The Chemical Nature of Matter – Grade 7, Level 4

Lesson Overview

In this lesson, students will test various solutions using litmus paper, pH paper and Phenolphthalein to classify as either an acid, base or neutral. They will also develop their own understanding of the pH scale prior to being introduced and actually using it. Throughout the lesson, multiple opportunities are provided for students to capture and share their progressive learning through written and oral form.

Alignment

Standard/Indicator Addressed

Science **7.P.2B.3** Analyze and interpret data to compare the physical properties, chemical properties (neutralization to form a salt, reaction with metals), and **pH of various solutions** and **classify solutions as acids or bases**.

Mathematics **7.RP.2** Identify and model proportional relationships given multiple representations, including tables, graphs, equations, diagrams, verbal descriptions, and real-world situations.

ELA Writing **Standard 1:** Write arguments to support claims with clear reasons and relevant evidence.
1.1 Write arguments that:
- e. develop the claim providing credible evidence and data for each;
- i. provide a concluding statement or section that follows from and supports the argument

Standard 6: Write independently, legibly, and routinely for a variety of tasks, purposes, and audiences over short and extended time frames.
6.1 Write routinely and persevere in writing tasks over short and extended time frames, for a range of domain specific tasks, and for a variety of purposes and audiences.

ELA Communication

Standard 1: Interact with others to explore ideas and concepts, communicate meaning, and develop logical interpretations through collaborative conversations; build upon the ideas of others to clearly express one's own views while respecting diverse perspectives.
1.2 Participate in discussions; ask probing questions and share evidence that supports and maintains the focus of the discussion.

Standards for Mathematical Practice (as appropriate)

2. Reason both contextually and abstractly.

a. Make sense of quantities and their relationships in mathematical and real-world situations.

6. Communicate mathematically and approach mathematical situations with precision.

a. Express numerical answers with the degree of precision appropriate for the context of a situation.

b. Represent numbers in an appropriate form according to the context of the situation.

c. Use appropriate and precise mathematical language.

d. Use appropriate units, scales, and labels.

7. Identify and utilize structure and patterns.

a. Recognize complex mathematical objects as being composed of more than one simple object.

b. Recognize mathematical repetition in order to make generalizations.

Science and Engineering Practices (as appropriate)

7.S.1A.1 Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge claims.

7.S.1A.3 Plan and conduct controlled scientific investigation to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses, (2) identify materials, procedures, and variables, (3) select and use appropriate tools or instruments to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. Use appropriate safety procedures.

7.S.1A.4. Analyze and interpret data from informational texts, observations, measurements, or investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning or (2) support hypotheses, explanations, claims, or designs.

ELA Inquiry Standards (as appropriate)

Standard 1: Formulate relevant, self-generated questions based on interests and/or needs that can be investigated.

1.1 Develop questions to broaden thinking on a specific idea that frames inquiry for new learning and deeper understanding

Standard 3: Construct knowledge, applying disciplinary concepts and tools, to build deeper understanding of the world through exploration, collaboration, and analysis.

3.1 Develop a plan of action by using appropriate discipline-specific strategies.

Standard 5: Reflect throughout the inquiry process to assess metacognition, broaden understanding, and guide actions, both individually and collaboratively.

5.1 Acknowledge and value individual and collective thinking; use feedback from peers and adults to guide the inquiry process.

5.2 Employ past and present learning in order to monitor and guide inquiry.

5.3 Assess the processes to revise strategies, address misconceptions, anticipate and overcome obstacles, and reflect on completeness of the inquiry.

Connections

Disciplinary Literacy Strategies (for Purposeful Reading, Meaningful Writing, and Productive Dialogue)

- Pre-writing
- Line of Learning
- Student Dialogue
- Exit Ticket
- P-E-O Probe
- Graphic Organizer: Venn Diagram
- Bounce Cards
- Proof Paragraph

Computational Thinking

*Computational thinking (CT) is a problem-solving process that includes (but is not limited to) the following **characteristics**:*

- Logically organizing and analyzing data
- Representing data through abstractions such as models and simulations
- Generalizing and transferring this problem solving process to a wide variety of problems

*These skills are supported and enhanced by a number of dispositions or attitudes that are essential dimensions of CT. These **dispositions or attitudes** include:*

