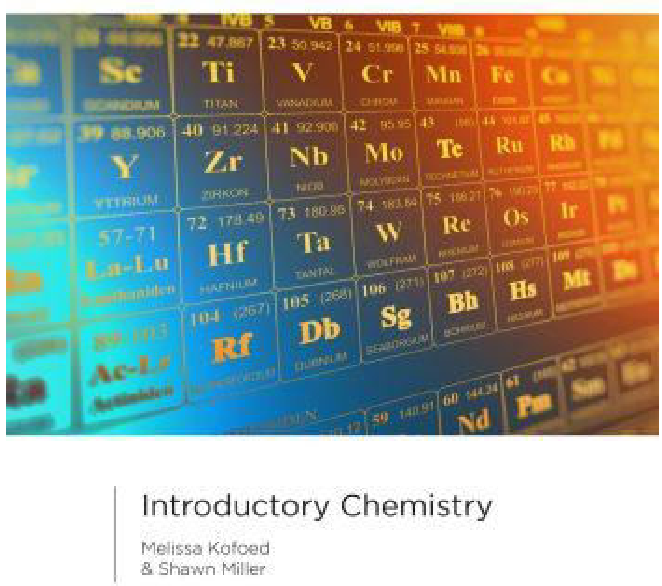
Introductory Chemistry

by Melissa Kofoed; Shawn Miller; and Utah State University



Introductory Chemistry is designed to cover the wide range of topics typically covered in a one-semester chemistry course for non-science majors. This re-mixed textbook is an adaptation of chapters predominantly from three open source chemistry texts-

Boundless Chemistry by LumenLearning, *Chemistry: Atoms First (2e)* by OpenStax, and *General Chemistry: Principles, Patterns, and Applications* by Salyor Academy. This specific text was created to align with the flow of topics taught in the course Chemistry 1010 at Utah State University.

Creative Commons Attribution ShareAlike

READ BOOK

CONTENTS

HIDE ALL CONTENTS

BOOK INFORMATION

AUTHORS

Melissa Kofoed; Shawn Miller; and Utah State University

LICENSE

Introductory Chemistry Copyright © by Utah State University is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License, except where otherwise noted.

SUBJECT

Chemistry

↓

METADATA

TITLE

Introductory Chemistry

AUTHORS

Melissa Kofoed; Shawn Miller; and Utah State University

LICENSE

Introductory Chemistry Copyright © by Utah State University is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License, except where otherwise noted.

PRIMARY SUBJECT

Chemistry

Powered by Pressbooks

Pressbooks User Guide | Pressbooks Directory

64.

STRENGTH OF ACIDS

LumenLearning

Strong Acids

In water, strong acids completely dissociate into free protons and their conjugate base.

LEARNING OBJECTIVES

KEY TAKEAWAYS

Key Points

- Strong acids can catalyze chemical reactions.
- Strong acids are defined by their pK_a. The acid must be stronger in aqueous solution than a hydronium ion, so its pK_a must be lower than that of a hydronium ion. Therefore, strong acids have a pK_a of <-174.
- Strong acids can be organic or inorganic.
- Strong acids must be handled carefully because they can cause severe chemical burns.
- Strong acids are essential for catalyzing some reactions, including the synthesis and hydrolysis of carbonyl compounds.

Key Terms

- carbonyl: a divalent functional group (-CO-), characteristic of aldehydes, ketones, carboxylic acids, amides, carboxylic acid anhydrides, carbonyl halides, esters, and others.
- ester: a compound usually formed by condensing an alcohol and an acid and eliminating of water. it contains the functional group carbon-oxygen double bond joined via carbon to another oxygen atom
- hydrolysis: a chemical process of decomposition; involves splitting a bond and adding the hydrogen cation and water's hydroxide anion

