|  |  |
| --- | --- |
| **Section of Project** | **Industrial Applications for Secondary STEM Education** |
| **Title** | **Industrial Knowledge of Acids and Bases** |
| **Introduction** | Acids and bases play a central role in chemical processes. Most industries use chemical processes to meet manufacturing needs. The processes, and the daily handling of the chemicals, require a deep knowledge and understanding of their properties, applications, and dangers. In this lesson, students will become familiar with the physical and chemical properties of acids and bases, as well as become familiar with how DuPont Fayetteville Works uses such substances for production and manufacturing purposes. Finally, students will learn about various legislative acts that protect the environment from the industrial use of potentially harmful substances. |
| **Real Science Application** | **NCDPI Applications*** Physical properties of acids and bases
* Chemical properties of acids and bases (H+ and OH-)
* pH scale
* Indicator tests

**DuPont Applications*** Practical applications of common acids and bases
* RCRA laws about waste materials, EPA laws about emissions.
* DuPont Fayetteville Works/NAFION (uses for materials)
 |
| **Curriculum Alignment**  | **North Carolina Essential Standards for Chemistry**Chm.3.2 Understand solutions and the solution process.* Chm.3.2.1Classify substances using the hydronium and hydroxide concentrations
* Chm.3.2.2 Summarize the properties of acids and bases
* Chm.3.2.3 Infer the quantitative nature of a solution (molarity, dilution, and titration with a 1:1 molar ratio)
* Chem.3.2.4 Summarize the properties of solutions

**North Carolina Essential Standards for Physical Science**PSc.2.2 Understand chemical bonding and chemical equations* PSc.2.2 summarize the characteristics and interactions of acids and bases
 |
| **Learning Outcomes**  | * Students will become familiar with the physical and chemical properties of acids and bases.
* Students will become familiar with how DuPont Fayetteville Works uses such substances for production and manufacturing purposes.
* Students will learn about various legislative acts that protect the environment from the industrial use of potentially harmful substances.
 |

|  |  |
| --- | --- |
| **Time Required and Location**  | 180 minutes. (2 days, 90 minute periods) in a lab classroom |
| **Materials Needed**  | * Debate cards
* Lecture material and worksheets
* Fruit and vegetables: celery, banana, grape, tomato, lemon, apple, orange, grapefruit
* Knife
* Paper towels
* Large paper plate
* Baking soda (NaHCO**3)**
* Pure distilled water
* Milk
* Sea water
* Coffee
* Lemon juice
* Coke
* Milk of magnesia
* Ammonia
* Washing soda
* Blue and red litmus paper
* Poster paper
* Markers
 |
| **Safety**  | Students and instructor should comply with typical laboratory safety procedures for behavior and chemical disposal. |
| **Participant Prior Knowledge**  | This lesson is appropriate during a matter or chemical reactions unit in chemistry or physical science. Students should already having working knowledge of the structure of matter, bonding, and types of chemical reactions. |
| **Facilitator Preparations**  | Prepare lab equipment and chemical solutions ahead of time. Have materials laid out in such a way that students can easily access them. |
| **Activities**  | **Pre-Activities/ Hook:** (20 min.)* Break students into four groups. (two “pro” groups vs. two “con” groups)
* Groups should be given scenarios to debate “pros” vs. “cons” without any prior exposure to content material. These scenarios involve controversial real-world manufacturing issues.

(See attached document)**Activities:** (140 min. combined)**Introduction Lab:** 10 min. (recommended for pairs or small groups)1. Cut up various fruits and vegetables so that students can take a plate and place one small piece of each on their plates.
2. Place a pinch of baking soda on each sample.
3. Observe and discuss.

**Whole group instruction:** 30 min. (see attached lecture notes)Use lecture information to deliver information about the following knowledge-based content.* Physical properties of acids and bases
* pH scale
* Chemical properties of acids and bases (H+ and OH-)
* Indicator tests

**Lab activity:** 30 min. (see attached lab worksheet)1. Students will perform tests on various household items using litmus paper.
2. They should record data using outlined worksheet.

**Lab follow-up activity:** 10 min.Students will complete a pH scale according to the data collected. * + Students should use white paper and draw straight lines with rulers.
	+ Students will use crayons to indicate color scale.
	+ Students will label scale with data collected.

