Determination of K_a of Weak Acids

Inquiry Guidance and AP* Chemistry Curriculum Alignment

Introduction

Acids vary greatly in their strength—their ability to ionize or produce ions when dissolved in water. What factors determine the strength of an acid? In this experiment, the strength of acids are determined by the equilibrium constants for their ionization reactions in water.

Opportunities for Inquiry

Measuring the pH of a half-neutralized weak acid to determine its K_a nicely blends the concepts of several chemistry big ideas and learning objectives involving titration, acid–base equilibrium, and buffering. Determining Ka of weak acids requires students to develop science practice skills involving mathematical reasoning and data analysis.

Transition the classic experiment to guided inquiry by increasing student preparation and involving students in the design of the experiment. The following inquiry strategies will increase the level of student engagement and their ownership of experiment results.

- Introduce the lab by demonstrating the general setup for titrating and taking pH readings. Follow this with a basic outline of the experiment. "The purpose of this experiment is to determine the K_a of weak acids. The weak acids will be combined with their conjugate bases so that the K_a of each acid can be determined by measuring the pH of the resultant solution."
- Extend the lab to include determining K_b for a series of weak bases, such as ammonia or ethylendiamine. Prepare solutions of each and have students design both the titrations and the calculations needed to discover the K_b values.
- Prepare a solution containing two different weak acids and challenge students to identify the acids and the molarity of each in solution. By titrating the mixed solution with a standard base solution, students are challenged to determine both the identity and the molarity of each acid by examining the titration curve.
- Many consumer products, such as drinks, shampoos, and other products, contain weak acids. Extend the experiment to identify the weak acid contained in selected products.

Alignment with AP Chemistry Curriculum Framework—Big Ideas 1 and 6

Enduring Understandings and Essential Knowledge

Atoms are conserved in physical and chemical processes. (Enduring Understanding 1E)

1E2: Conservation of atoms makes it possible to compute the masses of substances involved in physical and chemical processes. Chemical processes result in the formation of new substances, and the amount of these depends on the number and the types and masses of elements in the reactants, as well as the efficiency of the transformation.

Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal. (Enduring Understanding 6A)

6A2: The current state of a system undergoing a reversible reaction can be characterized by the extent to which reactants have been converted to products. The relative quantities of reaction components are quantitatively described by the reaction quotient, Q.

Chemical equilibrium plays an important role in acid-base chemistry and in solubility. (Enduring Understanding 6C)

6C1: Chemical equilibrium reasoning can be used to describe the proton-transfer reactions of acid-base chemistry.

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Learning Objectives

1.20 The student can design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution.

6.2 The student can, given a manipulation of a chemical reaction or set of reactions (e.g., reversal of reaction or addition of two reactions), determine the effects of that manipulation on *Q* or *K*.

6.14 The student can, based on the dependence of K_w on temperature, reason that neutrality requires $[H^+] = [OH^-]$ as opposed to requiring pH = 7, including especially the applications to biological systems.

6.16 The student can identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculate the pH and concentration of all species in the solution, and/ or infer the relative strengths of the weak acids or bases from given equilibrium concentrations.

Science Practices

1.4 The student can use representations and models to analyze situations or solve problems qualitatively and quantitatively.

2.2 The student can apply mathematical routines to quantities that describe natural phenomena.

4.2 The student can design a plan for collecting data to answer a particular scientific question.

5.1 The student can analyze data to identify patterns or relationships.

6.2 The student can construct explanations of phenomena based on evidence produced through scientific practices.

6.1 The student can justify claims with evidence.

6.4 The student can make claims and predictions about natural phenomena based on scientific theories and models.

The *Determination of* K_a *of Weak Acids—AP Chemistry Classic Laboratory Kit* is available from Flinn Scientific, Inc.

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