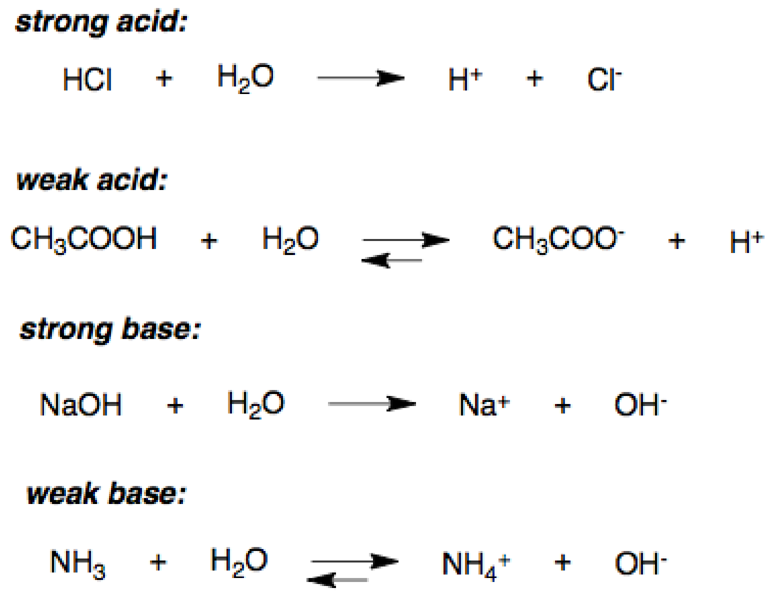
Definition of Strong Acids

The strength of an acid refers to the ease with which the acid loses a proton. A strong acid ionizes completely in an aqueous solution by losing one proton, according to the following equation:

$$\mathrm{HA}(aq) \rightarrow \mathrm{H}^+(aq) + \mathrm{A}^-(aq)$$

where HA is a protonated acid, H^+ is the free acidic proton, and A^- is the conjugate base. Strong acids yield weak conjugate bases. For sulfuric acid, which is diprotic, the "strong acid" designation refers only to the dissociation of the first proton:

More precisely, the acid must be stronger in aqueous solution than a hydronium ion ($\mathrm{H^+}$), so strong acids have a pKa < -1.74. An example is hydrochloric acid (HCl), whose pKa is -6.3. This generally means that in aqueous solution at standard temperature and pressure, the concentration of hydronium ions is equal to the concentration of strong acid introduced to the solution.



Ionization of acids and bases in water: A strong acid ionizes completely in an aqueous solution by losing one proton (H+).

Due to the complete dissociation of strong acids in aqueous solution, the concentration of hydronium ions in the water is equal to the total concentration (ionized and un-ionized) of the acid introduced to solution:

$[\mathrm{H^+}] = [\mathrm{A^-}] = [\mathrm{HA}]_{\mathrm{total}}$ and $\mathrm{pH} = \text{-}\log[\mathrm{H^+}]$.

Strong acids, like strong bases, can cause chemical burns when exposed to living tissue.

Examples of Strong Acids

Some common strong acids (acids with pKa < -1) include:

- Hydroiodic acid (HI): pKa = -9.3
- Hydrobromic acid (HBr): pKa = -8.7

- Sulfuric acid (H_2SO_4): $pKa1$ ≈ -3 (first dissociation only)
- p-Toluenesulfonic acid: pKa = -2.8
- Nitric acid (HNO_3): pKa ≈ -1.4
- Chloric acid ($HClO_3$): pKa ≈ 1.0

Weak Acids

A weak acid only partially dissociates in solution.

LEARNING OBJECTIVES

Solve acid-base equilibrium problems for weak acids.

KEY TAKEAWAYS

Key Points

- The dissociation of weak acids, which are the most common type of acid, are only partial.

Key Terms

- **conjugate acid**: the species created when a base accepts a proton
- **conjugate base**: the species created after donating a proton.
- weak acid: one that dissociates incompletely, donating only some of its hydrogen ions into solution

A weak acid is one that does not dissociate completely in solution; this means that a weak acid does not donate all of its hydrogen ions (H^+) in a solution. Weak acids have very small values for K_a (and therefore higher values for pK_a) compared to strong acids, which have

Previous: Acids and Bases

Next: Strength of Bases

dissociates in water in a 0.1 mol/L solution. Therefore, the concentration of H^+ ions in a weak acid solution is always less than the concentration of the undissociated species, HA. Examples of weak acids include acetic acid (CH_aCOOH), which is found in vinegar, and oxalic acid ($H_2C_2O_4$), which is found in some vegetables.

LICENSES AND ATTRIBUTIONS

CC LICENSED CONTENT, SHARED PREVIOUSLY

- Curation and Revision. **Provided by**: Boundless.com. **License**: *CC BY-SA: Attribution-ShareAlike*

