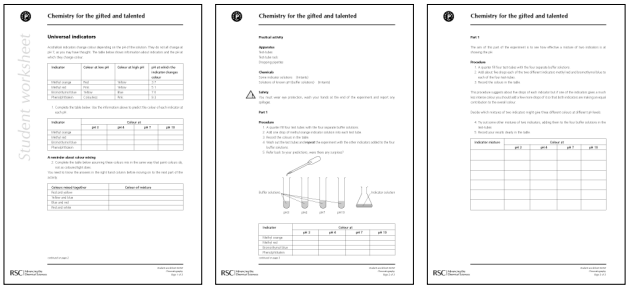
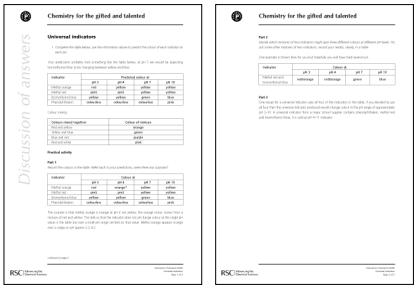
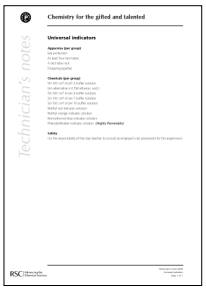
Universal indicators



Student worksheet: CDROM index 05SW



Discussion of answers: CDROM index 05DA



Technician's notes: CDROM index 05TN

Topics

Indicators, universal indicators and pH.

Level

Able students aged 11–13.

Timing

The full worksheet should take a double period. There is quite a bit of flexibility in how many binary mixtures of indicators they try.

Prior knowledge

Acids, alkalis and indicators.

Rationale

This activity develops understanding of universal indicators and single indicators. The students build up their understanding by mixing two indicators. They also develop an awareness that the observed colour may be due to a mixture of colours.

Use

This activity is best used as an extension to work on single indicators and pH.

Alternative

An alternative activity with a less structured problem solving approach would be *Making your own indicator* Activity 1 in the RSC publication *In search of solutions* which can be downloaded at ***www.chemsoc.org/networks/learnnet/solutions.htm*** (accessed April 2007).

Apparatus (per group)

Eye protection
At least four test-tubes
A test-tube rack
Dropping pipettes

Chemicals (per group)

50-100 cm^3 of pH 3 buffer solution
(An alternative is 0.5 mol dm^{-3} ethanoic acid)
50-100 cm^3 of pH 4 buffer solution
50-100 cm^3 of pH 7 buffer solution
50-100 cm^3 of pH 10 buffer solution
Methyl red indicator solution
Methyl orange indicator solution
Bromothymol blue indicator solution
Phenolphthalein indicator solution **(Highly flammable)**

Safety

It is the responsibility of the class teacher to consult an employer's risk assessment for this experiment.

Technician's notes

Universal indicators

Apparatus (per group)

Eye protection
At least four test-tubes
A test-tube rack
Dropping pipettes

Chemicals (per group)

50-100 cm^3 of pH 3 buffer solution
(An alternative is 0.5M ethanoic acid)
50-100 cm^3 of pH 4 buffer solution
50-100 cm^3 of pH 7 buffer solution
50-100 cm^3 of pH 10 buffer solution
Methyl red indicator solution
Methyl orange indicator solution
Bromothymol blue indicator solution
Phenolphthalein indicator solution **(Highly flammable)**

Safety

It is the responsibility of the class teacher to consult an employer's risk assessment for this experiment.

Student worksheet

Universal indicators

Acid/alkali indicators change colour depending on the pH of the solution. They do not all change at pH 7, as you may have thought. The table below shows information about indicators and the pH at which they change colour.

Indicator	Colour at low pH	Colour at high pH	pH at which the indicator changes colour
Methyl orange	Red	Yellow	3.7
Methyl red	Pink	Yellow	5.1
Bromothymol blue	Yellow	Blue	7.0
Phenolphthalein	Colourless	Pink	9.3

1. Complete the table below. Use the information above to predict the colour of each indicator at each pH.

Indicator	Colour at			
	pH 3	pH 4	pH 7	pH 10
Methyl orange				
Methyl red				
Bromothymol blue				
Phenolphthalein				

A reminder about colour mixing

2. Complete the table below assuming these colours mix in the same way that paint colours do, not as coloured light does.

You need to know the answers in the right hand column before moving on to the next part of the activity.

