Acids + Bases = Salts

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INTRODUCTION

Because of the special students that I teach, I have chosen to incorporate technology in order to learn as much as possible about acids and bases using multi-media format. It is my desire that this unit will provide a strong foundation in this area using an eye-capturing form. The purpose of this curriculum is to use a sophisticated array of devices to provide new opportunities for the study of acids and bases. By allowing these students to manipulate and control variables, science can provide a unique opportunity for these students to learn and operate in a responsible way and gain self-confidence.

Students with disabilities are able to participate fully and comfortably in science programs if they are provided with appropriate instruction and access to technology. There are several effective ways to ensure access to technology and tailor instruction to the special needs of these students.

In general, research has found an active multi-sensory approach including hands-on science and science inquiry to be effective for children with disabilities, as it is with any other children. As one study concluded, the science teacher who uses reading and writing as the sole means of instruction will give all of his or her students a handicap (Kober, 34-35). Children may need to carry out explorations differently. An individualized approach tailored to each student's need is advisable. Educational technology is adaptable for use by these students for expanding their learning opportunities. Technology used in the science classroom provides an environment that emphasizes and promotes cooperative learning, inquiry, explorational investigations and creative adventuring while developing thinking skills. Technological science education has become an intriguing and exciting place for students and educators.

The first part of the unit will consist of a PowerPoint illustration of the three classes of electrolytes – acids, bases, and salts – with emphasis on their behavior in water solution. The presentation will began by comparatively illustrating and defining acids, bases, and salts according to three concepts: Arrhenius definition, Bronsted-Lowry definitions, and the Lewis Theory. After the students know the definition of acids and bases, they will be taught with the use of the overhead projector how to name them. The properties and behavior of acids, bases, and salts are discussed qualitatively and then expressed and applied in a quantitative manner. Some emphasis in this curriculum will be on conducting hands-on activities, such as pH testing manually and titration activities using the computer and necessary probes. The concentrations of acids and bases can be graphed using the calculator and Calculator-Based Laboratory System (CBLS). Students will design simulations, perform treasure hunts, solve simple problems and graph their results using the graphing calculators.

GOALS

Over the past twenty plus years, I have attended and presented numerous lessons and workshops. Some of the topics included acids and bases, therefore this topic was chosen since acids and bases play a central role in much of the chemistry that affect our daily lives. They are widely used in the manufacturing processes. The manufacturing of computer chips usually involve the use of acids. Acids are used to etch patterns of circuitry into the silicon wafer that eventually form the memory chip of the computer (Matta, 432). Many different acids have been used in this process. Typically a solution containing phosphoric acid, nitric acid, acetic acid, water and a wetting agent is used.

Sulfuric acid is one of the most important chemicals. It is used in petroleum refining, steel processing, and fertilizer production. Phosphoric acid and nitric acid are two other important industrial acids used primarily in making fertilizers.

The student population that this curriculum was designed for is my integrated Chemistry classes and the middle school Physical Science classes. This curriculum unit is designed with PowerPoint lectures and computer and calculator activities that will encompass everyday application of acids and bases. This unit will take approximately three to four sessions on a 90-minute block-scheduled class. These students might already have a minimal basic knowledge of acids, bases, and salts, but through this unit they can tremendously extend their knowledge about acids, bases, and salts. As the student-teacher ratio in the extended classes is about 13 or 14 to one, considerable amount of individual attention may be given each student. Each student’s working pace can vary depending on the activity he or she is doing. This curriculum unit encourages students to be active learners as well as to develop simple projects and perform laboratory experiments that are intriguing and interesting.

This curriculum is designed in order to incorporate various technological media or tools to develop an understanding of acids, bases, and salts and enhances this information through the use of technology. This acid and base curriculum will be presented from a non-hazardous point of view as well as from a hazardous point of view. The students will use acids, bases, and salts found in their own kitchens or homes to run various tests. It is important that students perform these tests since acids, bases, and salts are extremely important in the correct functioning of our bodies.

