Indicator puzzle

- Your task

Extract colours from given plants and use them to determine the pH of three given solutions. No indicator paper is allowed!

Based on a suggestion by P. Borrows.

Time

70 minutes.

Group size

3–4.

Equipment & materials

Eye protection.

General
Test tubes and racks (or spotting tiles – if possible, 2 per group), small beakers, pestles and mortars, glass droppers, filter funnels and papers, scissors, labels. Students may need access to hot water (*eg* a kettle, NOT Bunsen burners).

Sand.

Solvents: Ethanol and propanone (acetone).

Samples of coloured plants: Red cabbage, beetroot, geranium petals (strongly recommended because they show two colour changes, at low and high pH), rose petals, violets, delphiniums, lupins, elderberries, blackberries *etc.* Dark-coloured flowers will work best. (Suitable materials could be collected in season and stored in a freezer.)

Access to buffer solutions with clearly marked pH values, *eg* pH 2.0, 4.0, 6.0, 8.0, 10.0.

Solutions X, Y, and Z of unknown pH (you could also provide 'buffers' here).

Health & Safety notes

This is an open-ended problem solving activity, so the guidance given here is necessarily incomplete. Teachers need to be particularly vigilant, and a higher degree of supervision is needed than in activities which have more closed outcomes. Students must be encouraged to take a responsible attitude towards safety, both their own and that of others. In planning an activity students should always include safety as a factor to be considered. Plans should be checked by the teacher before implementing them.

You must always comply with your employer's procedures and in some cases may decide that a particular activity is inappropriate in your situation. Further information on Health and Safety should be obtained from reputable sources such as CLEAPSS [*http://science.cleapss.org.uk/*] in England, Wales and Northern Ireland and, in Scotland, SSERC [*https://www.sserc.org.uk/*].

Propanone (acetone) is highly flammable and an eye/respiratory irritant.

Ethanol is highly FLAMMABLE (if methylated spirits are used, they are also harmful if ingested and cause damage to organs).

Because of the use of flammable solvents, Bunsen burners should not be used. If a hot solution is required, make hot water available from a kettle.

Eye protection should be worn.

It is the responsibility of the teacher to carry out a suitable risk assessment.

Curriculum links

Indicators. Buffers. Acids and alkalis.

Possible approaches

To extract colours from given plants ("A local florist very helpfully gave us some "newly dead" flowers for free and they were excellent!") and use them to determine the pH values of three given solutions. Initially students could tackle the problem individually to prepare one plant extract, then in groups to solve the X, Y, Z puzzle.

Red cabbage was found to be the best indicator with a sensitive enough response to allow accurate pH estimations (changes through red(cerise) – mauve – blue – turquoise). Other materials (blackberry, beetroot) are interesting to try but very much the same in their response (red up to about pH 6, blue-red above this value). Red rose and carnation were also tried – results seemed to vary, some students finding these more useful than others. **NB** "Especially interesting are the extracts from red cabbage, radish skin, rhubarb skin, and turnip skin, which act as universal indicators" (see "Edible Acid-Base Indicators" Robert C. Mebane and Thomas R. Rybolt. J.Chem.Educ., April 1985, Volume 62, Number 4, p285).

Difficulties with the sequence of events:- Some students will not see the relevance of testing the 'indicator' against known pHs, then using their results to test X, Y and Z. The concepts may need to be explained to them. Also they tend to know universal indicator quite well and assume that all indicators are red in acid and blue in alkali. Teachers could cut the buffers down to only four and label them:- strong acid (pH 3), weak acid (pH 6), weak alkali (pH 8), strong alkali (pH 10). Likely areas for giving guidance:-

how to prepare a plant extract;

how to tackle the testing of the extract systematically;

how to record systematically;

how to interpret results.

Experiments could also be re-stated for lower ability range – maybe as a series of structured steps, to make it easier to understand:-

* * *

"Indicator puzzle"
Can you make an indicator solution and use it to find out the pH of unknown solutions X, Y and Z?

You do have some solutions whose pHs you know – pH 2, pH 4, pH 6, pH 8 & pH 10.

Stage 1
Each person's job is to extract the colour from the plant sample they have been given.

Stage 2
Is your coloured extract an indicator? Try to find out, using the solutions whose pHs we know.

Stage 3
Working in a group, decide which is the most useful indicator to help solve this problem:

What are the pH's of X, Y & Z?

Write down your answers.

Suggested write-up

Students produce a colourful poster on natural indicators.

Evaluation of solution

Groups who get closest to the pH values of the three solutions are the winners.

Experiment could be used as an assessed practical, *ie* planning & carrying out, group work, and communication (a written report at the end) could all be assessed.

Extension work

Test a variety of household substances with your natural indicator. Make natural indicator 'papers' by putting the plant pigment onto a piece of blotting paper.

Credits

Health & safety checked May 2018

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