- Confidence in dealing with complexity
- Tolerance for ambiguity
- The ability to communicate and work with others to achieve a common goal or solution

Content Area (2 or more) Connections

- Science
- Mathematics

- ELA
- *Computational Thinking*

Lesson Plan – Part A: Distinguishing between acids and bases using litmus paper

Time Required – (Two 60-minute classes)

Disciplinary Vocabulary – Physical properties, Chemical properties, pH, Acids (acidic), Bases (basic), Neutrals, Neutralization, Indicators, Litmus paper, Phenolphthalein, pH paper

Materials Needed:

- *For **each** student:*
  - Safety goggles / glasses
  - Aprons
- *For each group of **two** students:*
  - Testing Surface (*NOTE: can use laminated sheets with circles – See attached*)
  - Litmus paper (red and blue)
- For the **class**: (approximately 10 mL of each solution per group)
  - Ammonia (NH_3)
  - Orange juice
  - Sodium Bicarbonate ($NaHCO_3$) *(*Baking soda)
  - Water (H_20)
  - *White Vinegar (*CH_3COOH)
  - Toothpaste

Formative Assessment Strategies: Pre-write, Student Dialogue, Venn Diagram, Exit Ticket

Computational Thinking: Students are asked to organize/represent data collected in a way that makes sense for them or a "model" of their current thinking; this foundational to support their future understanding of a pH Scale.

Misconceptions: Two conceptions that students often hold is "acids eat material away" and "acids can burn you"; this leads to the misconception that these are the only characteristics of acids and the only manner that acids can be determined. Students often also incorrectly believe that bases are something that makeup acids when in reality substances are either acidic basic or neutral as determined by the pH. The use of models for acids and bases has also proven to be confusing for students since often they will encounter several different models where the words and ideas change meaning but students are not always made aware of this.

Safety Note(s): Students should know and practice the procedures for glass and chemical safety. Students should not us a taste test on laboratory chemicals. Touching an unknown substance to observe if it feels slippery should not be done on laboratory chemicals as some strong bases burn the skin when touched. Ammonia can cause nosebleeds and eye irritation. Be sure students are wearing safety glasses/goggles/aprons at all times.

Engage

- Recall what you learned in 5th grade about solutes and solvents *(SC Performance Indicator 5.P.2B.4 Construct explanations for how the amount of solute and the solvent determine the concentration of a solution.)*
- Solicit examples from the students of solutions commonly found that are made of solvents and solutes. Have students include in their responses which is the solvent and solute and why.
- As a class generate a list of what their current knowledge and understanding about acids and bases entails.
- Have students individually respond in their notebooks as a **Pre-Write** to the **Focus Question** "How could someone determine whether a solution is an acid or base by using litmus paper?"
- Discuss as a class "How might the idea of solutes and solvents be applied to acids and bases?" After class brainstorming session, respond with, an acid is a solution with a high concentration of one type of substance while a base is a solution with a high concentration of a different type of substance. *(NOTE: The intent of this is for students to understand the general differences between acids and bases as they relate to solute and solvent. It is not important at this time to introduce the actual substances which are hydrogen ions and hydronium ions - they will further develop these concepts in high school.*

Explore

- Question to the class: Have you ever brushed your teeth and then drank a glass of orange juice? What do you taste afterwards? Yuck! It leaves a really bad taste in your mouth, but why? Hopefully we will figure out some reasons as we learn about acids and bases.
- In the 3rd grade (*SC Science Performance Indicator 3.E.4A.1*) you collected data from various tests to infer if the solids were rocks or minerals. We are going to use a similar technique.
- Although we know that an acid feels sticky and a base feels slippery, it is not a good idea as scientists to use our fingers since it would not be an accurate or fair test; not to mention a safety concern. So, we need to learn another manner to test if a solution is acidic or basic and how strong it is.

- Today we are going to use a simple test to determine if a solution is an acid or a base. Litmus paper is a special colored paper that turns bright/deep red when placed in an acidic solution and bright/deep blue when placed in a basic solution.

