Technician in trouble! Which solutions are which?

The science technician has problems! She has five colourless solutions labelled A, B, C, D and E. She wrote down which solution was which and gave this list to the teacher. BUT ... the teacher has lost the sheet! The technician has to find out quickly the identity of each solution because they are needed for the next class!

She does remember that one solution is water, one is a strong alkali, one is a weak acid, one is a strong acid and one is phenolphthalein. However, the pH meter is broken and the indicator papers are lost! HELP!!!

She needs a quick answer – any group who can solve the problem doesn't get a science homework!

- Your task

Think how to do the experiment, then ... have a go!

Based on an idea from the APU science question 'indicators'.

Time

40–70 minutes. (Likely to be variable according to ability of students.)

Group size

2–3.

Equipment & materials

Eye protection – safety glasses.

Per group
5 dropping bottles (or test tubes and long glass droppers) labelled A, B, C, D and E. (Each bottle (or test tube) contains a colourless liquid).

A test tube rack containing 6 test tubes, glass stirring rod.

Solutions A to E:

A = strong acid (hydrochloric acid) …….. 20 cm^3
B = water …….. 20 cm^3
C = strong alkali (sodium hydroxide) …….. 20 cm^3
D = * weak acid (carbonic acid or tartaric acid) ….. 20 cm^3
E = ** "phenolphthalein indicator + water" mixture . 20 cm^3
* preferably one that doesn't have a recognisable smell. Students can identify vinegar (ethanoic acid) by smell.

** **NB** This needs to be made up on the day its needed as it loses its strength. (Phenolphthalein indicator is made up in alcohol. If you add phenolphthalein/alcohol indicator solution to water, the water goes CLOUDY. You don't want this to happen. You will therefore need to make a "phenolphthalein/alcohol indicator + water" mixture (keep adding water until the solution clears) which:

(i) when added to water, does not make the water cloudy, and

(ii) when added to alkali will go pink.

- Recommend keep 250 cm^3 of each solution in stock in case of spillages *etc.*

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/*].

Phenolphthalein is carcinogenic, mutagenic and a reproductive toxin. Below 1%, though, the solutions are of low hazard.

Hydrochloric acid, 0.5 mol dm^{-3} HCl (aq), is CORROSIVE.

Sodium hydroxide solution, 0.4 mol dm^{-3} NaOH (aq), is CORROSIVE.

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

Curriculum links

Neutralisation. Acids and alkalis.

Possible approaches

At the start of the exercise show students the colour changes for phenolphthalein indicator (colourless in acid and water, pink in alkali). Tell students always to replace the glass droppers in the right bottles (or test tubes) – *ie* point out dangers of contaminating solutions.

A possible sequence of operations:-

Mix each unknown solution with every other unknown solution. The only colour change is pink (E + C = phenolphthalein and alkali, but students won't know which is which). As long as students know the colour changes of phenolphthalein indicator they should get this far.

Next, add the other liquids to (E+C):
(E+C), add A – pink solution goes colourless quickly, also test tube feels hot.
(E+C), add B – pink solution remains pink, just becomes more dilute. Therefore B = water.
(E+C), add D – pink solution eventually goes colourless, but more D is needed than A for neutralisation. Therefore D = weak acid, and A = strong acid.

Finally, to find out which is the indicator and which is the alkali:- Mix a small amount of A (strong acid) with a small amount of C (strong alkali) and lots of E (indicator) – solution stays colourless. Then, mix a small amount of A (strong acid) with a small amount of E (indicator) and lots of C (strong alkali) – solution goes pink. This proves that C is the alkali. Alternatively, add a lot of C (strong alkali) to E (indicator) – this gives a weak pink colour. Then, add a lot of E (indicator) to C (strong alkali) – this gives a strong pink colour. This confirms that E is the indicator. (The indicator makes the colour.)

Students should be encouraged to do a flow chart or table.

Credits

Health & safety checked May 2018

Page last updated October 2018