Colours mixed together	Colour of mixture
Red and yellow	
Yellow and blue	
Blue and red	
Red and white	

continued on page 2

Practical activity

Apparatus

Test-tubes
Test-tube rack
Dropping pipettes

Chemicals

Some indicator solutions (Irritants)
Solutions of known pH (buffer solutions) (Irritants)

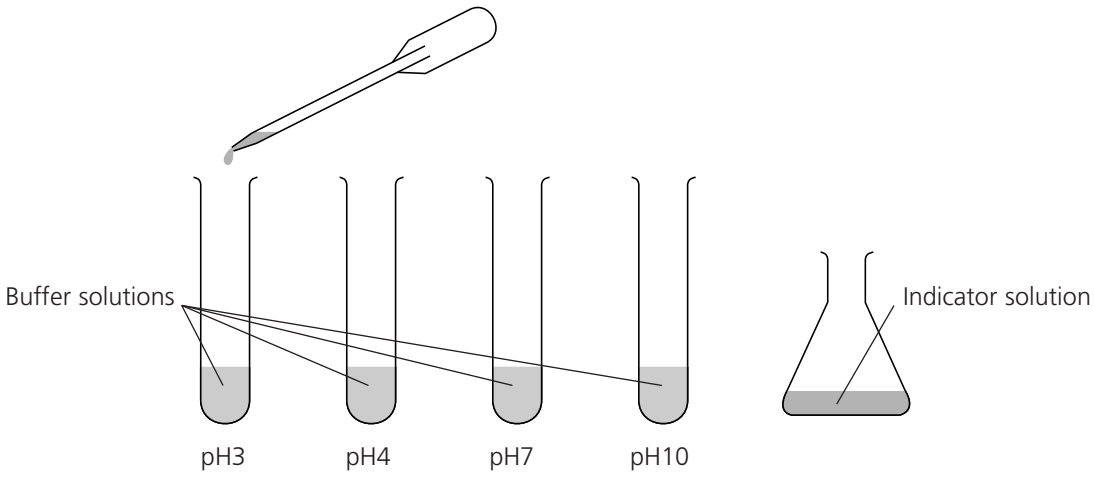
Safety

You must wear eye protection, wash your hands at the end of the experiment and report any spillages.

Part 1

Procedure

1. A quarter fill four test tubes with the four separate buffer solutions.
2. Add one drop of methyl orange indicator solution into each test tube.
3. Record the colours in the table.
4. Wash out the test tubes and **repeat** the experiment with the other indicators added to the four buffer solutions.
5. Refer back to your predictions, were there any surprises?



Indicator	Colour at			
	pH 3	pH 4	pH 7	pH 10
Methyl orange				
Methyl red				
Bromothymol blue				
Phenolphthalein				

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Part 2

The aim of this part of the experiment is to see how effective a mixture of two indicators is at showing the pH.

Procedure

1. A quarter fill four test-tubes with the four separate buffer solutions.
2. Add about five drops each of the two different indicators methyl red and bromothymol blue to each of the four test-tubes.
3. Record the colours in the table.

This procedure suggests about five drops of each indicator but if one of the indicators gives a much less intense colour you should add a few more drops of it so that both indicators are making an equal contribution to the overall colour.

Decide which mixtures of two indicators might give three different colours at different pH levels.

4. Try out some other mixtures of two indicators, adding them to the four buffer solutions in the test-tubes
5. Record your results clearly in the table.

Indicator mixture	Colour at			
	pH 3	pH 4	pH 7	pH 10

Part 3

Universal indicators are mixtures of several indicators.

Design your own universal indicator – state which indicators you will mix together and the relative quantities of each (one drop: two drops *etc*).
Estimate the range of pH values that your Universal Indicator will work over – *eg* 1–14, 5–9 *etc*.

With your teacher's permission, try out your recipe for your universal indicator. If a digital camera is available you could try to produce a colour chart so that others could use your universal indicator successfully.

Discussion of answers

Universal indicators

1. *Complete the table below, use the information above to predict the colour of each indicator at each pH.*

Your predictions probably look something like the table below, at pH 7 we would be expecting bromothymol blue to be changing between yellow and blue.

Indicator	Predicted colour at			
	pH 3	pH 4	pH 7	pH 10
Methyl orange	red	yellow	yellow	yellow
Methyl red	pink	pink	yellow	yellow
Bromothymol blue	yellow	yellow	green	blue
Phenolphthalein	colourless	colourless	colourless	pink

Colour mixing

Colours mixed together	Colour of mixture
Red and yellow	orange
Yellow and blue	green
Blue and red	purple
Red and white	pink

Practical activity

Part 1

Record the colours in the table. Refer back to your predictions, were there any surprises?

Indicator	Colour at			
	pH 3	pH 4	pH 7	pH 10
Methyl orange	red	orange*	yellow	yellow
Methyl red	pink	pink	yellow	yellow
Bromothymol blue	yellow	yellow	green	blue
Phenolphthalein	colourless	colourless	colourless	pink

The surprise is that methyl orange is orange at pH 4 not yellow, the orange colour comes from a mixture of red and yellow. This tells us that the indicator does not all change colour at the single pH value in the table but over a small pH range centred on that value. Methyl orange appears orange over a range on pH approx 3.2–4.2.

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Part 2

Decide which mixtures of two indicators might give three different colours at different pH levels. Try out some other mixtures of two indicators, record your results, clearly, in a table.

One example is shown here for you but hopefully you will have tried several out.

Indicator	Colour at			
	pH 3	pH 4	pH 7	pH 10
Methyl red and bromothymol blue	red/orange	red/orange	green	blue

Part 3

One recipe for a universal indicator uses all four of the indicators in the table, if you decided to use all four then the universal indicator produced would change colour in the pH range of approximately pH 3–10. A universal indicator from a major school supplier contains phenolphthalein, methyl red and bromothymol blue, it is sold as pH 4–11 indicator.