CSEO SCIENTIST IN THE CLASSROOM PARTNERSHIP

Acids and Bases

Last Updated: July 2023

LEARNING GOAL: To introduce students to acids and bases.
8.PS4.1 Develop and use models to represent the basic properties of waves including frequency, amplitude, wavelength, and speed.
8.PS4.2 Compare and contrast mechanical waves and electromagnetic waves based on refraction, reflection, transmission, absorption, and their behavior through a vacuum and/or various media.

This lesson was adapted from Vanderbilt Student Volunteers for Science. Additional information about the lesson may be found at https://studentorg.vanderbilt.edu/vsvs/.

MATERIALS

3	10oz clear plastic cups
1	4 oz. bottle white vinegar - labeled Acid
1	4 oz. bottle of water - labeled Water
1	4 oz. bottle of water with 1/4 tsp. baking soda mixed in - labeled Base
16	containers of red litmus paper (at least 15 pieces)
16	containers of blue litmus paper (at least 15 pieces)
16	containers of pHydrion paper (at least 15 pieces)
16	24-well trays
8	plastic bags containing a numbered dropper bottle of each of the following household liquids: **#1, vinegar** **#3, distilled water** **#4, rainwater** **#5, shampoo** **#6, apple juice** **#7, lemon juice** **#8, 7-up** **#11, ammonia** **#12, laundry detergent**
32	Results sheets with chart (optional use)
16	Observation sheets with diagram
1	Training manual contains ppt. and observation sheets
4	Answer sheets (two sided)

Write the following vocabulary words on the board:
acid, base, neutral, litmus paper, indicator, universal indicator

I. INTRODUCTORY DEMONSTRATION - Defining Acids and Bases

Materials

- **3 10 oz. clear plastic glasses**
- **1 4 oz. bottle of vinegar - labeled acid**
- **1 4 oz. bottle of water - labeled water**
- **1 4 oz. bottle of water with 1/4 tsp. of baking soda - labeled base**
- **3 strips red litmus paper**
- **3 strips blue litmus paper**

- Hold the 3 clear plastic glasses up so students can see them.
- Tell the students that you have three liquids.
- Pour the contents of the bottle labeled acid into the first glass.
- Pour the contents of the bottle labeled water into the second glass.
- Pour the contents of the bottle labeled base into the third glass.
- Have a student describe the three liquids they see.

Note: Describe liquids based on visual cues only. Students may assume that all three glasses contain water. At this point that is an appropriate assumption based on visual cues alone. Since the liquids were in different containers, the students may think that the liquids are different.

Ask students if they have ever heard of litmus paper. If so, what is it used for?

Litmus paper is used to test whether something is acidic or basic.

Test each glass of clear liquid by dipping first the red and then the blue litmus paper into the liquid and noting what changes, if any, occur. (You may want to record the changes on the board for later reference.)

Note: Do not identify the liquids at this point. The vinegar should turn the blue litmus paper red; the water should not change the color of either paper, and the baking soda water should turn red litmus paper blue.
Set the glasses aside. Tell the students that you will see if they can tell you what was in each of the glasses after they do the experiments in today's lesson.

Explain to students: In this experiment, the liquids turned the litmus paper different colors because one is an **acid**, one is a **base**, and one is a **neutral** (neither an acid nor a base). Litmus paper is an **indicator** which can identify whether a substance is an acid or a base.

Ask students if they can name any other indicators?

Students may be familiar with bromothymol blue, universal indicator, phenyl red. These are chemical indicators. Red cabbage juice extract is a natural indicator. Many other plant extracts also change color in basic or acidic solutions.

Tell students that:

Indicators are substances that change colors when mixed with an acid or base.
Indicators are used by scientists to identify what the pH of a substance is.
Tell students to look at the handout. Point out a few examples of how they can be useful in different ways.

eg litmus can tell us if something is either a base or an acid
methyl orange indicator changes color at ph3/4. It is red below pH 4 and yellow above pH 4.
universal indicator has a large number of color changes at different pH's and can more precisely tell us what the pH of a solution is.

II. DISCUSSION OF ACIDS AND BASES

Ask: *What do you know about acids?* (You might ask students to name some acids.)

Responses may include references to battery acid, acid indigestion, stomach acid, acid rain, citrus acid, and chemicals in a lab.

Ask: *What do you know about bases?* (You might ask students to name some bases.)
Most students know less about bases than acids. Responses may include lye, detergents.

