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| Simple Chemical Reactions |
| CO2 and the acidity of soda water |

 **Introduction**

CfE Advanced Higher

 Inorganic & Physical Chemistry

In this experiment, soda water containing methyl red indicator is ‘de-gassed by reducing the pressure in a luer lock syringe or similar.

As the CO2 comes out of solution, there is less dissolved in the water and the solution becomes less acidic. This is shown by a change in the colour of the indicator.

**You will need**

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| One 50 cm3 plastic syringe. (A smaller one will work but is less easily visible.) | Syringe cap (optional). |
| One 5 cm nail. | One small beaker. |
| methyl red indicator | Soda water or carbonated mineral water. (A fresh, unopened bottle is best). |

**Preparation**

To prepare the syringe:

1. Pull out the plunger so that the volume of air in the syringe is 50 cm3
2. Hold the nail in a pair of tongs (or pliers and heat it in a Bunsen flame
3. When it is hot, push it through the stem of the plunger as shown in the diagram. The hot nail will melt through the plastic.
4. Wiggle it about a little to make sure the hole is large enough that the nail will fit in easily when it is cold.
5. Remove the nail and leave both it and the syringe to cool.
6. When the nail is in place, the plunger can be ‘locked’ at the 50 cm3 mark.

**To do**

1. Pour a few cm3 of soda water into the beaker and add a few drops of methyl red to give a red solution.
2. Draw about 5 cm3 of this solution into the syringe.
3. Place a syringe cap over the end of the syringe (or use a finger), pull the plunger out to the 50 cm3 mark and lock it with the nail.

*Bubbles of carbon dioxide will be seen out-gassing and the indicator will begin to turn orange.*

1. Shake the syringe to speed up the out-gassing.
2. Holding the syringe vertically with the nozzle pointing upwards, remove the syringe cap and then the nail
3. Push in the plunger to expel the gas but not the solution.
4. Stopper the syringe again and repeat the above cycle.

*More CO2 bubbles will be seen and the indicator will turn more towards a yellow colour.*

1. Several more cycles can be repeated until the indicator becomes yellow.

**What is happening?**

Soda water contains carbon dioxide that has been dissolved in it under pressure (Henry’s Law). The equilibria involved are:

CO2 (g) ⇋ CO2(aq) (1)

CO2 (aq) + H2O(I) ⇋ H2CO3(aq) (2)

carbonic acid

H2CO3(aq) ⇋ H+(aq) + HCO3- (aq) (3)

 hydrogencarbonate ions

HCO3- (aq) ⇋ H+(aq)) + CO3 2-(aq) (4)

 carbonate ions

Thus the solution is acidic.

Reducing the pressure allows CO2 to come out of solution, ie, drags equilibrium (1) to the left.

The result is that the other three equilibria also move to the left, removing H+ ions from the solution and making the solution less acidic.

**Comments**

This experiment will not work with lemonade or tonic water as they contain citric acid as well as CO2.

The bottle of soda water should be relatively freshly opened. On standing it loses CO2 and thus the pH changes.

It can be very difficult for one person to lock the syringe with the nail – it is best for pupils to work in pairs for this (if it is being done as an experiment rather than a demonstration),

Students may not be familiar with methyl red. If so, demonstrate its colours in acid and alkali beforehand. It is red below pH 4.2 and yellow above pH 6.3.

**Extensions**

Boil some soda water containing a little methyl red. This will expel the carbon dioxide, which is less soluble at high temperatures, and also show the colour change of the indicator from red to yellow.

Leave samples of soda water containing indicator in different places to compare the effect of environment on the degassing of CO2. Eg on the bench, in a fridge, on a radiator, in a cupboard etc.

**Safety**

There are no chemical issues of note for pupils but they should be careful pulling the syringe plunger under pressure.

**It is the responsibility of teachers doing this demonstration to carry out an appropriate risk assessment.**