



Eco Friendly Students Training Methods in Analytical Chemistry

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Abstract

Various segments of environment are polluted due to the discharge of chemicals mainly from anthropogenic sources. In academic institutions, students (UG&PG) need to be trained in various instrumental analytical techniques so as to provide skilled human resource to the industry and research organizations. After the experiments, the discharged chemicals increase the pollution load of the environment. Information and Communication Technology (ICT) can provide a possible solution to this problem by incorporating eco friendly students training methods in Analytical Chemistry. In the present scenario ICT methods will prove to be a boon to the students community at large while protecting the environment. Virtual methods have been discussed.

Introduction

Biotic and abiotic spheres of the environment are polluted due to the entry of chemicals generally from anthropogenic sources. One way of controlling this pollution would be to reduce the amount of chemicals discharged into the environment. In Analytical Chemistry laboratory various chemicals are routinely used for the training of students in analytical techniques. After the experiments the chemicals are discharged into the drainage system. Considering the large number of UG&PG students, the pollution of the environment shall be considerable. Hence it is necessary to search for eco friendly methods which will reduce the pollution load. Information and Communication Technology (ICT) can provide a possible solution to achieve this goal. Using available computer simulation programmes, students can perform experiments virtually on the screen and develop required skills. pH-metric acid–base titrations are the analytical methods which are used commonly in chemistry. Theory and practice of these titrations is well documented in the literature¹⁻⁴.

Experimental

Indian Academy of Sciences⁵, Bangalore had prepared a Compact Disc (CD) titled as “Resonance Internet Software Collection (RISC) for Chemistry in 2001 and was made available to the Chemistry fraternity with a nominal cost of Rs100/-. We procured the CD in 2001-02 and studied the software collection. In this collection, we found “Titrt10 Software” for performing pH-metric acid–base titrations. To open this programme, we have to double click in following order.

RSIC→Windows→Chemistry→Education→Titrt10→Titrate.Exe→Titrate→Titration.



Select appropriate type of acid-base titration. A window will appear on the screen showing a beaker with 10 mL of the acid and a burette filled with the given base. Students are provided with a code for the given acid. The addition rate of the base is controlled using a scroll bar at the lower left of the Screen. Adjust the scroll bar by clicking on the thumb control or the arrows on the scroll bar. The titration is started by Pressing “Home Key” and can be momentarily stopped by Pressing “End Key”. When the titration is stopped at any point, the volume of base added and pH of the solution at that instant is displayed on the screen. The titration may be repeated any number of times by selecting “Repeat Menu”.

Results and Discussion

When the programme is run, a graph is simultaneously plotted on the screen (Fig.1) between pH of the solution and the volume of the base added. We suggest that the first run should be carried out with high addition rate so that from the titration curve the student will know the approximate equivalence point. After that the same titration may be repeated with very small addition rate (0.01 mL). In the beginning of the titration the base is added about 1 mL at a time and the pH of the solution is recorded. However, in the close vicinity of the equivalence point the base is added in small installments of about 0.1 mL only. The data can be plotted manually on a graph paper as shown below (Fig.1) and the end point is detected from the point of inflection