EXPLAIN ACIDS AND BASES USING SOME OF THE FOLLOWING INFORMATION:
(Note: Feel free to add other appropriate information but keep this discussion brief.)

ACIDS

Natural acids in food give foods a sour, sharp flavor.
Strong acids can burn your skin.
Many acids are corrosive. They eat away metals and other substances.
Some acids can be helpful. The acid in your stomach aids in digestion.
Two acids (sulfuric acid and nitric acid) cause damage in acid rain.

BASES

Bases taste bitter and feel slippery.
Some bases are used to settle upset stomachs.
Detergents and many cleaning solutions are basic.
Strong bases can burn the skin.

Ask the students: *Has anyone heard of the pH scale?*

For information only: In 1909, the Danish biochemist S.P.L. Sorenson devised a scale that would be useful in his work of testing the acidity of Danish beer. This scale became known as the pH scale from the French *pouvoir hydrogene*, which means hydrogen power.

The pH scale was designed to measure the acidity or basicity of solutions.
On the pH scale, lower numbers are more acidic solution and higher numbers are more basic. Most household chemicals have pH's between pH 0 and 14, but more concentrated solutions of acids and bases exist that go beyond either end of this scale.

Like the Richter scale used to measure the extent of ground movement in earthquakes, the pH scale is a logarithmic scale. This means that a substance at pH 6 is ten times more acidic than a substance of pH 7, a substance at pH 5 is one hundred times more acidic than a substance of pH 7 and so on.

Note: The important concept at this grade level is to understand the 0-14 scale that identifies which substances are acids and bases. It is not necessary to spend lots of time explaining the logarithmic aspect of the scale.

III. TESTING ACIDS AND BASES

Ask: *How can scientists tell which solutions are acidic or basic?*
(Based on the first experiment, some students may be able to reason that scientists could use different shades of color to tell how acidic or basic a solution is.)

Ask: *"When red litmus paper is used as the indicator, what color do the basic solutions turn it?" (blue)*

Ask: *"When blue litmus paper is used as the indicator, what color do the acidic solutions turn it? (red)*

TESTING THE ACIDITY/BASICITY OF HOUSEHOLD ITEMS

- Organize the class into 16 groups/pairs.
- Tell students that they will test several household items to determine if they are acidic, basic, or neutral.
- Distribute the following materials to **each group (there are enough materials for 16 groups – the dropper bottles will be shared between two groups).**
    - 1 well tray
    - 1 container of each: blue litmus, red litmus, and pHydrion papers (at least 15 in each)
    - 1 observation sheet with the diagram
    - 2 result sheets with chart
    - 1 bag containing household liquids **(to be shared between two groups/pairs)**

- **Tell the students that they need to replace the red cap on the dropper bottle after each solution is tested.**

Management tip – do one household chemical at a time, put the results on the board, and then go to the next chemical.

Tell the students to:

- Arrange the bottles of household chemicals in numerical order (1- 12, there will be no #s 2, 9, or 10).
- Place their well-plate on the observation sheet on top of the diagram, so that they can see the numbers through the bottom of each well.
- Squirt a small amount of liquid from the #1 dropper bottle **(vinegar)** into the first well and test its acidity/basicity by dipping a piece of each blue litmus, red litmus, and pHydrion paper into the liquid in the well.
- Place the 2 litmus papers and the pHydrion paper in the labeled rectangles above **1. vinegar.**
- Compare the color of the pH paper directly after the test to the colors on the vial and record the corresponding pH # on the line below **1. vinegar.**
- Report findings to the chart on the board.
  OR - if the students are using the RESULTS chart (not recommended for grades below 5th), circle the color change on the results sheet, circle whether the substance is an acid, base, or neutral, and fill in the pH number.
- Repeat this with all the liquids (3- 12, no 9 or 10)

SCP Fellow: Put the Testing Household Items chart (below) on the board (if the students aren't using the worksheet with the chart).

