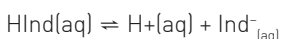




DIY Indicators

THE SCIENCE

Acids and bases (alkalis) form solutions that have a pH of <7 or >7 respectively. The pH is a measure of acidity and is defined as $-\log_{10}[\text{H}^+]$. Indicators are substances which exhibit different colours in acid and base(alkaline) solutions. They are often coloured organic substances such as litmus, which is extracted from lichen. Litmus turns red in acids and blue in alkalis. Indicators are normally weak acids:



Where HInd is a weak acid and Ind⁻ is its conjugate base; both have different colours. The change in colour results from a change of structure as a H⁺ is removed from or attached to the molecule. In acid solution, HInd predominates; in alkali solution, the H⁺ ions are removed from the equilibrium, more HInd ionises and the conjugate base Ind⁻ predominates.

Anthocyanins are organic dyes found in many plants (eg geraniums, poppies and rose petals) and which are partly responsible for the autumn colours of leaves. They also are found in red cabbage and can be used as pH indicators because they exhibit different colours in acids and bases; they are red in acid, purple in neutral and blue in basic solution.

MATERIALS

You will need:

- a small red cabbage;
- a knife;
- coffee filter papers;
- Pyrex (heat-proof) glass container or casserole dish;
- eight small glasses;
- baking soda (sodium hydrogencarbonate, NaHCO₃);
- washing soda (sodium carbonate, Na₂CO₃);
- lemon juice (citric acid, C₆H₈O₇);
- cream of tartar (potassium hydrogentartrate, KHC₄H₄O₆);
- vinegar (ethanoic acid, CH₃COOH);
- antacids (calcium carbonate, calcium hydroxide, or magnesium hydroxide);
- Alka-seltzer (carbonic acid, H₂CO₃);
- hydrochloric acid (found in some household cleaners or masonry cleaner).

EXPERIMENT 1

Chop the cabbage into small pieces until you have about two cups full. Place the cabbage in the large Pyrex glass container (or casserole dish) and add boiling water to cover the cabbage. Allow at least 10 minutes for the colour to leach out of the cabbage into the water, which should change from transparent to red.

Now filter the plant material to obtain the red/purple liquid. This liquid is at *circa* pH 7. The exact colour will depend on the pH of the water in your household taps.

Pour about 100 ml of your red cabbage indicator into each small glass. Add various household solutions to your indicator until a colour change is obtained. Use separate containers for each household solution, and do not mix the separate household solutions because they may react unexpectedly. Confirm whether the solutions are acidic or basic (see Table).

EXPERIMENT 2

Try a 'titration' using the solutions and red cabbage indicator. Add an acidic solution, such as lemon juice, to the indicator until the colour is red. Now drip in a solution of baking soda – the colour should change as the pH rises.

EXPERIMENT 3

You can prepare pH litmus paper using the red cabbage indicator. Take a fresh piece of coffee filter paper and soak it in a concentrated red cabbage juice solution, which you can make by using more cabbage and boiling in less water. Leave overnight and then allow the paper to dry. Cut into strips and use to test the pH of various solutions.

RED CABBAGE pH INDICATOR COLOURS

pH	Colour
2	Red
4	Purple
6	Violet
8	Blue
10	Sea-green
12	Yellowish-green

HEALTH & SAFETY

Wear a lab coat or apron/overall, eye protection and disposable laboratory gloves (or Marigold-type gloves) throughout these experiments. Take care when using boiling water – it will scald.

At the end of the experiments rinse the working area thoroughly with water and pour the solutions down an outside drain, rinsing through with plenty of water.