Instructions for groups:

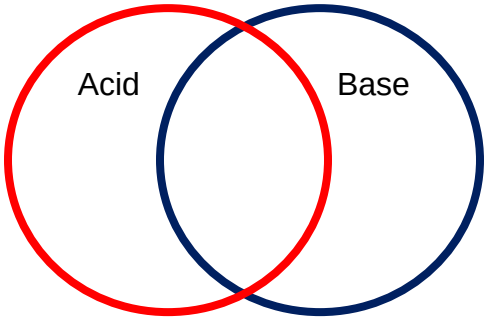
- Put about 5 mL on a round circle on the laminated sheet; each circle with a different chemical. *The baking soda will have to be mixed with water and shaken until it dissolves to make the solution.*
- Test each liquid with a small strip of both red and blue litmus paper. Be sure to test using both strips of litmus paper (red and blue) since a neutral solution will not affect the color on either test strip of litmus paper. Observe and record the color of the litmus paper in a data table (such as the example below). Use your observations to conclude if each liquid is an acid a base or neutral.

Liquid	Red Litmus paper	Blue Litmus paper	Acid, Base or Neutral?
Orange juice			
Vinegar			
Water			
Sodium Bicarbonate			
Ammonia			
Toothpaste			

- As students are working to complete the activity, teacher should monitor closely posing clarifying questions such as:
  - Which of the liquids are acidic? Basic? How do you know?
  - Which of the liquids neutral (not acidic or basic)? How do you know?
- Repeat the same steps using different concentrations of the liquids; be sure to note if the solution is more or less concentrate with the solute (use water as the solvent). Determine if each new solution is an acid, base or neutral.
- As a class, compare what you know about the substances you tested and what you learned from the acid/base test.
- Groups should then write generalizing statements about the characteristics of acids and bases. Compare your statement to two other groups.

Explain

- Have a class discussion about the characteristics discovered that make acids and basis similar and unique.
- Independently in your notebooks, generate a graphic organizer to compare and contrast the characteristics of acids and bases (ex. **Venn Diagram** as shown below).



- Independently in your notebooks, organize the data collected about the substances tested in a way that currently makes sense for you – include all solutions of various concentrations (i.e. graphically represent the mental model you currently hold). *NOTE: This is a foundational assignment designed to help students begin to make sense of the pH scale. They should NOT be introduced to the pH scale at this point.*
- **TEACHER NOTES***:*
    - *An **acid** (from the Latin acidus/acere meaning sour) is any chemical compound that, when dissolved in water, gives a solution with a pH less than 7.0 in its standard state; strong acids have a pH closer to zero while weaker acids have a pH closer to 6.9. Acids can be identified by their sour taste (for example lemons and oranges contain acids); by their reaction with some metals such as zinc, and by their reaction with bases to form a neutral pH solution (for example, vinegar reacting with limestone).*
    - ***Bases** can commonly be thought of as any chemical compound that, when dissolved in water, gives a solution with a pH higher than 7.0; stronger bases have a pH closer to fourteen while the pH of weaker bases are closer to 7.1. Bases can be identified by their bitter taste (for example, unsweetened cocoa has a bitter taste); by its slippery feel (for example, dish detergent) and by its reaction with acids to form a neutral pH solution (for example, an antacid to soothe an acid stomach).*
    - ***Neutral solutions are** neither an acid nor a base. For example, pure water is a neutral solution and has a pH of 7.*
    - *Answer to question posed in #1 of Explore – Orange juice and toothpaste by themselves taste good. But the terrible taste results from an acid/base reaction that is going on inside your mouth. Orange juice is a weak acid and toothpaste is a weak base. When they are put together they neutralize each other and produce a product that is unpleasant to taste.*
- Students should create a "Wanted" poster to alert any unsuspecting citizen of the warning signs for both acids and bases. Be sure to include distinguishing characteristics and safety hazards.
- As a class, discuss ideas on "How might our results be more accurate when determining if something is an acid or base?" (*ex. To determine the strength of the acid or base by identifying the actual pH.)*

- Have students complete an **Exit Ticket** connecting back to the **Focus Question** "How could someone determine whether a solution is an acid or base by using litmus paper?"

