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9.1 Titration.

Sometimes it is necessary to know the exact concentration of acid or base in a solution.

To determine the molarity of a solution, we carry out a titration. A titration uses a buret, a calibrated tube with a stopcock at the bottom that allows a solution of known molarity to be added in small quantities to a solution of unknown molarity.

The procedure for determining the total acid concentration of a solution of HCl is illustrated in Figure6.5.

How does a titration tell us the concentration of an HCl solution?

A titration is based on the acid–base reaction that occurs between the acid in the flask (HCl) and the base that is added (NaOH).

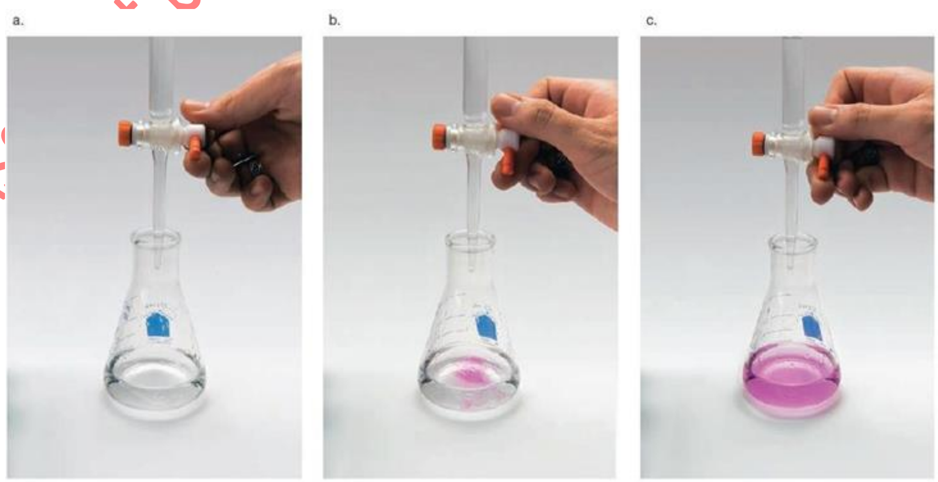

Fig.9.1:: Titration of an Acid with a Base of Known Concentration.

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Steps in determining the molarity of a solution of HCl

Add a measured volume of HCl solution to a flask. Add an acid–base indicator, often phenolphthalein, which is colorless in acid but turns bright pink in base.

Fill a buret with an NaOH solution of known molarity and slowly add it to the HCl solution.

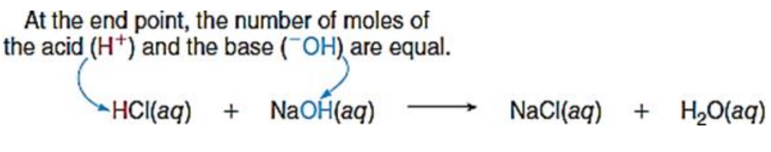
Add NaOH solution until the end point is reached, the point at which the indicator changes color. At the end point, the number of moles of NaOH added equals the number of moles of HCl in the flask.

In other words, all of the HCl has reacted with NaOH and the solution is no longer acidic.

Read the volume of NaOH solution added from the buret

Using the known volume and molarity of the NaOH solution and the known volume of HCl solution, the molarity of the HCl solution can be calculated.

When the number of moles of base added equals the number of moles of acid in the flask, the acid is neutralized, forming a salt and



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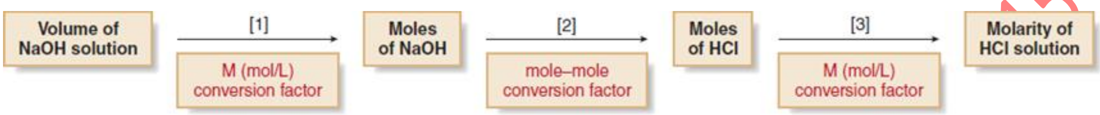
To determine an unknown molarity from titration data requires three operations:



First, we determine the number of moles of base added using its known molarity and volume.

Then we use coefficients in the balanced acid–base equation to tell us the number of moles of acid that react with the base. Finally, we determine the molarity of the acid from the calculated number of moles and the known volume of the acid.

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Buffer

A buffer is a solution whose pH changes very little when acid or base is added. Most buffers are solutions composed of approximately equal amounts of a weak acid and the salt of its conjugate base.

The weak acid of the buffer reacts with added base, ^{-}OH.

The conjugate base of the buffer reacts with added acid, H_3O^+

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General Characteristics of a Buffer

The effect of a buffer can be illustrated by comparing the pH change that occurs when a small amount of strong acid or strong base is added to water, with the pH change that occurs when the same amount of strong acid or strong base is added to a buffer, as shown in Figure 4.10.