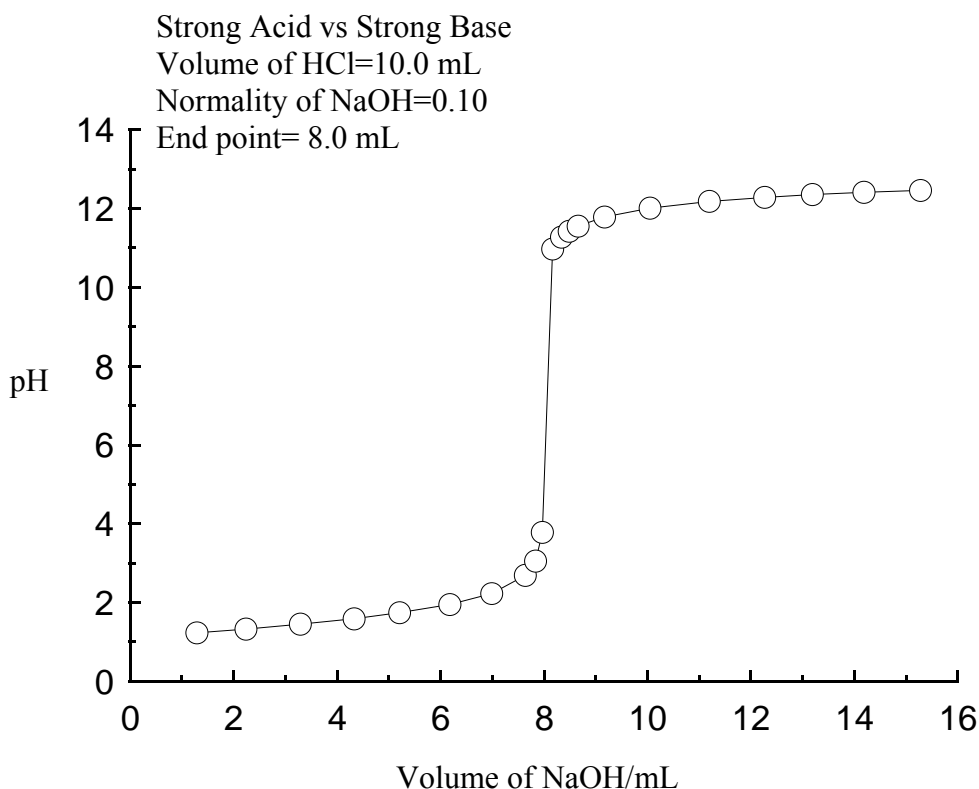


Fig. 1 .Strong acid vs Strong base Titration



A derivative curve may also be obtained by plotting ΔpH as a function of mean volume of the base added. Students can perform four different types of acid-base titrations and compare the nature of titration curves. These titration curves are very useful in the selection of proper indicator for the manual titration. Another application of the same programme is the determination of dissociation constants (K_a) of the weak monobasic and dibasic acids. For a weak acid like CH_3COOH , the pH metric titration is performed against a strong base like $NaOH$ and a titration curve is obtained (Fig.2.).

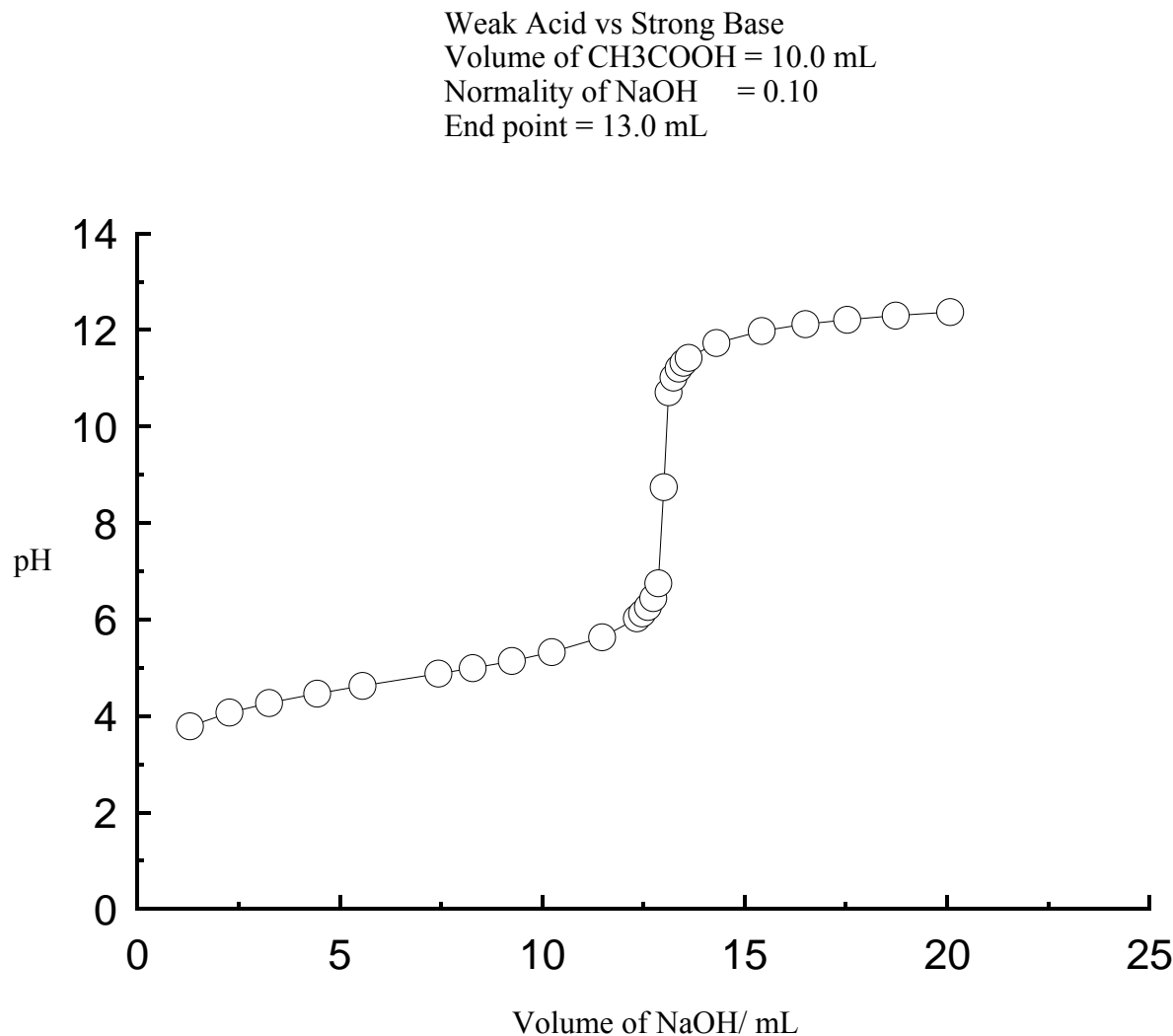


Fig.2 .Weak Acid vs Strong Base Titration

After locating the end point, the pH at half the equivalence point is noted from the graph. Using the Henderson's equation⁶