Testing Household Items

Item	Color Change	Color Change	Result of Test	pH Number
	Does the BLUE litmus paper change to red?	Does the RED litmus paper change to blue?	acid base or neutral	What is the pH number?
1. vinegar	yes no	yes no	acid base or neutral	
3. distilled water	yes no	yes no	acid base or neutral	
4. rain water	yes no	yes no	acid base or neutral	
5. shampoo	yes no	yes no	acid base or neutral	
6. apple juice	yes no	yes no	acid base or neutral	
7. lemon juice	yes no	yes no	acid base or neutral	
8. 7-up	yes no	yes no	acid base or neutral	
11. ammonia	yes no	yes no	acid base or neutral	
12. laundry detergent	yes no	yes no	acid base or neutral	

Testing Household Items - Answers

Item	Color Change	Color Change	Result of Test	pH Number
	Does the BLUE litmus paper change to red?	Does the RED litmus paper change to blue?	acid base or neutral	What is the pH number?
1. vinegar	**yes** no	yes **no**	**acid**	**3**
3. distilled water	yes **no**	yes **no**	**Neutral**	**7**
4. rain water	**yes** no	yes **no**	**acid**	**5-6**
5. shampoo	yes **no**	yes **no**	**neutral**	**7**
6. apple juice	**yes** no	yes **no**	**acid**	**4**
7. lemon juice	**yes** no	yes **no**	**acid**	**3**
8. 7-up	**yes** no	yes **no**	**acid**	**3-4**
11. ammonia	yes **no**	**yes** no	**base**	**11**
12. laundry detergent	yes **no**	**yes** no	**base**	**12**

Ask students *(have them fill in the answers on their results sheet)*:

Are the **foods** that we have tested acidic or basic?

Mostly acidic.

Are the **cleaners** that we have tested acidic or basic?

Basic *(the shampoo may be either acidic, basic or neutral)*

Is there any difference in acidity of distilled water and rain water?

Rain water usually tests slightly acidic because of dissolved carbon dioxide. Pollutants from burning fossil fuels such as sulfur oxides and nitrogen oxides can cause the rain water to be even more acidic (hence acid rain).

Distilled water should be neutral.

How is litmus paper made?

Litmus paper is simply paper that has been infused with lichens. Ask students if they have seen lichens growing? They may not be aware that lichens are very common and can be found growing on rocks, trees, walls and in soil just about anywhere in the world. They have a natural ability to change color depending on the conditions they are growing in. Several varieties of lichens are used to make litmus paper.

How is Universal indicator made?

It is a combination of several chemical indicators so that there is a continuous change of colors over the pH range of 0-14. Universal Indicator can also be impregnated into paper to be used as the Hydrion paper. Red cabbage extract has a similar range of colors due to the natural compound anthocyanin. You can make Red cabbage indicator paper at home using red cabbage extract (by boiling red cabbage in water) and soaking coffee filter paper in it.

Reference: Fun with Chemistry, Vol. 2, 2nd edition; Sarquis, M; Sarquis, J. Eds., Publ. 91-005, Institute for Chemical Education, University of Wisconsin: Madison, 1991; pp. 53-62.

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Acids/Bases Results Sheet Name _____

Read the name of the item. As you do the experiment, circle the actual color change and circle if the substance is an acid, base or is neutral.

Testing Household Items

Item	Color Change	Color Change	Result of Test	pH Number
	Does the BLUE litmus paper change to red?	Does the RED litmus paper change to blue?	acid base or neutral	What is the pH number?
1. vinegar	yes no	yes no	acid base or neutral	
3. distilled water	yes no	yes no	acid base or neutral	
4. rain water	yes no	yes no	acid base or neutral	
5. shampoo	yes no	yes no	acid base or neutral	
6. apple juice	yes no	yes no	acid base or neutral	
7. lemon juice	yes no	yes no	acid base or neutral	
8. 7-up	yes no	yes no	acid base or neutral	
11. Ammonia	yes no	yes no	acid base or neutral	
12. laundry detergent	yes no	yes no	acid base or neutral	

