Experiment 7: Determination ofpK_a of weak acid using pH meter

Significance of the experiment: The acid dissociation constant (pK_a) is among the most frequently used physicochemical parameters, and its determination is of interest to a wide range of research fields.[1,2] The related concept of the acid dissociation constant (pK_a) as a substance property is recognized as being among the most commonly used parameters in modern-day chemistry. Both pH and pK_a are essential for understanding the behavior of chemical substances in everyday life. The quantitative behaviour of acids and bases in solution can be understood only if their pK_a values are known.[3] In particular, the pH of a solution can be predicted when the analytical concentration and pK_a values of all acids and bases are known; conversely, it is possible to calculate the equilibrium concentration of the acids and bases in solution when the pH is known. These calculations find application in many different areas of chemistry, biology, medicine, and geology. For example, many compounds used for medication are weak acids or bases, and a knowledge of the pK_a values, together with the water–octanol partition coefficient, can be used for estimating the extent to which the compound enters the blood stream. Acid dissociation constants are also essential in aquatic chemistry and chemical oceanography, where the acidity of water plays a fundamental role. In living organisms, acid-base homeostasis and enzyme kinetics are dependent on the pK_a values of the many acids and bases present in the cell and in the body. In chemistry, a knowledge of pK_a values is necessary for the preparation of buffer solutions and is also a prerequisite for a quantitative understanding of the interaction between acids or bases and metal ions to form complexes. Experimentally, pK_a values can be determined by potentiometric (pH) titration using pH meter. pH meter is one of the most innovative equipments of 20th century. This instrument is an essential component of any pharmaceutical lab, clinical lab, research labs of biochemistry, molecular biology and chemistry. The main application of pH meter is determination of pH of buffers. Due to its accuracy, this is an essential component in every place where aqueous buffers are used.

Aim: To determine pK_a value of a weak acid using pH meter.

Principle : The strength of an acid is experimentally measured by determining its equilibrium constant or dissociation constant(K_a). Since strong acids are strong electrolytes, they are ionised almost completely in aqueous solutions. It is not meaningful to study the ionic equilibrium of strong acids and calculate their equilibrium constants, as the un-ionised form is present to such a small extent. Hence, the study of ionic equilibrium and calculation of K_a is applicable only to weak acids.

Acetic acid dissociate into ions but not completely as shown below.

CH_3COOH (aq.) + H_2O (l) $\rightleftharpoons$ H_3O^+ (aq.) + CH_3COOH (aq.)

$$Ka = \frac{[\mathrm{H3O}^+][CH3COO^-]}{[CH3COOH]}$$

pK_a is a modern method of expressing acid strength pK_a= - $\log_{10}$[K_a].

pK_a is determined by measuring the changes in pH of acid solution at different amounts of the base added.During the titration of an acid with a base, the pH of the solution rises gradually at first, then more rapidly and until at the equivalence point, there is a very sharp increase in pH for a very small quantity of added base. Once past the equivalence point, the pH increases only slightly on addition of excess base. The titration curve is obtained by plotting changes in pH at different amounts of the base added and the equivalence point is determined.

According to Henderson-Hasselbalch equation, $pH = pK_a + \log_{10}(\frac{[salt]}{[acid]})$

At half equivalence point, [salt] = [acid] and therefore, pH at half equivalence point gives the **p**K_a of weak acid.

Procedure:

Pipette out of 25 cm^3 of the given weak acid into a beaker. Immerse a glass electrode-calomel electrode assembly into the acid and connect the cell to a pH meter. Measure the pH of the acid. Fill a burette with the sodium hydroxide solution, add 0.5 ml increments of NaOH and Stir the solution thoroughly and measure the pH after each addition, Continue till there is rapid increase in pH and take another 4 or 5 values after rapid increase.

Plot graph $\Delta p^H / \Delta V$ against the volume of NaOH. Determine the equivalence point plot another graph of pH against volume of NaOH and determine pKa of the given weak acid

Result:

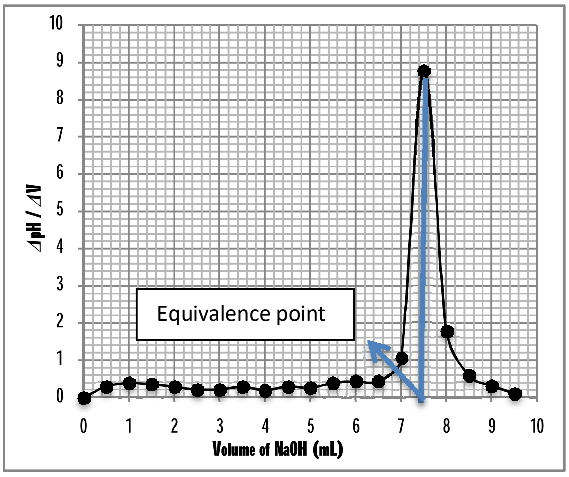
ThepK_a value of the given weak acid is = ...

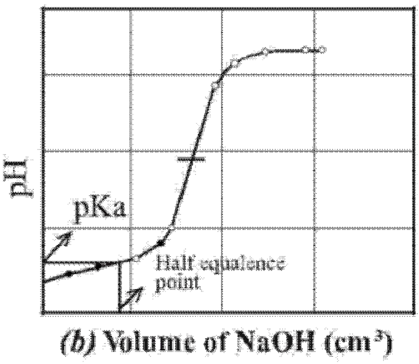
Links to the external sources of information about the topic:

1. https://www.emich.edu/chemistry/genchemlab/documents/10-pka.pdf
2. http://en.wikipedia.org/wiki/Acid_dissociation_constant
3. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3747999/

Experiment 7: Observation and Calculations

Volume of NaOH (mL) (V)	pH	ΔpH	ΔV	$\Delta pH/\Delta V$
0.0		--	--	--





Equivalence point = ……………

Half-equivalence point = ………………

pH at half-equivalence point = ………………

pK_a of weak acid = pH at half-equivalence point

Result: The pK_a value of the given weak acid is = ...