MAGIC RAINBOW

How does adding sugar to the water affect its density?

Which layer is the densest?

Why do the layers sit in the order they do?

Equipment required:

Tablespoon
5 glasses
Sugar
Water
4 x food colourings (i.e. blue, green, red, yellow)

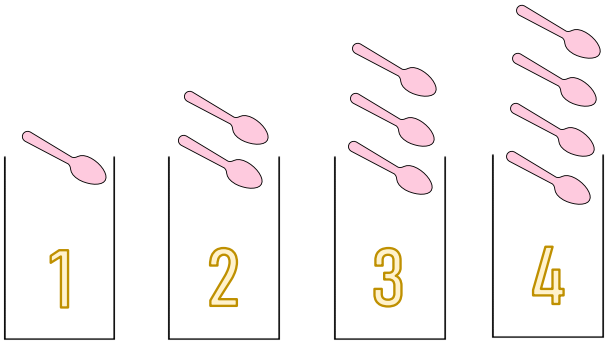
Can you explain the findings?

Magic Rainbow

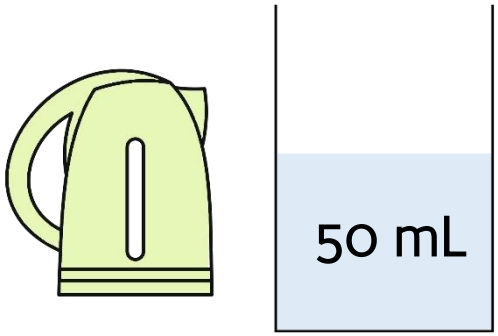
DEPARTMENT OF CHEMISTRY

UNIVERSITY OF OXFORD

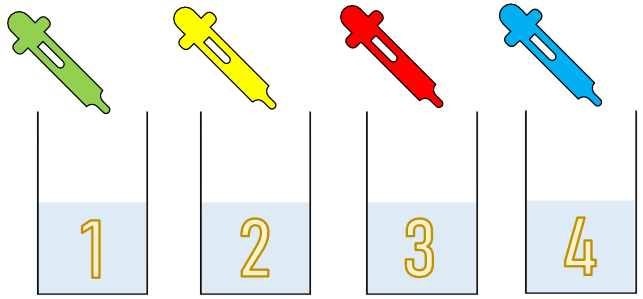
1 Add following amounts of sugar to separate glasses:
1 tbsp, 2 tbsp, 3 tbsp, 4 tbsp



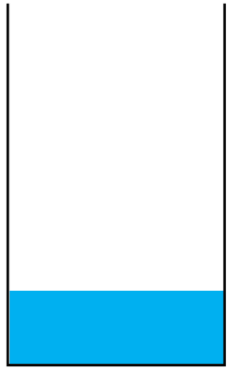
2 Add 50 mL warm water to each glass and stir to dissolve the sugar fully



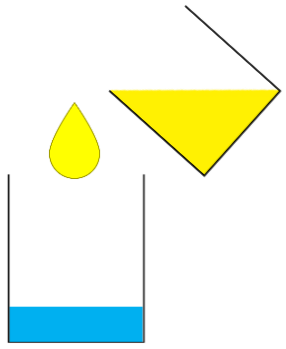
3 Add different coloured food colouring to each sugar solution as shown below:



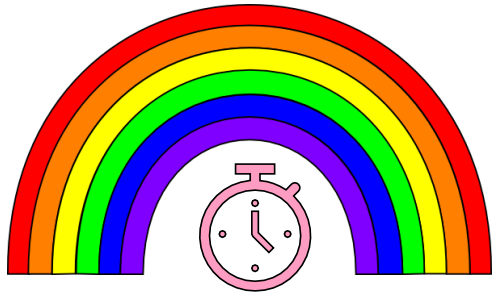
4 Carefully pour the blue solution into an empty glass to just under ¼ full