**Whole group instruction:** 40 min. (see attached lecture material and memo)* Applications of common acids and bases
* DuPont Fayetteville Works/NAFION (uses for materials)
* RCRA laws about waste materials, EPA laws about emissions
	1. Provide students with information about the common uses of acids and bases. While discussing, have them keep graphic organizer about the positive uses and harmful application of acids and bases.
	2. Have students examine a real processes chart from DuPont Fayetteville Works. Students should note the various acidic chemicals that are used for input and/or product.
	3. Use DuPont Fayetteville Works memo with probing questions for further supplemental discussions.
	4. Provide students with information about various environmental policies that DuPont must comply with including RCRA laws for waste materials, and EPA laws about emissions and soil.

**Follow-up Activity:** 20 min.Students will make a protest posters either supporting or against a new industrial proposal for the area. This is follow-up to initial “Hook” activity. |
| **Assessment**  | **Assessment:** Typical multiple-choice quiz - 30 min. (see attached assessments)  |
| **Critical Vocabulary**  | AcidActivityBaseBufferEPAHydroxidepHRECRA |
| **Modifications**  | Notes for acids and bases are available in Spanish for certain ESL students. |
| **Supplemental Information**  | **News and Events:**[Folic Acid Lowers Risk of Heart Disease](http://www.visionlearning.com/library/x_linker.php?moid=1223)U. Michigan (ScienceDaily)**Research:**[Google Scholar](http://www.visionlearning.com/library/x_linker.php?moid=4143)Google - Research database allows searching of the scholarly literature.**Related Modules:**[Water](http://www.visionlearning.com/library/x_linker.php?moid=2121&l=)**People:** [Svante Arrhenius](http://www.visionlearning.com/library/x_linker.php?moid=1225)[Johannes Brønsted](http://www.visionlearning.com/library/x_linker.php?moid=1226)**Further Exploration:**[Acid and Base, pH Tutorial](http://www.visionlearning.com/library/x_linker.php?moid=2099)Chemistry Dept., U. British Columbia - An excellent, comprehensive set of tutorials on acid/base chemistry, including practice tests.[Acid-Base Tutorial](http://www.visionlearning.com/library/x_linker.php?moid=1231)J. Park, ChemTeam - Extensive tutorials detailing acid base chemistry in historical context.[Development of Acid and Base Theory](http://www.visionlearning.com/library/x_linker.php?moid=2100)ChemWorld - A summary of major advances in acid-base research.**Resources:**[Visionlearning Glossary](http://www.visionlearning.com/library/x_linker.php?moid=1938&l=)An alphabetical glossary of relevant scientific terms. |
|  |  |

**Debate Topics for Introductory Activity**

Topic One:

The local news has just interrupted your television show to report a breaking story:

The local Excalibur Industrial Plant that manufactures various textiles has discovered a large gas leak from one of their underground lines on site. Local soil samples and groundwater test positive for toxic substances. Wildlife in the area is also suffering. Protesters are beginning to rally outside the front gates of Excalibur to campaign to shut down the plant. Engineers from Excalibur have made a statement that they plan to close the valve which controls the gas flow, and they will change the line to rectify the problem. They also have a plan to prevent this event from happening again in the future. Excalibur is the leading economic resource for the area. Excalibur employs over 500 people and produces billions of dollars in textiles. However, safety issues continue to arise.

**Discuss why the protesters should convince the public to close Excalibur.**

**~or~**

**Discuss why the plant should continue with production at its location.**

Topic Two:

After great debate, the town voted to build a new chemical factory, Cleanox, which will make a variety of toxic cleaning supplies. Cleanox will employ 350 new people and is sure to bring other industry and retail to the area. The leaders of this company have a bad reputation for putting sales before safety. The town citizens support bringing new industry to the area, but they are concerned that the various chemicals involved in the manufacturing process are extremely toxic and pose many unforeseen dangers.

**Discuss all of the concerns of the citizens, including potential hazards, and should they allow this project to continue.**

**What precautionary measures could be put in place for prevention of injury or disaster?**

**Acids and Bases Lecture Notes**

An Introduction

by Anthony Carpi, Ph.D.

For thousands of years people have known that vinegar, lemon juice and many other foods taste sour. However, it was not until a few hundred years ago that it was discovered why these things taste sour - because they are all [acids](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=). The term acid, in fact, comes from the Latin term acere, which means "sour". While there are many slightly different definitions of acids and [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=), in this lesson we will introduce the fundamentals of acid/base chemistry.