BACKGROUND

The study of chemistry often enables students to predict when chemical reactions occur and how to control the reactions. It is therefore helpful to classify reactions according to a unifying scheme. One major classification is the acid-base reactions. Many foods have distinctive tastes. Some are bitter. Other foods are salty or sour. It is now known that a lemon or a grapefruit has a sour taste because they contain a compound called an acid. Soaps that contain lye (a base) taste bitter. Salty foods taste salty because they contain a salt, sodium chloride. A model for the behavior of acids and bases was proposed in 1887 by the Swedish chemist Svante Arrhenius. He knew that solutions of acids or bases conducted an electric current. According to this model, 1) acids dissociate to produce hydrogen ions (H^+) as their only positive ions; 2) bases dissociate to produce hydroxide ions (OH^-) as their only negative ion; and 3) Electrolytes that contain positive ions other than H^+ and negative ions other than OH^- are called salts. However, there are situations that seem to call for an expanded definition of acids and bases. Ammonia (NH_3) is generally considered a base. Its solutions turn litmus blue and feel slippery to the touch. Yet NH_3 contains no OH^- ions. Thus Arrhenius would not consider ammonia to be a base. The Arrhenius model applies only to aqueous solutions.

His model also explained why some acids and bases are strong and others are weak. According to the model, strong acids ionize almost completely, yielding a maximum quantity of H^+ ions. Similarly, strong bases ionize almost completely, yielding a maximum quantity of OH^- ions.

$$\text{Strong acid: } HCl \rightarrow H^+ + Cl^-$$

$$\text{Strong base: } NaOH \rightarrow Na^+ + OH^-$$

Weak acids and bases, on the other hand, ionize only partially and yield a small quantity of ions. Equilibrium exists between the molecules and the ions. Arrhenius also believed that bases were substances that ionized to produce hydroxide ions (OH^-) in water solution (Cohen, 383). As the knowledge of catalysts and non-aqueous solutions increased, it became necessary to redefine the terms acid and base. In 1923 an English scientist, T. M. Lowry, and a Danish scientist, J. N. Bronsted, independently proposed a new definition. They stated that in a chemical reaction, any substance that donates a proton is an acid and any substance that accepts a proton is a base. According to Bronsted-Lowry theory, an acid is a proton donor while a base is a proton acceptor. Free protons are hydrated by water molecule to form H_3O^+ the hydronium ion.

In 1923, the same year that Bronsted and Lowry proposed their theory, another new idea appeared. Gilbert Newton Lewis, an American chemist, proposed an even broader definition of acids and bases. The same type of reasoning as Bronsted's and Lowry's led to his proposals. Lewis focused on electron transfer rather than proton transfer. He defined an acid as an electron-pair acceptor and a base as an electron-pair donor (Cohen, 383). This definition is more general than Bronsted's. It applies to solutions and reactions that do not even involve hydrogen ions.

Frequently, acid and base concentrations are expressed in a system called pH system.

Table 1: pH Range

Acid	Neutral	Base
1	7	14

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The approximate pH of a solution can be determined by using indicators. These are substances that are different colors in acidic or basic solutions. Below are listed common indicators and their respective color changes. An example of how to read this chart follows. At pH value, the normal pH range is from 1 to 14. Below 4.5, litmus paper is red; above 8.3, it is blue. Between these values, it is a mixture of colors.

Table 2: Indicators

Indicators	**pH Range of Color Change**	**Color below Lower pH**	**Color above Lower pH**
Methyl Orange	3.1 - 4.4	Red	Yellow
Bromthymol Blue	6.0 - 7.6	Yellow	Blue
Litmus	4.5 - 8.3	Red	Blue
Phenolthalen	8.3 - 10.0	Colorless	Red
Congo Red	3.0 - 5.0	Blue	Red
Alizarin	10.1 – 12.1	Yellow	Red

As part of this unit, students will determine the effect of acids and bases on indicators found around their home. Students will also examine the pH of solutions and determine the effect of the pH on an indicator. Students will see how the concept of pH is used to measure the strength of acidic and basic solutions. Hair product labels will be checked for reference of pHs. Students will use log functions calculators to graph the alkalinity or acidity of solutions. As an extended project, students will visit a hospital and observe how a respiratory therapist measures blood pH and ask appropriate questions concerning the use of technology to maintain the technology techniques. The pH of the body fluids has a very strong effect on the activity of enzymes in your body. The pH of a solution is a critical indicator of how the solution will function.