$$pH = pK_a + \log \left[\frac{[salt]}{[acid]} \right]$$

The pH at half the equivalence point will give pKa for acetic acid. Dissociation constant is calculated using the relation $pK = -\log K_a$. In case of diprotic weak acid like oxalic acid, the pH metric titration is performed against a strong base like NaOH and a titration curve (Fig.3.) is obtained.

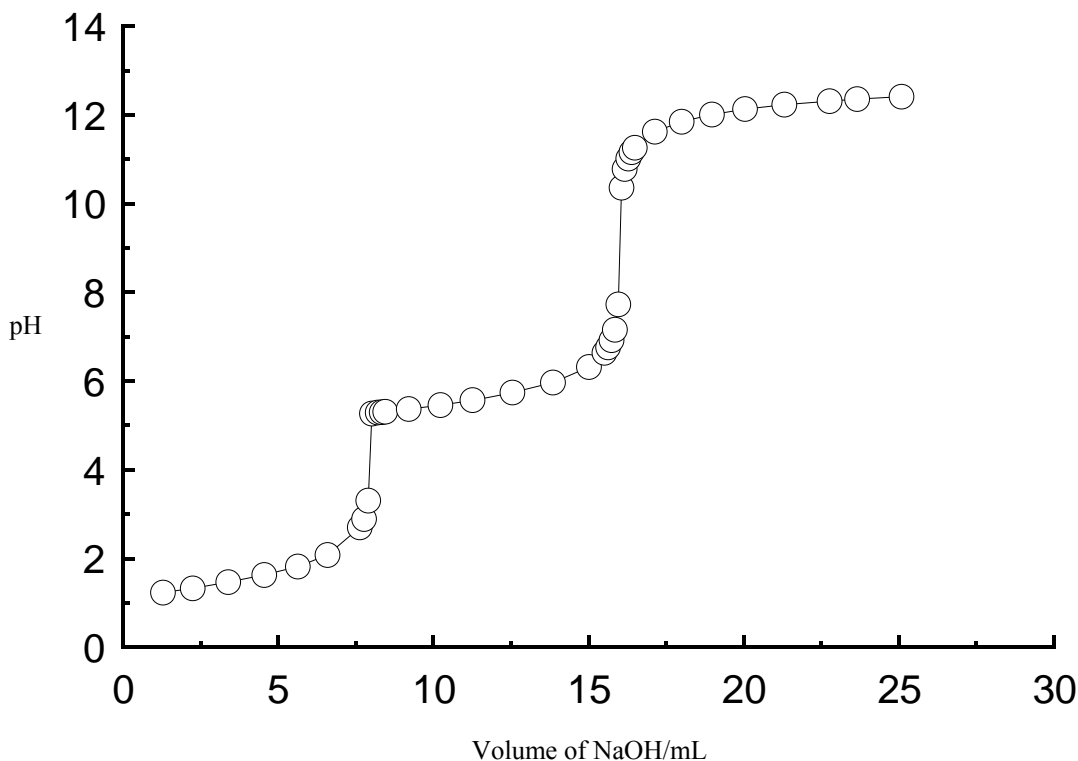
Weak Diprotic Acid vs Strong Base

Volume of $H_2C_2O_4 = 10.0 \text{ mL}$

Normality of NaOH = 0.10

First end point = 8.0 mL

Second end point = 16.0 mL



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Fig.3.Weak Diprotic Acid vs Strong Base

First equivalence point corresponds to the dissociation of first proton which gives pK_{a1} while pK_{a2} can be calculated from the second equivalence point. These programmes can be run on a Desk Top computers or Lap Tops. We have procured four Desk Top machines for our Chemistry Laboratory and we are using these programmes from last seven years to train our UG students with excellent feedback. We realise that these methods can not substitute the real time experiments for hands on experience. However, the confidence and skill of the students can be improved to a great extent by performing these virtual experiments.



Conclusion

We observe that analytical instrumentation is either not available in large number of UG colleges or even if available, the number of working instruments is inadequate to cater to the needs of large number of students enrolled for UG and PG courses due to various reasons. Another advantage of these methods is that the teacher can demonstrate the Experiment to the entire class using LCD Projector and the software may be distributed to the students so that they can perform the experiment at their home. Secondly, the cost of chemicals is increasing by leaps and bounds and hence considerable saving on chemicals can also be achieved. Thus, it appears that, in the present scenario ICT methods will prove to be a boon to the students community at large while protecting the environment.

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