In the seventeenth century, the Irish writer and amateur chemist [Robert Boyle](http://www.visionlearning.com/library/pop_glossary_term.php?oid=4459&l=) first labeled substances as either [acids](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=) or [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=) (he called bases alkalies) according to the following characteristics:

Acids taste sour, are corrosive to metals, change litmus (a dye extracted from lichens) red, and become less acidic when mixed with [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=).

Bases feel slippery, change litmus blue, and become less basic when mixed with [acids](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=).

While Boyle and others tried to explain why [acids](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=) and [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=) behave the way they do, the first reasonable definition of acids and bases would not be proposed until 200 years later.

In the late 1800s, the Swedish scientist [Svante Arrhenius](http://www.visionlearning.com/library/pop_glossary_term.php?oid=4525&l=) proposed that water can [dissolve](http://www.visionlearning.com/library/module_viewer.php?mid=57#solvent) many [compounds](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1517&l=) by separating them into their individual [ions](http://www.visionlearning.com/library/pop_glossary_term.php?oid=853&l=). Arrhenius suggested that [acids](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=) are compounds that contain hydrogen and can dissolve in water to release hydrogen ions into [solution](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1571&l=). For example, hydrochloric acid (HCl) dissolves in water as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| HCl | H2Oarrow | H+(aq) |  +  | Cl-(aq) |

Arrhenius defined [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=) as substances that dissolve in water to release hydroxide [ions](http://www.visionlearning.com/library/pop_glossary_term.php?oid=853&l=) (OH-) into [solution](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1571&l=). For example, a typical base according to the Arrhenius definition is sodium hydroxide (NaOH):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NaOH | H2Oarrow  | Na+(aq) |  +  | OH-(aq) |

The Arrhenius definition of [acids](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=) and [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=) explains a number of things. Arrhenius's [theory](http://www.visionlearning.com/library/pop_glossary_term.php?oid=4854&l=) explains why all acids have similar properties to each other (and, conversely, why all bases are similar): because all acids release H+ into [solution](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1571&l=) (and all bases release OH-). The Arrhenius definition also explains Boyle's observation that acids and bases counteract each other. This idea, that a base can make an acid weaker, and vice versa, is called [neutralization](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1578&l=).

Neutralization

As you can see from the equations, [acids](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=) release H+ into [solution](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1571&l=) and [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=) release OH-. If we were to mix an acid and base together, the H+ [ion](http://www.visionlearning.com/library/pop_glossary_term.php?oid=853&l=) would combine with the OH- ion to make the [molecule](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1518&l=) H2O, or plain water:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| H+(aq) | +   | OH-(aq) |  arrow  | H2O |

The [neutralization](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1578&l=) reaction of an [acid](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=) with a [base](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=) will always produce water and a [salt](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1575&l=), as shown below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Acid |  | Base |  | Water |  | Salt |
| HCl |  +  | NaOH |  arrow  | H2O |  +  | NaCl |
| HBr |  +  | KOH |  arrow  | H2O |  +  | KBr |

Though Arrhenius helped explain the fundamentals of acid/base chemistry, unfortunately his theories have limits. For example, the Arrhenius definition does not explain why some substances, such as common baking soda (NaHCO3), can act like a [base](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=) even though they do not contain hydroxide [ions](http://www.visionlearning.com/library/pop_glossary_term.php?oid=853&l=).

In 1923, the Danish scientist [Johannes Brønsted](http://www.visionlearning.com/library/pop_glossary_term.php?oid=4526&l=) and the Englishman Thomas Lowry published independent yet similar papers that refined Arrhenius' [theory](http://www.visionlearning.com/library/pop_glossary_term.php?oid=4854&l=).  In Brønsted's words, "... [acids](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=) and [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=) are substances that are capable of splitting off or taking up hydrogen [ions](http://www.visionlearning.com/library/pop_glossary_term.php?oid=853&l=), respectively."  The Brønsted-Lowry definition broadened the Arrhenius concept of acids and bases.

The Brønsted-Lowry definition of [acids](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=) is very similar to the Arrhenius definition, any substance that can donate a hydrogen [ion](http://www.visionlearning.com/library/pop_glossary_term.php?oid=853&l=) is an acid (under the Brønsted definition, acids are often referred to as proton donors because an H+ ion, hydrogen minus its [electron](http://www.visionlearning.com/library/pop_glossary_term.php?oid=852&l=), is simply a proton).

