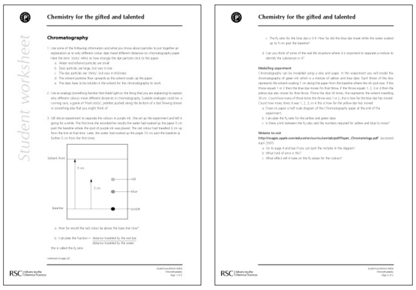
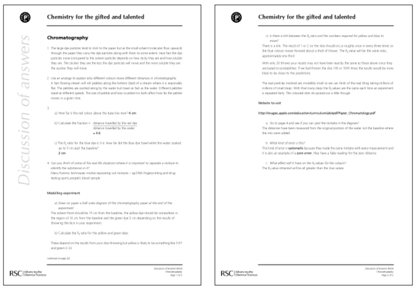
# Chromatography



*Student worksheet: CDROM index 04SW*



*Discussion of answers: CDROM index 04DA*

**Topics**

Chromatography, modelling and particles.

**Level**

Able students aged 11–13.

**Prior knowledge**

The students should have practical experience of paper chromatography and particle theory.

**Rationale**

This activity extends the students' understanding of chromatography. It links chromatography with particle theory and develops the tools of analogy and modelling.

**Use**

This activity could be used as extension work that the more able in a group can do individually or it could be done as a whole group. If a whole group of students is doing the activity they could develop their ideas about Question 1 into a concept cartoon[1]. Students could pool their results of the modelling experiment to get a greater number of steps.

[1] S. Naylor and B. Keogh, *Concept cartoons in science education*, Sandbach: Millgate House, 2000.

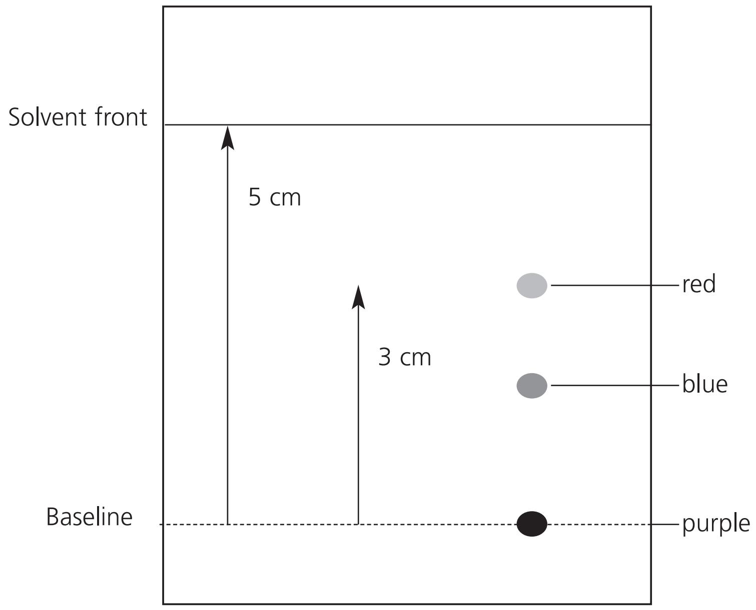
Student worksheet

## Chromatography

1. Use some of the following information and what you know about particles to put together an explanation as to why different colour dyes travel different distances on chromatography paper. Here the term 'sticky' refers to how strongly the dye particles stick to the paper.
   a. Water and ethanol particles are small
   b. Dyes particles are large, but vary in size
   c. The dye particles are 'sticky', but vary in stickiness
   d. The solvent particles flow upwards as the solvent soaks up the paper
   e. The dyes have to be soluble in the solvent for the chromatography to work.

2. Use an analogy (something familiar that sheds light on the thing that you are explaining) to explain why different colours move different distances in chromatography. Suitable analogies could be: a running race, a game of 'Pooh sticks', pebbles pushed along the bottom of a fast flowing stream or something else that you might think of.

3. Gill did an experiment to separate the colours in purple ink. She set up the experiment and left it going for a while. The first time she recorded her results the water had soaked up the paper 5 cm past the baseline where the spot of purple ink was placed. The red colour had travelled 3 cm up from the line at that time. Later, the water had soaked up the paper 10 cm past the baseline (a further 5 cm from the first time).




   a. How far would the red colour be above the base line now?

   b. Calculate the fraction = $\frac{\text{distance travelled by the red dye}}{\text{distance travelled by the water}}$

   this is called the $R_f$ ratio

*continued on page 2*

c. The $R_f$ ratio for the blue dye is 0.4. How far did the blue dye travel while the water soaked up to 5 cm past the baseline?

