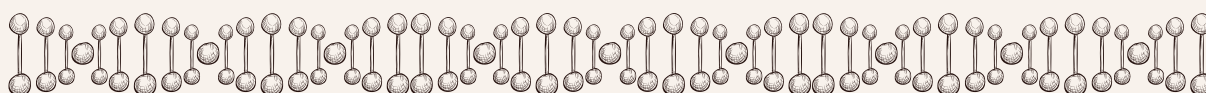


WHY THE HENDERSON–HASSELBALCH EQUATION WORKS, UNTIL IT DOESN'T

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$$pH = pK_a + \log_{10} \frac{[A^-]}{[HA]}$$

Figure 1: Henderson-Hasselbalch Equation where A⁻ is conjugate base and HA is the weak acid (Gunawardena, 2015).

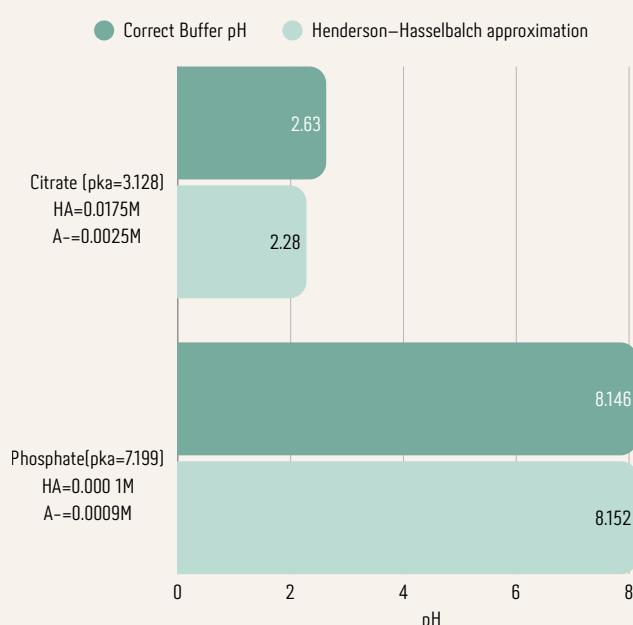


Figure 2: Comparison of Correct Buffer pH from calculation with CurTiPot_.xslm and calculated with Henderson–Hasselbalch Equation (Lucy, 2023)

04 How This Could Be Used for Learning

- Used as an introduction to a lesson about showing how the Henderson-Hasselbalch Equation as a simple way to calculate the pH.
- As students build their knowledge the teacher could show ways when the equation breaks down.
- Showcase to the students that models are great in simplified situations.
- However, real life scenarios require more complicated solutions.
- Hopefully, decrease student's memorization of the equations and instead make them build their understanding deeper.

05 References

Gunawardena, G. (2015, November 19). Henderson-hasselbach equation. Chemistry LibreTexts.https://chem.libretexts.org/Ancillary_Materials/Reference/Organic_Chemistry_Glossary/Henderson-Hasselbach_Equation

Lucy, C. A. (2023). Is Your Henderson–Hasselbalch Calculation of Buffer pH Correct? *Journal of Chemical Education*, 100(6), 2418–2422.<https://doi.org/10.1021/acs.jchemed.2c01203>

Po, H. N., & Senozan, N. M. (2001). The Henderson-Hasselbalch Equation: Its History and Limitations. *Journal of Chemical Education*, 78(11), 1499. <https://doi.org/10.1021/ed078p1499>

01 Scientific Example

- The Henderson-Hasselbalch Equation is a formula that connects an acid's dissociation constant to the pH of an aqueous acid solution (Gunawardena, 2015).
- Formula requires certain conditions for it to remain valid due to it being an algebraic approximation.
- Only considers the conjugated base and weak acid as initial analytical concentrations instead of the actual chemical behavior (Po and Senozan, 2001).
- The formula only considers ideal behavior due to the assumption that weak acids dissociation is so weak that it considered to be negligible (Gunawardena, 2015).
- As well, the equation considers the self-dissociation of water to be negligible (Gunawardena, 2015).
- Ignores other chemical variables like fluctuating activity coefficients, self-dissociation of water due to large amounts of dilution, and temperature changes.

02 Nature of Science Principle

- The Henderson-Hasselbalch equation is an example of the nature of science principle scientific models are useful, but they have limitations.
- The Henderson-Hasselbalch equation is an simplified algebraic model for buffer solutions and weak acid-base reactions that approximates the pH (Gunawardena, 2015).
- The model is simple and easy way to calculate pH and understand how pH and acid dissociation constants are related.
- However, once the condition can not be considered it causes a significant difference in the calculated and the real life pH.
- Models are great at representing processes at a very simple level, but it does not consider real life factors.
- The Henderson Henderson-Hasselbalch equation is not the only method to solve this type of problem and it is important to understand when the conditons allow for the formula to be used or when other method are required.

03 Why This Matters

- Teaches everyone that models are great starting points for understanding a complex concept.
- However, it must be understood that model might not consider the real life factors.
- Important to understands when the conditions allow for models to be used or when other equations should be applied.
- Great for teachers because it allows students to showcase the most simplified principles of the model as a starting point and as they build their understanding new concepts of how it applies to real life can be introduced.

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