The Brønsted definition of bases is, however, quite different from the Arrhenius definition.  The Brønsted [base](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=) is defined as any substance that can accept a hydrogen [ion](http://www.visionlearning.com/library/pop_glossary_term.php?oid=853&l=).  In essence, a base is the opposite of an [acid](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=).  NaOH and KOH, as we saw above, would still be considered bases because they can accept an H+ from an acid to form water.  However, the Brønsted-Lowry definition also explains why substances that do not contain OH- can act like bases.  Baking soda (NaHCO3), for example, acts like a base by accepting a hydrogen ion from an acid as illustrated below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Acid |  | Base |  |  |  | Salt |
| HCl |  +  | NaHCO3 |  arrow  | H2CO3 |  +  | NaCl |

In this example, the [carbonic acid](http://www.visionlearning.com/library/pop_glossary_term.php?oid=2192&l=) formed (H2CO3) undergoes rapid decomposition to water and gaseous carbon dioxide, and so the [solution](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1571&l=) bubbles as CO2 gas is released.

pH

Under the Brønsted-Lowry definition, both [acids](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=) and [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=) are related to the concentration of hydrogen [ions](http://www.visionlearning.com/library/pop_glossary_term.php?oid=853&l=) present.  Acids increase the concentration of hydrogen ions, while bases decrease the concentration of hydrogen ions (by accepting them).  The acidity or basicity of something, therefore, can be measured by its hydrogen ion concentration.

In 1909, the Danish biochemist Sören Sörensen invented the [pH](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1577&l=) scale for measuring acidity.  The pH scale is described by the formula:

|  |  |  |
| --- | --- | --- |
|

|  |  |
| --- | --- |
| pH = -log [H+] | Note: concentration is commonly abbreviated by using square brackets, thus [H+] = hydrogen [ion](http://www.visionlearning.com/library/pop_glossary_term.php?oid=853&l=) concentration.  When measuring [pH](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1577&l=), [H+] is in [units](http://www.visionlearning.com/library/pop_glossary_term.php?oid=848&l=) of [moles](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1515&l=) of H+ per liter of [solution](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1571&l=). |

 |

For example, a [solution](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1571&l=) with [H+] = 1 x 10-7 moles/liter has a [pH](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1577&l=) equal to 7 (a simpler way to think about pH is that it equals the exponent on the H+ concentration, ignoring the minus sign). The pH scale ranges from 0 to 14. Substances with a pH between 0 and less than 7 are [acids](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=) (pH and [H+] are inversely related - lower pH [means](http://www.visionlearning.com/library/pop_glossary_term.php?oid=4221&l=) higher [H+]). Substances with a pH greater than 7 and up to 14 are [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=) (higher pH means lower [H+]). Right in the middle, at pH = 7, are [neutral](http://www.visionlearning.com/library/pop_glossary_term.php?oid=855&l=) substances, for example, pure water. The relationship between [H+] and pH is shown in the table below alongside some common examples of acids and bases in everyday life.

|  |  |  |
| --- | --- | --- |
| [H+] | pH | Example |
| Acids | 1 X 100 | 0 | HCl  |
| 1 x 10-1 | 1 | Stomach acid |
| 1 x 10-2 | 2  | Lemon juice |
| 1 x 10-3 | 3  | Vinegar |
| 1 x 10-4 | 4 | Soda |
| 1 x 10-5 | 5 | Rainwater |
| 1 x 10-6 | 6 | Milk |
| Neutral | 1 x 10-7 | 7 | Pure water |
| Bases | 1 x 10-8 | 8 | Egg whites |
| 1 x 10-9 | 9 | Baking soda |
| 1 x 10-10 | 10 | Tums® antacid |
| 1 x 10-11 | 11 | Ammonia |
| 1 x 10-12 | 12 | Mineral lime - Ca(OH)2 |
| 1 x 10-13 | 13  | Drano® |
| 1 x 10-14 | 14  | NaOH |

**Purpose:** To learn about acids, bases and the pH scale.

**Background:** The pH scale is the way we measure the acidity and alkalinity of compounds. The pH scale is an exponential scale which means as you go up or down the scale, you increase alkalinity or acidity by powers of 10!

We will be using litmus paper to measure the pH of various common compounds. Litmus paper has been treated with a chemical that changes color based on the pH of the substance in which it comes in contact.

