Worksheet: The science behind pH

Background

Acids and bases are substances that are found all around us. Bases are also known as alkalis but only if they dissolve in water.

What is the difference between an acid and a base?

You might know that hydrogen is one part of the water molecule H2O. In any volume of water some of the molecules will spontaneously break down into hydrogen (H^+) and hydroxide (OH^-) ions. As long as the number of each of these ions is the same, the solution is said to be "neutral". If there are more H^+ than OH^- ions the solution is "acidic" and if there are more OH^- than H^+ the solution is "basic". So, in simple terms, an acid is something that increases the number of hydrogen ions and a base is something that decreases the number of hydrogen ions (or increases the number of hydroxide ions!).

What is pH?

When we are working with acids and bases we often need to know how strong they are. Some are very strong, like hydrochloric acid (acid) or sodium hydroxide (base), while others are weaker, like citric acid (acid) or baking soda (base). Many people have heard of acids being described as "corrosive", meaning they cause damage to the things they come into contact with, but the same is true of bases. Often the stronger the acid or base is, the more corrosive it is.

The pH scale is the way we give a number to the strength of an acid or base. This scale is "the negative log base ten of the number of hydrogen ions". Aside from being something you can quote to show off how smart you are, what this really means is 2 things:

1. It means that each number on the scale represents "x10". So a pH of 2 is 10 times less H^+ than a pH of 1 or 100 times more than pH of 4.
2. More importantly for us, it means that the *lower* the pH number, the *more* H^+ ions are present, so it is more acidic. Conversely, a *higher* pH value means *fewer* H^+ ions, so it is more basic.

How do find out the pH of a substance?

pH indicators are incredibly useful tools in science. A common indicator to use in a lab is "universal pH paper". A drop of solution on this paper will make it change

to a colour that is determined by the pH of the solution you chose. That colour can be compared to a chart to determine the pH of the solution. Other

indicators also exist and some, like the anthocyanins you see in the demonstration, can even be found in nature. (Anthocyanins are a compound that give some plants their colour). All pH indicators work on the same principle i.e. increasing or decreasing the number H^+ ions causes the indicator molecule to change its colour.

The experiment

In the video you will watch an experiment that uses anthocyanins as a pH indicator to test the pH of several household substances. You can repeat this experiment using the following protocol to determine the pH of other household substances you are interested in.

Making a pH indicator using red cabbage

You will need

- A red cabbage
- Water
- A heat resistant beaker or pan, and heat source
- Sieve / muslin cloth / filter paper
- Small tubes / bottles (15-50ml volume is fine)

What to do

1. Chop up the red cabbage as finely as possible.
2. Add the cabbage to the beaker or pan. If you have quite a lot then just ad enough to have 1-2cm deep.
3. Add enough water to make sure there is about the same height of water above the cabbage as the depth of cabbage itself.
4. Loosely cover to prevent water loss while heating
5. Put the beaker or pan onto the heat source and heat gently until boiling
6. Boil for 5-10 minutes, until you can see that water has changed to a purple colour
7. Remove from heat and leave to cool slightly
8. Filter using a sieve, muslin cloth or filter paper to remove the cabbage
9. Place the filtered cabbage water into the tubes and leave to cool

10. This is now your pH indicator and can be stored in the fridge for 1-2 weeks if necessary until you are ready to use

Testing your samples

In the video the following are tested

- Lemon juice
- Vinegar
- Sugar
- Washing Powder
- Toothpaste

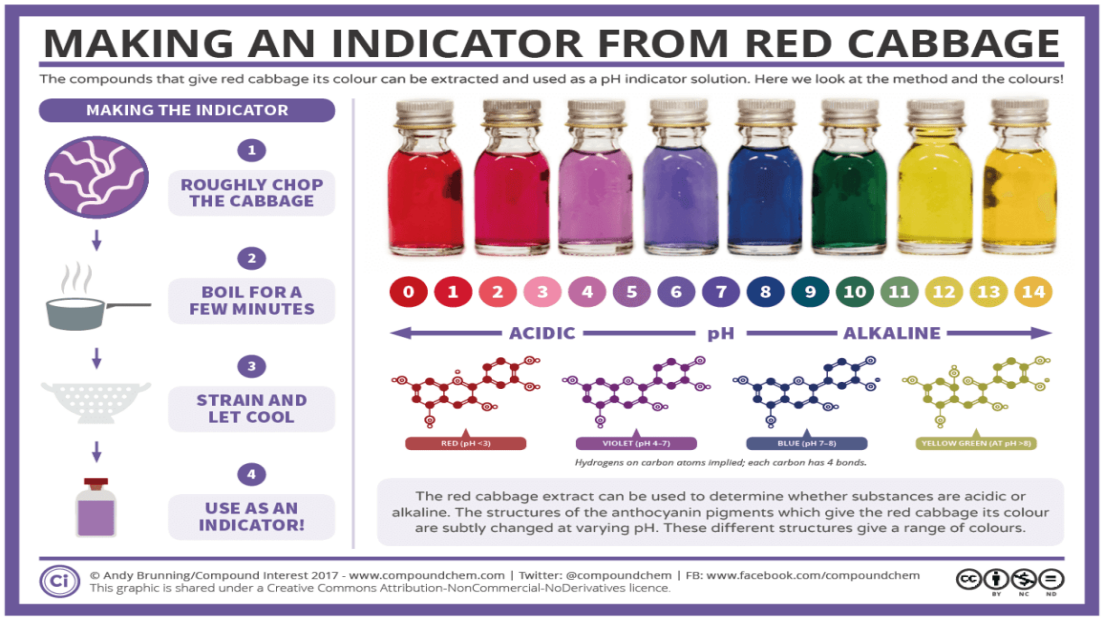
You can select any typical household substance to test its pH. However, note that anything that has a very strong colour will make it more difficult to determine the colour change.

You will need

- Your sample to test
- A tube (15-20ml) per sample to test
- Water, preferably deionised to minimise errors
- Your pH indicator solution
- A dropper to add the indicator solution

What to do

1. Dissolve about 1 teaspoon of your sample in 10 ml water
2. Note the original colour as this can impact your results
3. Add about 10 drops of the pH indicator and mix
4. Using the pH colour chart below try to determine the pH of your sample



Testing your understanding

1. In the video lemon juice was tested. Find out what component of lemon juice contributes to its pH and is therefore causing the colour change?
2. Which of your samples have high numbers of H^+ ions?
3. Think about why pH might be important in the world around us, in particular why might it be important to our bodies?

Share your findings

Why not share your results with us at the ICRGU STEM Academy, take some pictures of your experiment and experiences and you can tag us @icrgu_students or use #ICRGUSTEMAcademy