Lesson Plan – Part B: Determining relative pH of acids and bases using indicators

Time Required – (Two 60-minute classes)

Disciplinary Vocabulary – Physical properties, Chemical properties, pH, Acids (acidic), Bases (basic), Neutrals, Neutralization, Indicators, Litmus paper, Phenolphthalein, pH paper

Materials Needed: *(for groups of **two** students)*

- 5 mL solutions of:
  a. ammonia
  b. antacids tablets dissolved
  c. apple
  d. aspirin
  e. baking soda
  f. borax soap
  g. cream of tartar
  h. distilled water
  i. grapes
  j. hair conditioner
  k. lemon juice (or lemon)
  l. milk
  m. milk of magnesia
  n. orange
  o. orange juice
  p. pickling lime
  q. pine cleaner
  r. salt water
  s. soda
  t. shampoo
  u. tap water
  v. toothpaste
  w. tomato
  x. vinegar
- Phenolphthalein (10 mL)
- pH paper strips with corresponding scale
- Testing Surface (*NOTE: can use laminated sheets with circles – See attached*)

Formative Assessment Strategies: P-E-O Probe, Student Dialogue, Venn Diagram, Proof Paragraph

Computational Thinking: Early in the lesson, students are asked to create their own data table so they can learn how to logically organize and analyze data. Toward the end of the lesson, students are asked to consider several environmental scenarios and transfer this problem solving process to help solve each of the given problems.

Misconceptions: Two conceptions that students often hold is "acids eat material away" and "acids can burn you"; this leads to the misconception that these are the only characteristics of acids and the only manner that acids can be determined. Students often also incorrectly believe that bases are something that makeup acids when in reality substances are either acidic basic or neutral as determined by the pH. The use of models for acids and bases has also proven to be confusing for students since often they will encounter several different models where the words and ideas change meaning but students are not always made aware of this.

Safety Note(s): Students should know and practice the procedures for glass and chemical safety. Students should not us a taste test on laboratory chemicals. Touching an unknown substance to observe if it feels slippery should not be done on laboratory chemicals as some strong bases burn the skin when touched. Ammonia can cause nosebleeds and eye irritation. Be sure students are wearing safety glasses/goggles/aprons at all times.

Engage

- Have students discuss with a partner what the word "indicate" means to them? How might that relate to an indicator?
- In the 3rd grade (*SC Science Performance Indicator 3.E.4A.1*), you collected data from various tests to infer if the solids were rocks or minerals. One of the tests was to put vinegar on rocks to determine if it contained calcium carbonate; if it bubbled it contained the substance, if not it didn't. In this example, the vinegar was used as an "indicator". Being more precise with the composition helps geologists know more about the rock being examined. Just as the test you used in the 3rd grade was a reaction between an acid and a base, now we are going to further our understanding of the difference between the two.
- Today we are going to further explore indicators and how they help you determine the relative pH of a substance (i.e. the strength of an acid or base)
- Engage the students in a **P-E-O** (Predict, Explain, Observe) **Probe**, before each solution/substance is tested and record all information in notebooks. The predictions are which you think each might be (acid, base or neutral). *Note, your prediction is just a guess and not changed after the experiment is complete.*