**Question:** What is the pH of some common household products and what is the pH system?

**Procedure:**

1. You and your lab partner will receive 12 strips of litmus paper.

2. You will rotate through 12 stations that have various household products at each.

3. You and your partner will test and record the pH of each product at each station.

4. Please make sure you record both the color of the litmus paper and the actual numerical pH of each compound.

**Lab Report Checklist:**

**Introduction:** What are the goals and objectives for this lab?

**Hypothesis:** Make an educated guess as to the pH of the compounds to be tested on lab day. Creating a chart for these makes it look really professional and is a great way to organize your work.

**Procedure:** Outline a flowchart of what you did to perform this lab.

**Results:** Please include a list of each compound/product with its pH and the corresponding color that your litmus paper indicated. On that list, note the station number for each compound. (Please create a table for this section.)

**Conclusion:** You will need to research some of these questions online, in your notes or in your text book.

* What does pH actually stand for?
* Please explain how the pH scale works. Explain the range for acids, bases and neutral compounds.
* Which of our samples was the most alkaline?
* Which of our samples was the most acidic?
* What is the main factor that changes the pH of human blood?
* How do humans maintain homeostasis of blood pH? What process do we do to control the pH level in our blood?

**ESL Modified: Acids and Bases Lecture Notes**

Ácidos & Bases

Una Introducción

por Anthony Carpi, Ph.D.

Desde hace miles de años se sabe que el vinagre, el jugo de limón y muchos otros alimentos tienen un sabor ácido. Sin embargo, no fue hasta hace unos cuantos cientos de años que se descubrió por qué estas cosas tenían un sabor ácido. El término ácido, en realidad, proviene del término Latino acere, que quiere decir ácido. Anque hay muchas diferentes definiciones de los ácidos y las [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s), en esta lección introduciremmos los fundamentos de la química de los ácidos y las bases.

En el siglo XVII, el escritor irlandés y químico amateur Robert Boyle primero denominó las substancias como ácidos o [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s) (llamó a las bases alcalis) de acuerdo a las siguientes características:

Los [Ácidos](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1573&l=s) tienen un sabor ácido,corroen el metal, cambian el litmus tornasol (una tinta extraída de los líquenes) a rojo, y se vuelven menos ácidos cuando se mezclan con las [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s).

Las Bases son resbaladizas, cambian el litmus a azul, y se vuelven menos básicas cuando se mezclan con ácidos.

Aunque Boyle y otros trataron de explicar por qué los ácidos y las [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s) se comportan de tal manera, la primera definición razonable de los ácidos y las bases no sería propuesta hasta 200 años después.

Afinales de 1800, el científico sueco Svante Arrhenius propuso que el agua puede [disolver](http://www.visionlearning.com/library/module_viewer.php?mid=57&l=s#solvent) muchos [compuestos](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1517&l=s) separándolos en sus iones individuales. Arrhenius sugirió que los ácidos son compuestos que contienen hidrógeno y pueden disolverse en el agua para soltar iones de hidrógeno a la solución. Por ejemplo, el ácido clorídrico (HCl) se disuelve en el agua de la siguiente manera:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| HCl | H2Oarrow | H+(aq) | +  | Cl-(aq) |

Arrhenius definió las [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s) como substancias que se disuelven en el agua para soltar iones de hidróxido (OH-) a la solución. Por ejemplo, una base típica de acuerdo a la definición de Arrhenius es el hidróxido de sodio (NaOH):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NaOH | H2Oarrow | Na+(aq) | +  | OH-(aq) |

La definición de los ácidos y las [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s) de Arrhenius explica un sinnúmero de cosas. La [teoría](http://www.visionlearning.com/library/pop_glossary_term.php?oid=4854&l=s) de Arrhenius explica el por qué todos los ácidos tienen propiedades similares (y de la misma manera por qué todas las bases son similares). Por que todos los ácidos sueltan H+ ia la solución (y todas las bases sueltan OH-). La definición de Arrhenius también explica la observación de Boyle que los ácidos y las bases se neutralizan entre ellos. Esta idea, que una base puede debilitar un ácido, y vice versa, es llamada [neutralización](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1578&l=s).