Some solutions can withstand the addition of moderate amounts of acids or bases without undergoing a significant change in pH. Such solutions are called a *buffer solution*. As an example, students can consider a carbonate-bicarbonate buffer solution. A carbonate-bicarbonate buffer system is prepared so that the concentration of the carbonate ion HCO_3^- is equal to the concentration of the carbonate ion CO_3^{2-}. If an acid is added to the solution, the following reaction takes place.

$$CO_3^{2-} + H^+ \rightarrow HCO_3^-$$

The H^+ ions from the added acid react with CO_3^{2-} ions in the buffer system and are used up. The pH does not change appreciably. If a base is added, the following reaction takes place:

$$HCO_3^- + OH^+ \rightarrow H_2O + CO_3^{2-}$$

The OH^- ions from the added acid react with CO_3^- ions in the buffer system and are used up. Again, the pH does not change appreciably. A laboratory buffer can be prepared mixing equal molar quantities of a weak acid such as $HC_2H_3O_2$ and its salt, $NaC_2H_3O_2$. When a strong base such as NaOH is added to the buffer, the acetic acid reacts (and consumes) most of the excess OH^- ion. This does not alter the H^+ ion concentration much.

A buffer system exists in our blood stream. The pH of blood is 7.4 ± 0.05. If the pH varies by more than 0.04 units, serious difficulties may result. The buffer system helps protect the blood from any significant change in pH.

Students can use indicators to determine if a substance is acidic or basic. However, they cannot use an indicator to determine the concentration of an acid or base. To find the concentration of an acid or base in a solution, a method called *titration* is used. This method involves the reaction between an acid and a base, sometimes called *neutralization.* There are several ways to perform the titration process. It can be done manually using a burette whereby a solution of an acid is dispensed into the solution of the base from this instrument. The quantity of a base in some sample of an unknown can also be determined by titration. Titration is the process of gradually adding one reactant from a burette to another reactant until a color change signals that equivalent amounts of reactant have been reacted. Computer based titration lab activities are frequently used today.

STRATEGIES

This lesson will be presented in a semi-multi-media format using various forms of technology. The teacher will define and discuss properties of acids and bases, using PowerPoint presentations. Emphasis will be placed on conducting hands-on and minds-on activities, such as pH testing of non-hazardous acids and bases first and then on hazardous acids and bases, and on collecting of various substances in the immediate environment that are acids and bases. Hair product labels will be collected and classified according to their pHs. These investigations will require the students to comprehend terms as pH, buffer, solution, strong or weak solutions, concentrations, titration, and conductivity.

The curriculum is designed to integrate text, scientific journals, the Internet, and technology in the classroom. The approach for this curriculum is interdisciplinary, integrating math and science. There are four major components to this unit. The table below illustrates how the unit will be presented.

Table 3: Lesson Format

Component	Form	Description	Media/Technology
1	Lecture	Teacher will define acids and bases.	PowerPoint, over-head, computer
2	Presentations	Students and teacher will present concepts with active student participation, hands-on and student-designed activities.	Overhead projector, Internet, special projects, graphing calculator
3	Demonstrations	Demonstrate a concept using lab equipment, technology, and chemicals working in small groups.	Calculators, computer, 12 to 24 well plates, videos
4	Laboratory Experiment	Students, as a class, will perform the same experiments presented in the unit. Technology and comparison of data are utilized.	Calculator-Based Laboratory Systems (CBLS) pH probes, titration, LabWorks

At least one of the lesson components will be utilized in each sub-unit. There is a suggested component for each sub-strategy. The table below includes them.

Table 4: Sub-Strategies

Sub-Unit	**Component**	**Multi-media**	**Suggested platform**
Define and Identify Acids and Bases	1. Lecture 2. Presentations	PowerPoint, overhead projector	Teacher will define acids and bases and list properties.
Molar Concentration of Hydrogen Ions and pH Scale Relationship	1. Student presentations 2. Lab experiment	Overhead projector, lab titration, graphing calculator, CBLS	Students will introduce concepts in cooperative groups. Students will perform lab experiment illustrating this concept and graph the pH range.
Predict how hazardous spills can be neutralized	1. Student presentations 2. Demonstration	Computer lab, laboratory equipment, videotapes.	Students make predictions and demonstrate concept- using simulations on the computer.
Differentiate between strong and weak acids and bases	1. Lecture 2. Student presentations	Overhead projector, computer and lab equipment	Teacher will differentiate; students will use vocabulary to make scavenger hunt; Titration lab.
Computer simulations	1. Student presentations 2. Demonstrations	Lab equipment, video labs, conductivity testers	The teacher will demonstrate concept; students will make and perform conductivity experiment.