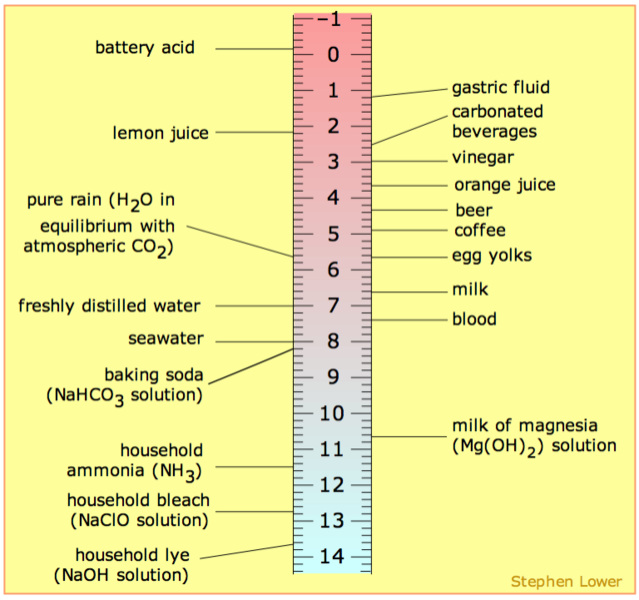
Explore

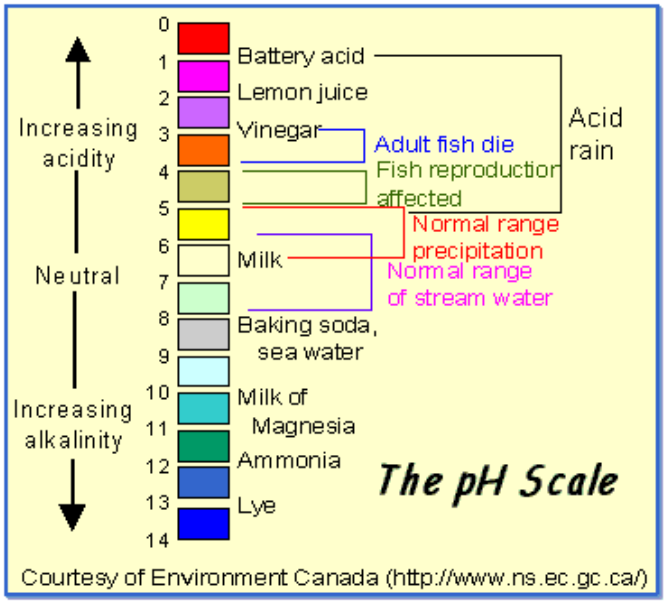
- Using the same method as in Part A, use the phenolphthalein solution and pH paper to determine the relative pH for each substance. *NOTE: Phenolphthalein is another chemical that scientists can use to identify acids and bases. Phenolphthalein is a colorless chemical that turns magenta (bright pink) in a base – the intensity of the color is an indicator of the strength of the base; the brighter the color, the stronger the pH. Phenolphthalein remains colorless in neutral or acidic solutions.*
    - How does phenolphthalein make your data more specific?
    - What might be some limitations by using phenolphthalein?
    - Be sure to record your data in your notebook in a table that you designed.
- As the groups are collecting data, the teacher should closely monitor the groups and ask clarifying questions such as:
    - How does the pH further describe household substances?
    - How does the using phenolphthalein and pH paper compare to using litmus paper?
    - Generally speaking, are fruits acidic or basic in nature? Cite evidence to support your response.

  - How might a pH scale be useful?
  - Which solutions are neutral? How do you know?
  - Compare the pH values of distilled water, salt water and tap water. What might be some reasons for this?
- Once all groups have completed the experiment, hold a class discussion around the questions listed above.
- Students should capture in notebooks their understanding of pH and how it relates to acids and bases.

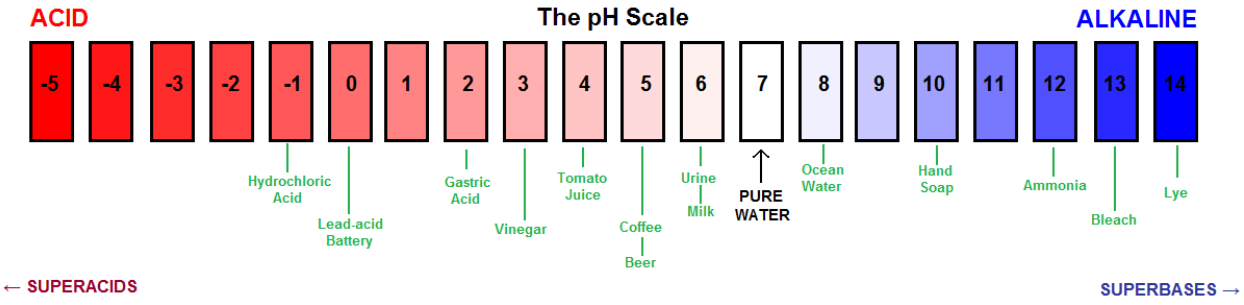
Explain

- Rank the 24 substances tested from very acidic to very basic. Use your evidence and understanding of solutes and solvents in a solution to explain your response.
- What does all this tell you? What does the value for pH tell you about a solution? Capture your thoughts in your notebooks.
- Students can further explore the idea of using indicators to determine acids and bases using the interactive websites at:
  - Alien Juice Bar Lab: Allows students to virtually use cabbage juice to test the pH of different substances to produce the appropriate pH substances for their customers. http://static.lawrencehallofscience.org/scienceview/scienceview.berkeley.edu/html/showcase/flash/juicebar.html
  - Public Broadcasting System (Acids and Bases) – http://www.pbskids.org/zoom/games/kitchenchemistry/virtual-start.html
- **TEACHER NOTES**: *The **indicators** used during this lesson each reveal something more specific about the solutions tested. **Litmus paper** is limited to just revealing if a substance is an acid or a base. **Phenolphthalein** works to further identify a base by the*