4. Can you think of some of the real life situations where it is important to separate a mixture to identify the substances in it?

### Modelling experiment

Chromatography can be modelled using a dice and paper. In this experiment you will model the chromatography of green ink which is a mixture of yellow and blue dyes. Each throw of the dice represents the solvent soaking 1 cm along the paper from the baseline where the ink spot was. If the throw equals 1 or 2 then the blue dye moves for that throw, if the throw equals 1, 2, 3 or 4 then the yellow dye also moves for that throw. Throw the dice 30 times, this represents the solvent travelling 30 cm. Count how many of those times the throw was 1 or 2, this is how far the blue dye has moved. Count how many times it was 1, 2, 3, or 4 this is how far the yellow dye has moved.

a. Draw on paper a half scale diagram of the Chromatography paper at the end of the experiment.
b. Calculate the $R_f$ ratio for the yellow and green dyes.
c. Is there a link between the $R_f$ ratio and the numbers required for yellow and blue to move?

### Website to visit

*http://images.apple.com/education/curriculumlabs/pdf/Paper_Chromatology.pdf* (accessed April 2007).

a. Go to page 4 and see if you can spot the mistake in the diagram!
b. What kind of error is this?
c. What effect will it have on the $R_f$ values for the colours?

Discussion of answers

## Chromatography

1. The large dye particles tend to stick to the paper but as the small solvent molecules flow upwards through the paper they carry the dye particles along with them to some extent. How fast the dye particles move (compared to the solvent particles depends on how sticky they are and how soluble they are. The stickier they are the less the dye particles will move and the more soluble they are the quicker they will move.

2. *Use an analogy to explain why different colours move different distances in chromatography.*
A fast flowing stream will roll pebbles along the bottom (bed) of a stream where it is reasonably flat. The pebbles are pushed along by the water but travel as fast as the water. Different pebbles travel at different speeds. The size of pebble and how rounded it is both affect how far the pebble moves in a given time.

3.
   a) How far is the red colour above the base line now? **6 cm**

   b) Calculate the fraction = $\frac{\text{distance travelled by the red dye}}{\text{distance travelled by the water}}$
   **= 0.6**

   c) The $R_f$ ratio for the blue dye is 0.4. How far did the blue dye travel while the water soaked up to 5 cm past the baseline?
   **2 cm**

4. *Can you think of some of the real life situations where it is important to separate a mixture to identify the substances in it?*
Many forensic techniques involve separating out mixtures – *eg* DNA fingerprinting and drug testing sports people's blood sample.

### Modelling experiment

a) *Draw on paper a half scale diagram of the chromatography paper at the end of the experiment.*

The solvent front should be 15 cm from the baseline, the yellow dye should be somewhere in the region of 10 cm from the baseline and the green dye 5 cm depending on the results of throwing the dice in your experiment.

b) Calculate the $R_f$ ratio for the yellow and green dyes.

These depend on the results from your dice throwing but yellow is likely to be something like 0.67 and green 0.33.

*continued on page 2*

c) *Is there a link between the $R_f$ ratio and the numbers required for yellow and blue to move?*

There is a link. The result of 1 or 2 on the dice should occur roughly once in every three times so the blue colours moves forward about a third of throws. The $R_f$ value will be the same ratio, approximately one third.

With only 30 throws your results may not have been exactly the same as those above since they are based on probabilities. If we had thrown the dice 100 or 1000 times the results would be more likely to be closer to the predictions.

The real particles involved are incredibly small so we can think of the real thing taking millions of millions of small steps. With that many steps the $R_f$ values are the same each time an experiment is repeated fairly. The coloured dots do spread out a little though.

Website to visit

*http://images.apple.com/education/curriculumlabs/pdf/Paper_Chromatology.pdf*

a. *Go to page 4 and see if you can spot the mistake in the diagram!*

The distances have been measured from the original position of the water not the baseline where the inks were added.

b. *What kind of error is this?*

This kind of error is **systematic** because they made the same mistake with every measurement and it is also an example of a **zero error**, they have a false reading for the zero distance.

c. *What effect will it have on the $R_f$ values for the colours?*

The $R_f$ value obtained will be all greater than the true values.