## SNC2D/2P Chemical Reactions/Chemical Reactions and their Practical Applications

# Teacher Demo/Student Activity: Red Cabbage Indicator

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| --- | --- |
| Topics properties of acids and bases  pH scale | Timing preparation: 20 min  demonstration: 10–15 min  activity: 20−25 min |

## Specific Expectations

### SNC2D

**A1.1** formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research

**A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions

**C2.6** plan and conduct an inquiry to classify some common substances as acidic, basic, or neutral (e.g., use acid-base indicators or pH test strips to classify common household substances) [IP, PR, AI]

**C3.7** describe how the pH scale is used to classify solutions as acidic, basic, or neutral (e.g., a solution with a pH of 1 is highly acidic; a solution with a pH of 7 is neutral)

### SNC2P

**A1.1** formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research

**A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions

**C2.6** conduct an inquiry to classify some common substances as acidic, basic, or neutral (e.g., use acid-base indicators or pH strips to classify common household substances) [PR, AI]

**C3.5** describe how the pH scale is used to identify the concentration of acids and bases

## Introduction

This demonstration illustrates the presence and importance of chemistry in everyday objects, including our food. It is an interesting way to start the discussion of acids and bases or to connect acids and bases to the pH scale and extend the discussion to acid–base indicators. Red cabbage is an example of a naturally-occurring acid–base indicator. Many household products are acids or bases and often products that are used for similar tasks have similar pH values.

## Materials

|  |  |
| --- | --- |
| chemical safety goggles  lab coat or apron  protective gloves  red cabbage  water  substances to test (e.g., lemon juice, white vinegar, apple juice, hand sanitizer, clear or white shampoo and conditioner, baking soda, milk, clear liquid soap)5 mL of 0.1 mol/L hydrochloric acid, HCl(aq)  5 mL of 0.1 mol/L sodium hydroxide, NaOH(aq)  knife or scissors  blender | 1 L beaker  strainer (or paper towels if no strainer is available)  250 mL beakers (one for each substance being tested)  marker for labeling beakers  10 mL graduated cylinder  stirring rod Student activity will also require: dropper bottles containing substances to be tested *or* 100 mL beakers and dropping pipettes  spot plates |

## Safety Considerations

* Provide MSDS sheets for all chemicals used.
* Sodium hydroxide solution is corrosive and will irritate your skin and eyes. Avoid skin or eye contact. Safety goggles, lab coats or aprons, and gloves must be worn at all times. Wash your hands and flush your eyes immediately if you come into contact with sodium hydroxide.
* Hydrochloric acid is corrosive. Avoid skin or eye contact. Safety goggles, gloves and lab coat/apron should be worn when handling. Wash your hands and flush your eyes immediately if you come into contact with hydrochloric acid.
* Contact with eyes should be avoided with all substances. Safety considerations will depend on substances tested.

## Hazardous Materials Identification System Rating

*(0-minimal 1-slight 2-moderate 3-serious 4-severe)*

|  |  |
| --- | --- |
| 0.1 mol/L hydrochloric acid | 0.1 mol/L sodium hydroxide |

## Procedure

Ensure that all participants are wearing appropriate PPE: chemical safety goggles and lab coat or apron.

Prepare the following before performing the demonstration. (Alternatively, the indicator could be prepared during the introduction.)

1. Cut up the red cabbage leaves and place them in the blender with 750–850 mL of water.
2. Turn on the blender for about 30 seconds. Using the strainer to collect and remove any remaining cabbage leaves, pour the mixture into the 1 L beaker. This should produce around 500–750 mL of red cabbage juice.
3. Pour 7–10 mL of each substance to be tested into a beaker and label accordingly.

Organize your class into groups of 2–4 students per group.

1. **Predict/Explain**

Ask each group to predict which substances will react similarly when the cabbage juice is added. Each group should also attempt to come up with a rationale for their prediction.

1. **Observe**

Using the graduated cylinder, pour 5 mL of red cabbage juice into each of the substances to be tested, including the hydrochloric acid and the sodium hydroxide solutions. Stir each one with the stirring rod. Provide time for students to record their observations.