La Neutralización

Tal como puede ver arriba, los ácidos sueltan H+ en la solución y las [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s) sueltan OH-. [Si](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1508&l=s) fuésemos a mezclar un ácido y una base, el ión H+ se combinaría con el ión OH- [ion](http://www.visionlearning.com/library/pop_glossary_term.php?oid=853&l=s) para crear la [molécula](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1518&l=s) H2O, o simplemente agua:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| H+(aq) | +  | OH-(aq) | arrow | H2O |

La reacción neutralizante de un ácido con una [base](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s) siempre producirá agua y [sal](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1575&l=s), tal como se muestra abajo:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Ácido |  | Base |  | Agua |  | Sal |
| HCl | +  | NaOH | arrow | H2O | +  | NaCl |
| HBr | +  | KOH | arrow | H2O | +  | KBr |

Aunque Arrhenius ayudó a explicar los fundamentos de la química sobre ácidos y [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s), lastimosamente sus [teorías](http://www.visionlearning.com/library/pop_glossary_term.php?oid=4854&l=s) tenían límites. Por ejemplo, la definición de Arrhenius no explica por qué algunas substancias como la levadura común (NaHCO3) puede actuar como una base, a pesar de que no contenga iones de hidrógeno.

En 1923, el científico danés Johannes Brønsted y el inglés Thomas Lowry publicaron diferentes aunque similares [trabajos](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1502&l=s) que redefinieron la [teoría](http://www.visionlearning.com/library/pop_glossary_term.php?oid=4854&l=s) de Arrhenius. En las palabras de Brønsted's words, "... los ácidos y las [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s) son substancias que tiene la capacidad de dividirse o tomar iones de hidrógeno respectivamente." La definición de Brønsted-Lowry ampliar el concepto de Arrhenius sobre los ácidos y las bases.

La definición de Brønsted-Lowry sobre los ácidos es muy similar a la de Arrhenius, cualquier substancia que pueda donar un ión de hidrógeno, es un ácido (en la definición de Brønsted, los ácidos son comúnmente referidos como donantes de protones porque un ión- hidrógeno H+ menos su [electrón](http://www.visionlearning.com/library/pop_glossary_term.php?oid=852&l=s) - es simplemente un protón).

Sin embargo, la definición de Brønsted de las bases es bastante diferente de la definición de Arrhenius. La [base](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s) de Brønsted es definida como cualquier substancia que puede aceptar un ión de hidrógeno. Esencialmente, la base es el opuesto de un ácido. El NaOH y el KOH, tal como vimos arriba, segruirían siendo consideradas bases porque pueden aceptar un H+ de un ácido para formar agua. Sin embargo, la definición de Brønsted-Lowry también explica por que las substancias que no contienen OH- pueden actuar como bases. La levadura (NaHCO3), por ejemplo, actua como una base al aceptar un ión de hidrógeno de un ácido tal como se ilustra siguientemente:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Acid |  | Base |  |  |  | Salt |
| HCl | +  | NaHCO3 | arrow | H2CO3 | +  | NaCl |

En este ejemplo, el acido carbónico formado (H2CO3) pasa por descomposición rápida a agua y dióxido de carbono gaseoso, y también las burbujas de solución como el gas CO2 se liberan.

pH

En la definición de Brønsted-Lowry, ambos los ácidos y las [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s) están relacionados con la concentración del ión de hidrógeno presente. Los ácidos aumentan la concentración de iones de hidrógeno, mientras que las bases disminuyen en la concentración de iones de hidrógeno (al aceptarlos). Por consiguiente, la acidez o la alcalinidad de algo puede ser medida por su concentración de iones de hidrógeno.

En 1909, el bioquímico danés Sören Sörensen inventó la escala [pH](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1577&l=s) para medir la acidez. La escala pH está descrita en la fórmula:

|  |  |  |
| --- | --- | --- |
|

|  |  |
| --- | --- |
| pH = -log [H+] | Nota: la concentración es comúmente abreviada usando logaritmo, por consiguiente H+] = concentración de ión de hidrógeno. Cuando se mide el [pH](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1577&l=s), [H+] es una [unidad](http://www.visionlearning.com/library/pop_glossary_term.php?oid=848&l=s) de [moles](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1515&l=s) H+ por litro de solución  |

 |

Por ejemplo, una solución con [H+] = 1 x 10-7 moles/litro tiene un [pH](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1577&l=s) = 7 (una manera más simple de pensar en el pH es que es igual al exponente del H+ de la concentración, ignorando el signo de menos). La escala pH va de 0 a 14. Las substancias con un pH entre S 0 o menos de 7 son ácidos (pH y [H+] están inversamente relacionados, menor pH significa mayor [H+]). Las substancias con un pH mayor a 7 y hasta 14 son [bases](http://www.visionlearning.com/library/pop_glossary_term.php?oid=1574&l=s) (mayor pH significa menor [H+]). Exactamente en el medio, en pH = 7, están las substancias neutra s, por ejemplo, el agua pura. La relación entre [H+] y pH está mostrada en la tabla de abajo, junto algunos comunes ejemplos de ácidos y base de la vida cotidiana.