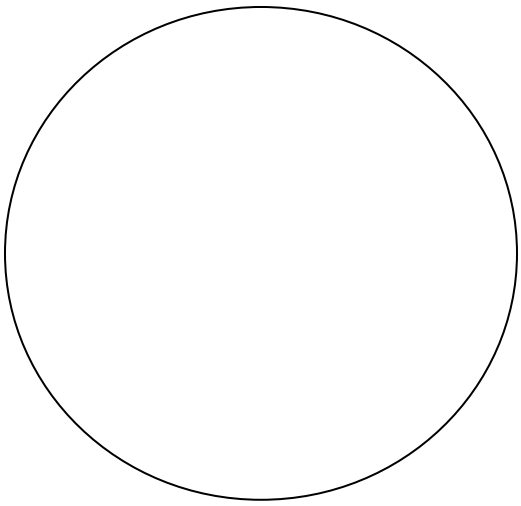
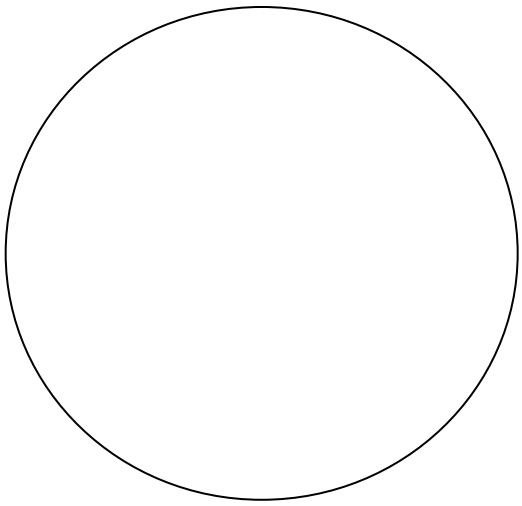
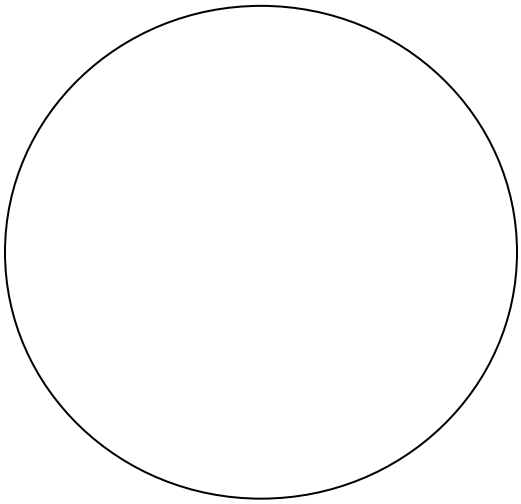
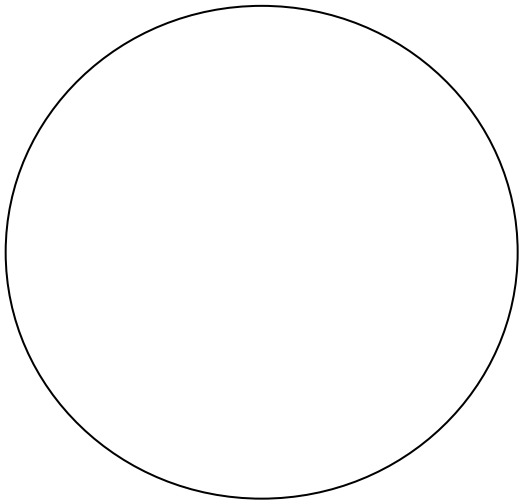
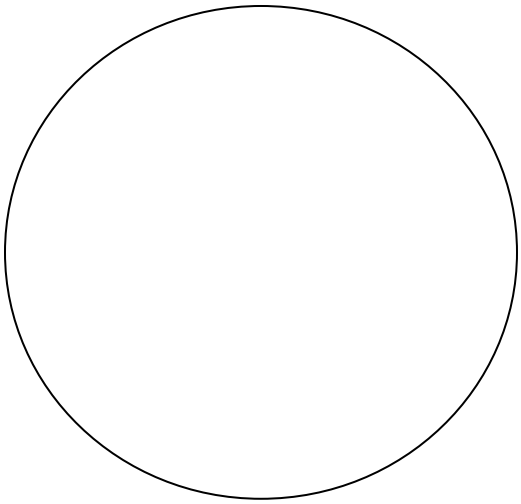
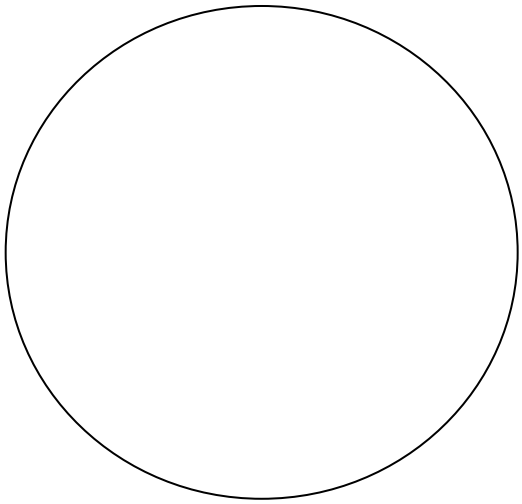


