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ANALYTICAL CHALLENGE

Titration endpoint challenge

Diego Alejandro Ahumada Forigua[1] · Juris Meija[2]

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We would like to invite you to participate in the Analytical Challenge, a series of puzzles to entertain and challenge our readers. This special feature of "Analytical and Bioanalytical Chemistry" has established itself as a truly unique quiz series, with a new scientific puzzle published every three months. Readers can access the complete collection of published problems with their solutions on the ABC homepage at http://www.springer.com/abc. *Test your knowledge and tease your wits in diverse areas of analytical and bioanalytical chemistry by viewing this collection.*

In the present challenge, titration is the topic. And please note that there is a prize to be won (a Springer book of your choice up to a value of €100). Please read on...

Meet the challenge

Acid–base titrations are a group of techniques of wide industrial and academic application. It is recognized that many of the advances and applications of these techniques have greatly contributed to the development of the chemical industry and therefore the development of chemical sciences. Indeed, in 1996 the Consultative Committee for Amount of Substance (CCQM) of the International Bureau of Weights and Measures recognized titration as one of the potential primary methods that exist for the determination of chemical amount. For these reasons, many of the national metrology institutes have focused their efforts on the practical aspects related to the sources of uncertainty of this technique.

Origins of titrimetry date back to 1690s, when Wilhelm Homberg (1652–1715) published the first report related to an acidity measurement [1]. Several decades later Claude Geoffroy (1729–1753) used this method to determine the strength of vinegar by adding small amounts of potassium carbonate until the no further effervescence was observed [2]. William Lewis (1708–1781), who is also considered one of the early pioneers of titration, recognized the difficulty in determining the endpoint of the titration through the process of cessation of effervescence, so he suggested the use of color indicators [3].

Today, the identification of sources of uncertainty for an acid–base titration is well established; however, the difficulty of evaluating the uncertainty associated with the equivalence point (V_{ep}) is recognized. Most notably, visual detection of titration endpoints might be subjective and vary between analysts. Furthermore, the observed endpoint might not always coincide exactly with the stoichiometric completion of the underlying chemical reaction [4].

If titration is carried out using visual indicator for the endpoint of titration, the Eurachem Guide suggests that the uncertainty due to the visual detection (with phenolphthalein) of the endpoint is approximately 0.03 mL [5]. Others have proposed that the uncertainty of the endpoint is related to the volume excess (V_{ex}) due to the pH difference between the equivalence point and the indicator color change [6]:

$$u(V_{ep}) = \frac{V_{ex}}{2\sqrt{3}} \quad (1)$$

or is related simply to the volume resolution (R) of the burette [7]:

✉ Diego Alejandro Ahumada Forigua
dahumada@inm.gov.co

[1] Chemical Metrology Division, National Metrology Institute, Colombia, Bogotá, D.C., Colombia

[2] Metrology, National Research Council, Ottawa, ON, Canada

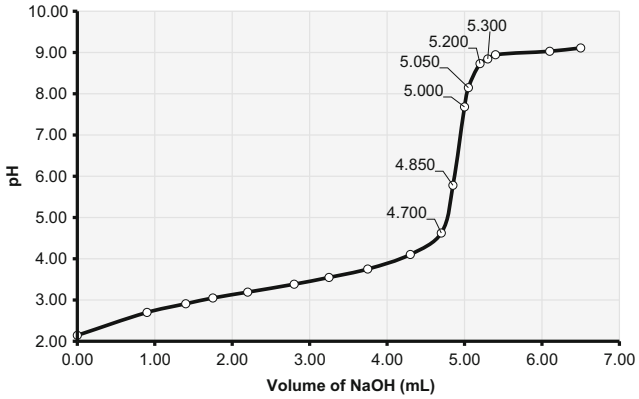

Fig. 1 Potentiometric titration curve for the acidity of milk. The volume corresponding to the equivalence point (first-order derivative method) was 5.00 mL. The endpoint with phenolphthalein was recorded as 5.05 mL

$$u(V_{ep}) = \frac{R}{2\sqrt{3}} \quad (2)$$

The challenge

Figure 1 shows a simple potentiometric titration curve for determining the acidity of milk. For this experiment the resolution of the burette was 0.05 mL, and both potentiometric and pH color indicators were used simultaneously.

What value and uncertainty would you assign for the endpoint volume of this titration, for both the visual and the potentiometric methods?

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We invite our readers to participate in the Analytical Challenge by solving the puzzle above. Please send the correct solution to abc-challenge@springer.com *by April 1, 2019. Make sure you enter "Titration endpoint challenge" in the subject line of your e-mail. The winner will be notified by e-mail and his/her name will be published on the "Analytical and Bioanalytical Chemistry" homepage at* http://www.springer.com/abc *and in the journal (volume 411/issue 17) where readers will find the solution and a short explanation.*

The next Analytical Challenge will be published in 411/10, April 2019. If you have enjoyed solving this Analytical Challenge you are invited to try the previous puzzles on the ABC homepage.