1. **Explain**

Ask each group to discuss their results and group them based on the colours produced. Have them compare their colours to the colours obtained for the acid and base.

### Alternative Procedure for Student Activity

1. Place each substance (including red cabbage indicator) into a dropper bottle or a small beaker with a dropping pipette in it.

Organize your class into groups of 2–4 students.

2. **Predict/Explain**

Ask each group to predict which substances will react similarly when the cabbage juice is added. Each group should also attempt to come up with a rationale for their prediction.

3. **Observe**

Students should place 1–2 drops of the substance to be tested (including hydrochloric acid and sodium hydroxide solution) in a cell of a spot plate. They should then add 1 drop of cabbage juice to each cell, and record the colour.

4. **Explain**

Ask each group to discuss their results and group them based on the colours produced. Have them compare their colours to the colours obtained for the acid and base.

## Disposal

Dilute acid and base can be added together to neutralize them. Household products can be rinsed down the drain. Follow disposal procedures that are consistent with school board protocol and appropriate for your municipality for all substances chosen for testing.

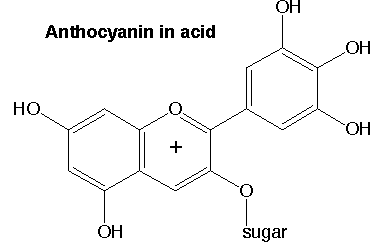
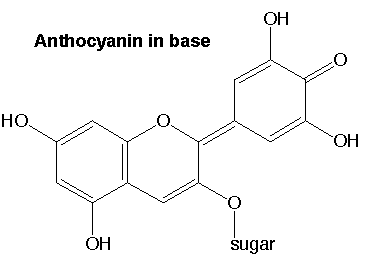
## What happens?

The red cabbage juice changes colour when mixed with the test substances. The colour depends on the pH of the solution.

## How does it work?

Red cabbage contains a water-soluble pigment that is one of a group of compounds called anthocyanins. Anthocyanins are found in cell vacuoles of plants, contributing to the colours of many fruits and vegetables such as eggplant, cherries, and many berries. Many anthocyanins act as acid–base indicators, changing colour when in different pH environments. The colour changes for the pigment in red cabbage are shown in the following table:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Colour** | Pink | Red | Violet | Blue | Bluish green | Greenish yellow |
| **Approximate pH** | 1 | 3 | 5–7 | 8 | 9 | 11 |
| **Classification** | acidic | | acidic–neutral | basic | | |

pink–red blue–green–yellow

## Teaching Suggestions/Hints

1. This demonstration can be modified very easily into a student activity. To emphasize the fact that red cabbage juice is a naturally occurring indicator, students can make their own red cabbage juice extract. If time and/or equipment are a concern, the indicator can be prepared ahead of time by the teacher.

2. Each substance can be tested with a pH meter, so students can see that the colour change is associated with the pH, rather than as a result of some other chemical reaction. Knowing the colour of each substance and its pH, students could create their own table of colour and pH, similar to the chart provided. Then the charts and natural indicators could be used to find the pH of a mystery solution. Different charts could be created for different indicators.

3. If you do not have access to a blender, the red cabbage leaves can be boiled in water and then strained to produce the red cabbage juice to use as the indicator solution.

4. When choosing substances to test, choose substances with a range of pH values. For the pH of common substances, see the link in Additional Resources below.

5. pH indicator paper can be created by soaking strips of filter paper in red cabbage juice and allowing them to dry.

6. Many other naturally coloured substances can be used. Red grape juice and juice from raspberries work well and are very easy to obtain.

## Next Steps

This could lead into an investigation that compares the clarity of the colour changes of natural and artificial acid–base indicators. It could even be extended to senior chemistry when explaining the colour changes that occur during an acid–base titration.

## Additional Resources

1. Video of a similar demonstration: <http://www.stevespanglerscience.com/experiment/red-cabbage-chemistry> (Click on the video tab.)

2. pH values of common substances and more information about the science of pH: <http://www.mpcfaculty.net/mark_bishop/pH_equilibrium.htm>

3. Source of anthocyanin images: <http://ww2.chemistry.gatech.edu/~lw26/bCourse_Information/red_cabbage_pH_indicator/cabbage.html>