LESSONS AND ACTIVITIES

Acids, bases, and salts will be defined explicitly by the teacher making a PowerPoint presentation on the computer and overhead projector. If a computer is not available, other resources can be used to teach the lesson. There are two films that define and describe properties of acids, bases, and salts. *Acids, Bases, and Salts* (C/MTI) defines these terms while *All About Acids and Bases* (Fm) describes properties of them.

Day One

Warm-up Activity

Write the words *lemon* and *vinegar* on the overhead projector. The students will list the properties that lemon juice and vinegar share. Explain how they are different from other substances.

As for directed inquiry, students will study acids and bases, and use the table to answer the following questions:

1. Which of these acids have you taken in your body?
2. What elements do all these acids contain?
3. Which acids are strong acids?
4. What base would you use to help your plants grow by reducing acid in garden soil?
5. Name a salt found in your household.

Table 5: Common Acids and Their Uses

Name of Acid	**Formula**	**Uses**
Acetic acid (vinegar)	HCl	Seasons and preserves food, cleans and deodorizes.
Sulfuric acid	H_2SO	Produced by stomach and aids digestion; used in toilet-bowl cleaners and for cleaning metal surfaces.
Phosphoric acid	H_3PO_4	Removes hard-water deposits; used in making fertilizers.
Nitric acid	HNO_3	Used in making explosives and fertilizers.
Carbonic acid	H_2CO_3	Formed in carbonated drinks.
Acetylsalicylic	$C_9H_8O_4$	Reduces pain and inflammation.

Table 6: Common Bases and Their Uses

Name of Base	**Formula**	**Uses**
Sodium hydroxide	$NaOH$	Making soap, drain and oven cleaners.
Calcium hydroxide	$Ca(OH)_2$	Softens water, neutralizes acids in soil.
Magnesium hydroxide	$Mg(OH)_2$	Used in antacids.
Ammonium hydroxide	NH_4OH	Used in cleaning solutions.
Sodium bicarbonate Baking soda	$NAHCO_3$	Used in baking and cleaning.

Assign Activity One to be completed at home.

Activity One

Do an inventory of acids and bases found in food products. Check product labels at home and at you local super market. Answer the following questions. Which acids are frequently found in food products? In what type of foods are acids most frequently listed as an ingredient? What types of food processing are associated with the use of acids in food?

Many bases are hydroxides; that is, they are compounds that contain hydroxide ions. Hydroxide ions are formed when a base is mixed with water. Bases are found in nature and they are also commercially prepared. How does one antacid differ from another as far as you can tell from the label?

Day Two

Pre-lab Activities

Define the following vocabulary words.

1. Acids
2. Bases
3. Solutions
4. Concentration
5. Strong acid
6. Strong base
7. Weak acid
8. Ionization
9. Salt
10. Neutralization
11. Titration
12. Conductivity tester
13. Phenolphthalein
14. Unknown
15. pH

Laboratory Activity: pH Testing Using 12 or 24 Well Plates

Pre-lab discussion: Have students read the entire activity.

Discuss the following points cooperatively before beginning the activity.

- Discuss the function of indicators.
- Discuss why the baking soda must be dissolved in water before it can be tested.
- Discuss the fact that phenolphthalein has a useful range of pH eight or ten.

Laboratory Activity: What is an acid? What is a base?

The objective is for students to observe, infer, interpret and analyze data to determine which substances are acidic and which substances are basic in nature. Safety precautions will be observed at all times. Students will copy the data table on a separate sheet of paper and test the items. They will analyze and draw and write the conclusions. Conclusions are based on student’s recorded observation. Record all your observations and determine what generalization you can make about the pH of foods. What generalization can you make about cleaning products?

