONCLUSION

An acid-base titration is a quantitative and qualitative examination with QC test in pharmaceutical medicine and of acids and bases. The titration progress can be observed by visual pointers, pH terminals, or both. The titration model displays a correlation between pH, pKa, volumes, and concentrations. And any other characteristics (pH, pKa, volume) of the substances used could be also determined. Due to comparing the values generated by the titration model to theoretical one, the percent efficiency is ~99.4% which is remarkable. If there is chances in the experiment of slightly error ~9%, which means the calculation, or the determination of the equivalence point is wrong.[4,5,6,7]

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