5 Carefully pour the same amount of the yellow solution on top. Repeat with red solution, then green.



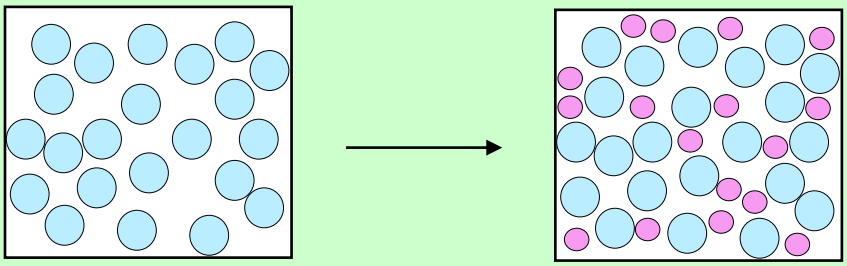
6 Allow the layers time to settle, then admire your rainbow!



The science behind the scenes...

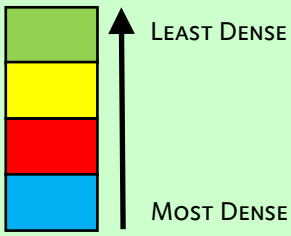
Density is a measure of a substance's mass per unit volume. Different substances have different densities, and these determine whether they **sink** or **float** in a specific medium. If a substance is less dense than the medium it is placed in, it will float, whereas it sinks if it is more dense than the medium it is placed in.

Water has a standard density of 1 g/mL, and can be made **denser** by dissolving solids in water. When the solid dissolves, the solid particles **fill the space** between the water molecules, increasing the mass per unit volume:



The **more solid** that is added to water, the **denser** the solution is that is made, as more of the space between the water molecules is being filled.

This experiment dissolves of sugar in water to change the density of the water solutions and ultimately create the rainbow layers. The densest sugar solution is the solution in which the most sugar was dissolved into (4 tbsp), and this is added first. The next solution added is the second densest solution. This is less dense than the first solution added, so will float on top of the first solution, forming two distinct layers. This is repeated with the third densest and then least dense solution. Each solution being added is less dense than the last which it is being poured over, and so we get the formation of the **layers** of solutions of different densities.



Practical investigation:

Equipment:

- ☐ Tablespoon
- ☐ 5 glasses
- ☐ Sugar
- ☐ Water
- ☐ Measuring jug
- ☐ 4 x food colourings (i.e. blue, green, red, yellow)

Method:

1. Source 4 empty glasses. Add the following amounts of sugar into separate glasses: 1 tbsp, 2 tbsp, 3 tbsp and 4 tbsp.
2. Ask an adult to help: to each glass, add 50 mL hot water (from boiled kettle) and stir to ensure all the sugar has dissolved in each.
3. Add 2-3 drops of green, yellow, red and blue food colouring to the 1, 2, 3 and 4 tbsp sugar solutions respectively
   (note: do not have to use these colours- these colours will be used to reference the solutions in this manual)
4. Carefully pour the blue 4 tbsp sugar solution into a 5th, empty glass to just under ¼ full.
5. Carefully pour the same amount of the yellow (2 tbsp sugar) solution on top. Repeat with red (3 tbsp) solution, then the green (4tbsp) sugar solution.
6. Allow the layers to settle, and admire your rainbow!

Questions:

(a) How does adding sugar to the water affect its density? [Sugar dissolves in water, filling the spaces between water molecules in the liquid, which therefore increases the density]

(b) Why do the layers form? [the different solutions have different densities, so when poured carefully (to avoid disturbing the layers) in order of most to least dense, layers form]

(c) Which layer is the densest? [The layer with the most sugar dissolved in, i.e. 4 tbsp sugar solution]

(d) Why do we use warm water? [Increasing the temperature of the water makes it easier for the sugar molecules to dissolve. A higher temperature gives the molecules more energy and makes it easier for the sugar molecules to fit in between water molecules, as the water molecules move around more]

(e) Has the sugar reacted with the water? [No: the sugar has only dissolved. A chemical reaction involved producing a new molecule using reactants, which has not happened]

Photo citations:
http://clipart-library.com/clipart/rcLxdxyGi.htm
https://www.vectorstock.com/royalty-free-vector/electric-kettle-icon-outline-style-vector-9886021