|  |  |  |  |
| --- | --- | --- | --- |
|  | [H+] | pH | Ejemplo |
| Ácidos | 1 X 100 | 0 | HCl  |
| 1 x 10-1 | 1 | Äcido estomacal  |
| 1 x 10-2 | 2  | Jugo de limón |
| 1 x 10-3 | 3  | Vinagre |
| 1 x 10-4 | 4 | Soda |
| 1 x 10-5 | 5 | Agua de lluvia |
| 1 x 10-6 | 6 | Leche |
| Neutral | 1 x 10-7 | 7 | Agua pura  |
| Bases | 1 x 10-8 | 8 | Claras de huevo |
| 1 x 10-9 | 9 | Levadura |
| 1 x 10-10 | 10 | Tums®antiácidos  |
| 1 x 10-11 | 11 | Amoníaco |
| 1 x 10-12 | 12 | Caliza [Mineral](http://www.visionlearning.com/library/pop_glossary_term.php?oid=2978&l=s) - Ca(OH)2 |
| 1 x 10-13 | 13  | Drano® |
| 1 x 10-14 | 14  | NaOH |

Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date\_\_\_\_\_\_\_\_\_\_\_

**Acids and Bases**

**1. A buffer solution**

A. maintains the pH of the solution

B. resists pH changes when acid or base is added

C. contains a weak acid or base and its salt

D. all of the above

**2. The product side of the balanced neutralization equation for Mg(OH)2 and HCl is**

A. g(OH)2 + 2H2O

B. gCl + H2O

C. gCl2 + 2H2O

D. gCl2 + H2O

**3. In this balanced neutralization equation, what is the coefficient needed for H2O? Al(OH)3 + HCl = AlCl3 + H2O**

A. 1

B. 2

C. 3

D. 6

**4. When an acid neutralizes a base**

A. a salt is produced

B. water is produced

C. the amount of H+ matches the amount of OH-

D. all of the above

**5. A 50.0 mL sample of a 6.0 M NaOH solution is diluted with 250 mL of water. What is the final concentration of the diluted NaOH solution?**

A. 6.0 M

B. 3.0 M

C. 1.2 M

D. 1.0 M

**6. KOH is a strong base because it**

A. produces K+ and OH- ions only in water

B. produces KOH, K+, and OH- ions in water

C. gives a low pH

D. does not dissolve in water

**7. A weak acid**

A. does not dissolve in water

B. ionizes slightly in water to give molecules and a few ions
C. ionizes 100% in water to give all ions

D. dissolves in water only as molecules

**8. What is the [[H3O+] of coffee if coffee has a pH of 5.0?**

A. 1 x 10-5

B. 1 x 10-9

C. 1 x 10-4

D. 1 x 10-7

**9. Of the following solutions, select the one that is basic: coffee pH 5.0, tomato juice pH 4.2, bleach pH 11.5, milk pH 6.4**

A. Milk

B. Tomato juice

C. Coffee

D. Bleach

**10. An ammonia solution has a [OH-] of 1 x 10-3. What is the pH of the ammonia solution?**

A. 14

B. 13

C. 11

D. 3

**11. Lemonade has a [H3O+] of 1 x 10-4. What is the pH of the lemonade?**

A. 2

B. 4

C. 10

D. 14

**12. On the pH scale, a pH of 1.5 would be**

A. Acidic

B. Very basic

C. Basic

D. Neutral

**13. A solution has a [H3O+] of 1 x 10-5. What is the [OH-] of the solution?**

A. 1 x 10-5

B. 1 x 10-7

C. 1 x 10-9

D. 1 x 10-14

**14. In a base**

A. the [OH-] is less than the [H+]

B. the [OH-] is equal to the [H+]

C. the [OH-] is greater than the [H+]

D. the [OH-] is less than 1 x 10-7 M

**15. Acids**

A. produce H+ (or hydronium ion H3O+) in water

B. taste sour

C. neutralize bases
D. all of the above