CC LICENSED CONTENT, SPECIFIC ATTRIBUTION

- Acid strength. **Provided by**: Wikipedia. **Located at**: http://en.wikipedia.org/wiki/Acid_strength%23Strong_acids. **License**: *CC BY-SA: Attribution-ShareAlike*
- Acid catalysis. **Provided by**: Wikipedia. **Located at**: http://en.wikipedia.org/wiki/Acid_catalysis. **License**: *CC BY-SA: Attribution-ShareAlike*
- Strong and Weak Acids or Bases. **Provided by**: wilenskychemistry Wikispace. **Located at**: http://wilenskychemistry.wikispaces.com/Strong+and+Weak+Acids+or+Bases. **License**: *CC BY-SA: Attribution-ShareAlike*
- Acid strength. **Provided by**: Wikipedia. **Located at**: http://en.wikipedia.org/wiki/Acid_strength%23Strong_acids. **License**: *CC BY-SA: Attribution-ShareAlike*
- Chemical burn. **Provided by**: Wikipedia. **Located at**: http://en.wikipedia.org/wiki/Chemical_burn. **License**: *CC BY-SA: Attribution-ShareAlike*
- carbonyl. **Provided by**: Wiktionary. **Located at**: http://en.wiktionary.org/wiki/carbonyl. **License**: *CC BY-SA: Attribution-ShareAlike*
- ester. **Provided by**: Wiktionary. **Located at**: http://en.wiktionary.org/wiki/ester. **License**: *CC BY-SA: Attribution-ShareAlike*
- hydrolysis. **Provided by**: Wiktionary. **Located at**: http://en.wiktionary.org/wiki/hydrolysis. **License**: *CC BY-SA: Attribution-ShareAlike*
- Original figure by Adrian Accurso. Licensed CC BY-SA 4.0. **Provided by**: Adrian

- A-level Chemistry/OCR (Salters)/Weak acids. **Provided by**: Wikibooks. **Located at**: http://en.wikibooks.org/wiki/A-level_Chemistry/OCR_(Salters)/Weak_acids. **License**: *CC BY-SA: Attribution-ShareAlike*
- Acid strength. **Provided by**: Wikipedia. **Located at**: http://en.wikipedia.org/wiki/Acid_strength%23Weak_acids. **License**: *CC BY-SA: Attribution-ShareAlike*
- General Chemistry/Properties and Theories of Acids and Bases. **Provided by**: Wikibooks. **Located at**: http://en.wikibooks.org/wiki/General_Chemistry/Properties_and_Theories_of_Acids_and_Bases%23Strong_and_Weak_Acids.2FBases. **License**: *CC BY-SA: Attribution-ShareAlike*
- Weak acid. **Provided by**: Wikipedia. **Located at**: https://en.wikipedia.org/wiki/Weak_acid%23Weak_acids. **License**: *CC BY-SA: Attribution-ShareAlike*
- conjugate base. **Provided by**: Wiktionary. **Located at**: http://en.wiktionary.org/wiki/conjugate_base. **License**: *CC BY-SA: Attribution-ShareAlike*
- conjugate acid. **Provided by**: Wiktionary. **Located at**: http://en.wiktionary.org/wiki/conjugate_acid. **License**: *CC BY-SA: Attribution-ShareAlike*
- Original figure by Adrian Accurso. Licensed CC BY-SA 4.0. **Provided by**: Adrian Accurso. **License**: *CC BY-SA: Attribution-ShareAlike*
- Original figure by Adrian Accurso. Licensed CC BY-SA 4.0. **Provided by**: Adrian Accurso. **License**: *CC BY-SA: Attribution-ShareAlike*
- Essig-1. **Provided by**: Wikimedia. **Located at**: http://commons.wikimedia.org/wiki/File:Essig-1.jpg. **License**: *CC BY-SA: Attribution-ShareAlike*
- Common-ion effect. **Provided by**: Wikipedia. **Located at**: http://en.wikipedia.org/wiki/Common-ion_effect. **License**: *CC BY-SA: Attribution-ShareAlike*
- Acid strength. **Provided by**: Wikipedia. **Located at**: http://en.wikipedia.org/wiki/Acid_strength. **License**: *CC BY-SA: Attribution-ShareAlike*
- dissociation. **Provided by**: Wiktionary. **Located at**: http://en.wiktionary.org/wiki/dissociation. **License**: *CC BY-SA: Attribution-ShareAlike*
- electrolyte. **Provided by**: Wiktionary. **Located at**: http://en.wiktionary.org/wiki/electrolyte. **License**: *CC BY-SA: Attribution-ShareAlike*

BY-SA: Attribution-ShareAlike

- acid. **Provided by**: Wiktionary. **Located at**: http://en.wiktionary.org/wiki/acid. **License**: *CC BY-SA: Attribution-ShareAlike*
- Original figure by Adrian Accurso. Licensed CC BY-SA 4.0. **Provided by**: Adrian Accurso. **License**: *CC BY-SA: Attribution-ShareAlike*
- Original figure by Adrian Accurso. Licensed CC BY-SA 4.0. **Provided by**: Adrian Accurso. **License**: *CC BY-SA: Attribution-ShareAlike*
- Essig-1. **Provided by**: Wikimedia. **Located at**: http://commons.wikimedia.org/wiki/File:Essig-1.jpg. **License**: *CC BY-SA: Attribution-ShareAlike*

This chapter is an adaptation of the chapter "Strength of Acids" in *Boundless Chemistry* by LumenLearning and is licensed under a CC BY-SA 4.0 license.

LICENSE

Introductory Chemistry Copyright © by Utah State University is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License, except where otherwise noted.

SHARE THIS BOOK