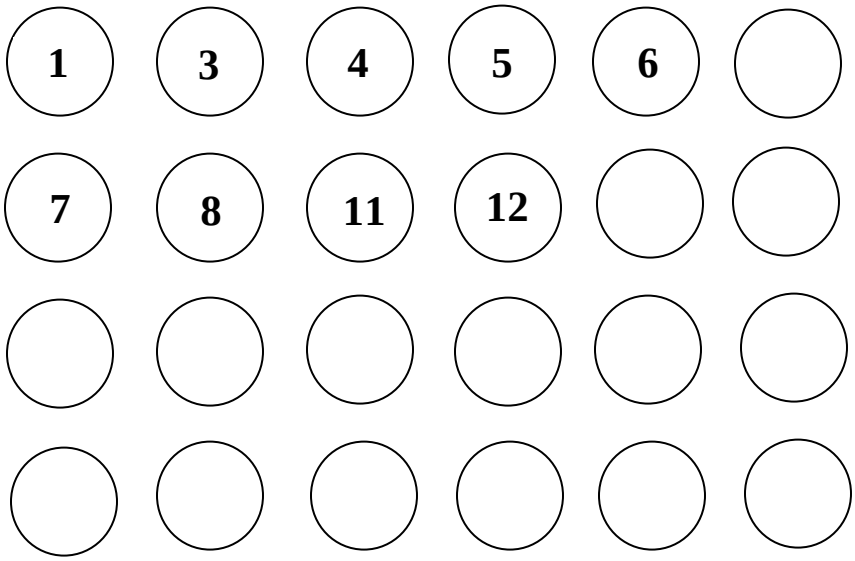
Are the **foods** that we have tested acidic or basic?

Are the **cleaners** that we have tested acidic or basic?

Is there any difference in acidity of distilled water and rain water?

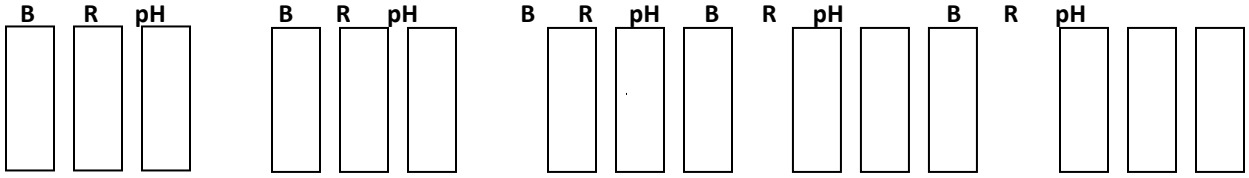
ACIDS AND BASES Name _____

1. Place well plates on the picture below. Make sure that you can see the numbers in the wells.



2. After you have tested the household chemical with the litmus paper and pH paper, place the pieces of litmus and pH paper in the boxes below. Determine if it is an acid, base or neutral liquid, and circle the correct answer. Record the actual pH number for each chemical on the line provided. ***Record the pH number based on the first color change of the pH paper!!! As it sits, the color of the paper will change.***

Note: B and R indicate the starting color of the litmus paper:



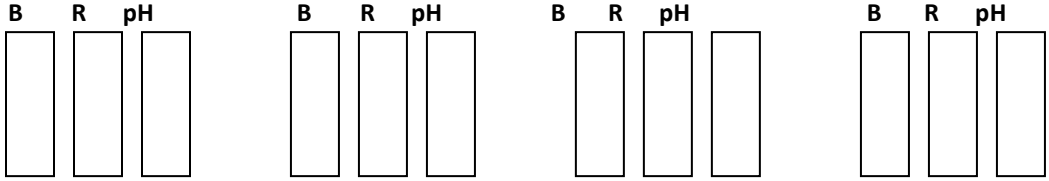
1. vinegar
acid
base
neutral
pH _____

3. distilled water
acid
base
neutral
pH _____

4. rain water
acid
base
neutral
pH _____

5. shampoo
acid
base
neutral
pH _____

6. apple juice
acid
base
neutral
pH _____



7. lemon juice
acid
base
neutral
pH _____

8. 7-Up
acid
base
neutral
pH _____

11. Ammonia
acid
base
neutral
pH _____

12. laundry detergent
acid
base
neutral
pH _____

Acids/Bases Answer Sheet

Read the name of the item. As you do the experiment, circle the actual color change and circle if the substance is an acid, base or is neutral.

Testing Household Items

Item	Color Change	Color Change	Result of Test	pH Number
	Does the BLUE litmus paper change to red?	Does the RED litmus paper change to blue?	acid base or neutral	What is the pH number?
1. vinegar	**yes** no	yes **no**	**acid**	**3**
3. distilled water	yes **no**	yes **no**	**Neutral**	**7**
4. rain water	**yes** no	yes **no**	**acid**	**5-6**
5. shampoo	yes **no**	yes **no**	**neutral**	**7**
6. apple juice	**yes** no	yes **no**	**acid**	**4**
7. lemon juice	**yes** no	yes **no**	**acid**	**3**
8. 7-up	**yes** no	yes **no**	**acid**	**3-4**
11. Ammonia	yes **no**	**yes** no	**base**	**11**
12. laundry detergent	yes **no**	**yes** no	**base**	**12**

Are the **foods** that we have tested acidic or basic?