Table 7: Table of pH Test

Substances	**Red Litmus Test**	**Blue Litmus Test**	**Phenolphthalein**
Baking Soda			
Vinegar			
Distilled water			
Tap water			
Lemon Juice			
Ammonia			
Aspirin			
Dish detergent			

Students will analyze by answering the following questions.

1. How does baking soda affect litmus paper and phenolphthalein? How does vinegar affect these indicators? What can you conclude from you observations?
2. What kind of substance is distilled water? Why might a water inspector test a sample of drinking water with an indicator?
3. Which substances affected the indicators the same way as baking soda? Are these substance acids or bases?
4. Which substances tested the same as distilled water? Classify these substances.
5. Did any substances test the same as vinegar? Are these substance acids or bases?

Students will write a paragraph summarizing their findings and answer two questions.

1. Which test method gave clearer results?
2. Can you use your data to determine the strength of each acid and base?

Day Three

Computer Simulations Activity

Students will use the computer to develop simulations predicting how non-hazardous spills can be neutralized. The concepts will be demonstrated using laboratory equipment and chemicals. Then the students will develop a computer simulation at the end of this activity. The following questions will be answered.

1. Where did your spill occur?
2. What type of surface area encompassed the spill?
3. How can you neutralize the spill?

This activity will serve as an enrichment activity for the learners.

Focus Activity Assignment (for the next day)

Explore at home and at a local drug store labels of hair cleaning products. Write the name and pH of each item down. Bring it to class the next day and compare your list with labels collected by your cooperative group members.

Day Four

Teacher differentiates between strong and weak acids and bases by using the pH scale on the overhead projector. There are many misconceptions held by students about acids. Some tend to think all acids are harmful and all harmful chemicals are acids. Have students brainstorm on acids and bases. Ask the learners to think about the foods that they have eaten that might contain acids or bases. Ask if they know of any acids that exist normally in your bodies? Explain that many bases, such as drain cleaners, are also dangerous. Students will use the vocabulary words from Day Two and perform a scavenger hunt.

Pre-Laboratory Discussion

Students will discuss the CBLS in order to collect information concerning the strengths of acids and bases. They will predict which substances might act as a buffer for strong acids.

Laboratory Activity: Strengths of Acids and Bases Using CBLS

Students will use the CBLS with appropriate probes connected to the CBLS and the CBLS connected to the computer with a link connection. Students will collect data and graph the pH variations. In this activity, students will combine classroom calculations with experimental observations mainly for the purpose of convincing yourself that what you did in class is actually applicable. The pH probe will test orange juice, lemon juice, milk, milk of magnesia, vinegar and baking soda. The students will measure the pH of various substances and then calculate what they expect the pH to be. Be sure to rinse the pH electrode with deionized water after each use. After measuring the pH of each substance, record the value on your data sheet. In these calculations, be mindful of the basic equations that define pH, the difference between the strong and weak bases, and the K_a for acetic acid ($1.75x10^{-5}$) and the K_b for ammonia ($1.8x10^{-5}$).

As an extension to this unit, students will check the acidic and basic solutions for conductivity by using a conductivity apparatus. The conductivity apparatus are prepared before the lesson begins. Conductivity is directly related to the concentration of ion in the solution. The concentration of ions is not the same in strong and weak acid solutions. This activity will help students understand this concept.

Table 8: Materials Used

Title	Equipment	Chemicals and Consumables
pH vs. Time of Antacid	Computer, CBLS pH sensors base and support rod beakers, 250 ml (2) buret clamp graduated cylinder, magnetic stirrer & spin mallet or hammer	Antacid tablets (Tums) buffer solutions, pH 7 & pH 4 distilled water hydrochloric acid, 0.10 molar waxed paper
Acid-Base Titration	pH sensor base and support rod beakers, 150 ml buret clamps (2) buret 50ml graduated cylinder 100ml pipet, 10ml pipet bulb or pump magnetic stirrer & spin	Buffer solutions, pH 7 and pH 4 distilled water hydrochloric acid, HCl solution of unknown concentration sodium hydroxide 0.10 molar phenolphthalein solution (optional)
What's an Acid and What's a Base?	40 walled micro plates medicine droppers red and blue litmus paper phenolphthalein solution	Distilled water Baking soda Colorless vinegar Tap water Lemon juice Aspirin and detergent

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