When 0.020 mol of HCl is added to 1.0 L of water, the pH changes from 7 to 1.7, and when 0.020 mol of NaOH is added to 1.0 L of water, the pH changes from 7 to 12.3. In this example addition of a small quantity of a strong acid or strong base to neutral water changes the pH by over 5 pH units.

In contrast, a buffer prepared from 0.50 M acetic acid (CH3COOH) and 0.50 M sodium acetate (NaCH3COO) has a ،pH of 4.74. Addition of the same quantity of acid.

mol HCl, changes the pH to 4.70, and addition of the 0.020 same quantity of base

mol of NaOH, changes the pH to 4.77. In this example, 0.020 the change of pH in the presence of the buffer is no more than 0.04 pH units

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Why is a buffer able to absorb acid or base with very little pH change?

Let's use as an example a buffer that contains equal concentrations of acetic acid ($CH3COOH$), and the sodium salt of its.

The pH of pure water changes drastically when a small amount of strong acid or strong base is added

The pH of a buffer changes very little when the same amount of strong acid or strong base is added.

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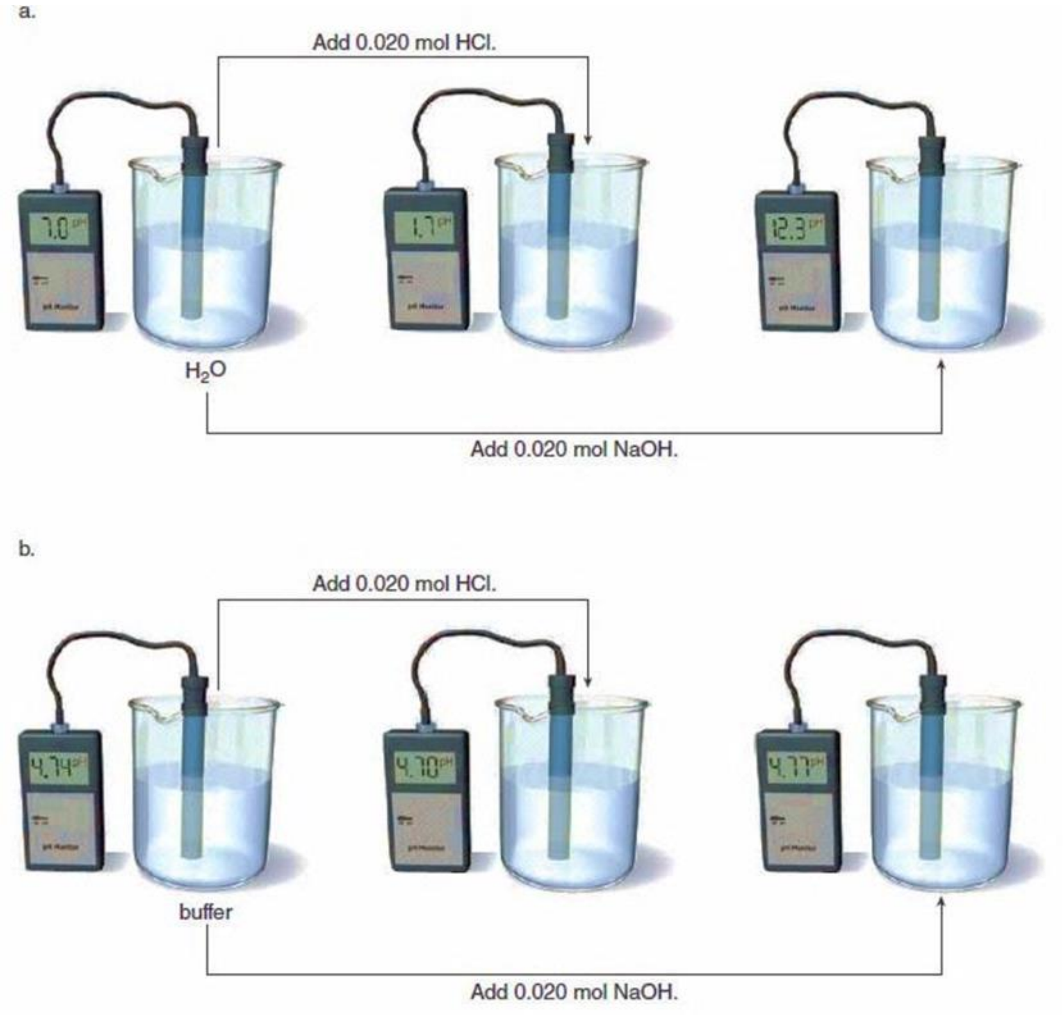

Fig.9.2: The Effect of a Buffer on pH Change

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