Mostly Acidic (Tums are basic – this is so they can reduce the amount of ACID in the stomach)

Are the **cleaners** that we have tested acidic or basic?

Mostly basic (shampoo can be either slightly acidic or basic)

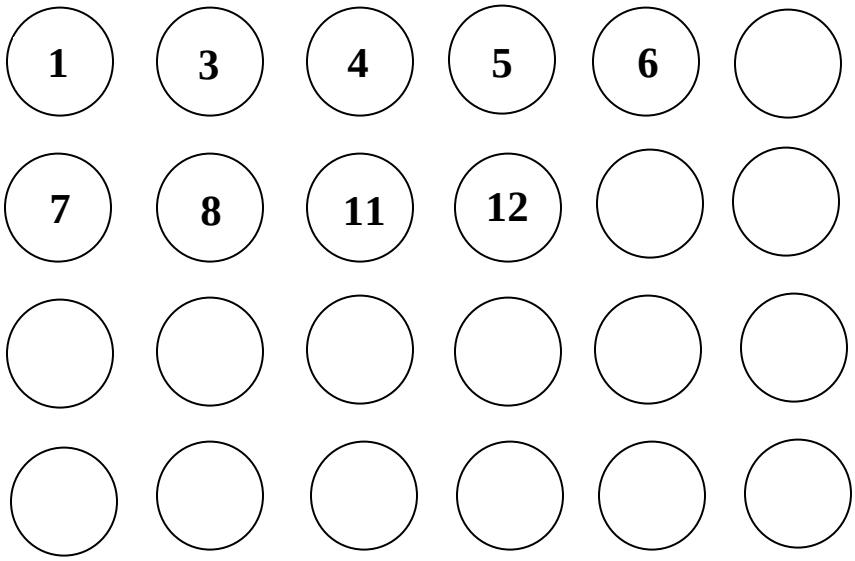
Is there any difference in acidity of distilled water and rain water?

Rain water usually tests slightly acidic because of dissolved carbon dioxide. Pollutants from burning fossil fuels such as sulfur oxides and nitrogen oxides can cause the rain water to be even more acidic (hence acid rain).

Distilled water should be neutral.

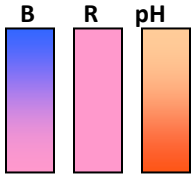
ACIDS AND BASES - Answer Key

2. Place well plates on the picture below. Make sure that you can see the numbers in the wells.



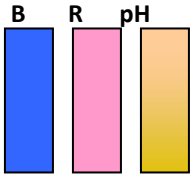
3. After you have tested the household chemical with the litmus paper and pH paper, place the pieces of litmus and pH paper in the boxes below. Determine if it is an acid, base or neutral liquid, and circle the correct answer. Record the actual pH number for each chemical on the line provided. ***Record the pH number based on the first color change of the pH paper!!! As it sits, the color of the paper will change.***

Note: B and R indicate the starting color of the litmus paper:



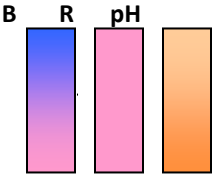
1. vinegar
acid

pH **3**



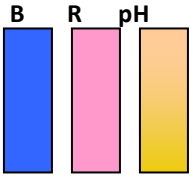
3. distilled water
neutral

pH **7**



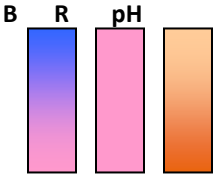
4. rain water
acid neutral

pH **5-6**



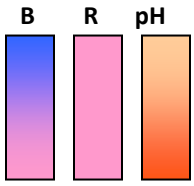
5. shampoo

pH **7**



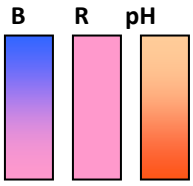
6. apple juice
acid

pH **4**



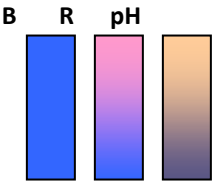
7. lemon juice
acid

pH **3**



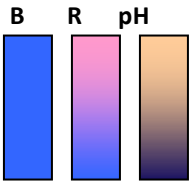
8. 7-Up
acid

pH **3-4**



11. Ammonia
base

pH **11**



12. laundry detergent
base

pH **12**