strength of the color pink; however, it does nothing to identify a neutral solution or an acid. ***pH*** *paper is the most accurate test used in this lesson for determining the strength of the solutions. Sequencing of the actual pH papers should result in a scale similar to the examples listed below:*



- *Stronger acids have a pH closer to zero (0) while weaker acids have a* ***pH*** *closer to 6.9. Stronger bases have a pH closer to fourteen (14) while the pH of weaker bases are closer to 7.1. Neutral solutions are neither an acid nor a base. For example, pure water is a neutral solution and has a pH of 7.*
- Using **Bounce Cards** in small groups, students should discuss solutions with evidence from their data to each of the following scenarios highlighting the environmental aspect of acids and bases:
    - Fish give off the base ammonia, NH_3, as waste. How might the release of ammonia affect the pH of the water in the aquarium? What can be done to correct the problem? *(Answer: The pH of the water will increase making it a harmful environment for fish to live. An acid can be added to lower the pH and correct the problem. For a household aquarium, changing the water can remove the unwanted ammonia.)*
    - Many insects, such as fire ants, inject a weak acid when they bite or sting. What kind of compound could you use to treat the bite? *(Answer: A weak base should be used to treat the bite; it will neutralize the acid)*
    - Farmers often can taste their soil to determine whether the soil has the correct acidity for their plants. How would taste help the farmer determine the acidity of the soil? *(Answer: Tasting the soil can determine if the soil is acidic or basic. If the soil tastes sour, it is acidic; if it tastes bitter it is basic. It is not suggested nor encouraged that students taste soil either at school or at home.)*
- Have students complete a **Proof Paragraph** in their notebooks, summarizing their findings as compared to the P-E-O probe they completed at the beginning of the lesson.

Test Surface for Solutions – (TEACHER NOTE: *Be sure to laminate prior to using)*

Other information on this indicator(s) can be found in the support documents/resources on the SC State Department website.

www.ed.sc.gov (Instruction → Standards and Learning → Mathematics or Science → Support Documents and Resources)

Content Area (Disciplinary) Literacy strategies and descriptions can be found on the S2TEM Centers SC website:

s2temsc.org (Resources → Disciplinary Literacy Virtual Library → Strategy Warehouse)

Computational Thinking Reference:

https://csta.acm.org/Curriculum/sub/CurrFiles/CompThinkingFlyer.pdf
https://csta.acm.org/Curriculum/sub/CompThinking.html

Additional Information

Level 1 lessons contain a realignment to the 2014 Science and/or the 2015 Mathematics Standards.

Level 2 lessons contain Level 1 information and Content Area Literacy and Disciplinary Literacy Strategies.

Level 3 lessons contain Level 1 and 2 information and Computational Thinking Connections.

Level 4 lessons contain Level 1, 2, and 3 and integration of at least 2 content areas.