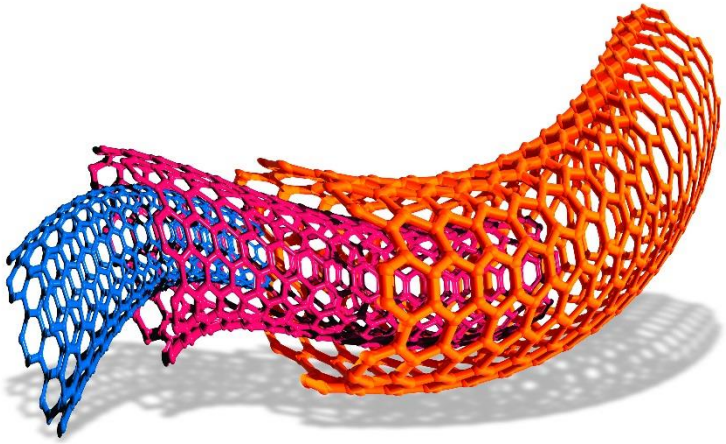
Cambridge Assessment International Education

Teaching Pack

Chromatography: pigments in leaves

Cambridge O Level

Chemistry 5070



Version 1.0

Cambridge Pathway

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Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note
Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

↓

Lab lesson (1 hour*)	
Option 1 – run the experiment	**Option 2 – virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practice the experiment skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practice the experiment skills introduced in the *Briefing lesson*.

↓

Debriefing lesson (1 hour*)
This lesson develops your learners' ability to evaluate and draw conclusions. It also provides opportunities to practise extended writing skills.

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this *Teaching Pack* you will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: Chromatography – pigments in leaves

This experiment pack focuses on the use of paper chromatography to separate pigments in different leaves.

Chromatography is a technique that can be used to find out the individual components in a mixture.

In this experiment learners will separate the different pigments present in a variety of leaves using chromatography.

The syllabus reference for this experiment is:

- 1.2 Methods of purification and analysis

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigation**:

- plan experiments and investigations, including equipment selection
- evaluate methods and suggest possible improvements.

Prior knowledge

Knowledge from the following syllabus topics is required for this experiment. It is useful to have covered them before carrying out this experiment. If these have not been covered yet, you will need to explain the concepts during the experiment or virtual experiment lesson.

- 1.2 Methods of purification and analysis

Going forward

The knowledge and skills gained from this experiment will be useful for when you teach learners about the use of chromatography to separate the products of protein and carbohydrate hydrolysis.

- 1.2 Methods of purification and analysis

Briefing lesson: Planning the experiment

Resources	• Worksheets A, B, C and D • Coloured counters
Learning objectives	By the end of the lesson: • ***all*** learners should have completed the planning sections of their experimental report • ***most*** learners should have detailed information in the planning sections of their experimental report • ***some*** learners will have compared their experimental set-up to the ideal and have made adjustments accordingly.

Timings	Activity
10 min	**Starter/introduction** Start with a formative assessment activity to assess the following prior learning points: • demonstrate knowledge and understanding of paper chromatography • interpret simple chromatograms. Give learners the chromatography paper template and table information on Worksheet A. Learners will need four different coloured counters for this activity. In pairs, get learners to look at the table of results for two chromatographic analysis experiments ('Analysis 1' and 'Analysis 2') and place the correct number of coloured spots on the template, at the correct positions.
20 min	**Main lesson** Group learners into pairs and give them the following information: *Plant leaves contain a mixture of pigments which give them colour. One pigment that you may have learned about is chlorophyll, which helps green plants make food by photosynthesis.* *You will have to think about the how you can release the pigments from the leaf and how you would separate them from each other.* Give learners Worksheet B and Worksheet C to help scaffold learning. Each group should discuss the variables involved in the experiment and fill in Worksheet C.
20 min	Then learners should have a group discussion regarding the equipment they would choose and how they would set it up. They should use Worksheet B to help with this. Remind them they will not need to use all the equipment, reagents and the tests that might be needed. They must remember to accurately draw their equipment set-up, on Worksheet D, which should be annotated so that their decisions are explained.
10 min	**Plenary** Show the learners the experimental set-up for the experiment (you can use the diagram shown in the ideal report). Ask learners to compare their illustrations with the ideal report and get them to identify any similarities and differences. Get the learners to adjust their experimental set-up in Worksheet D.

Lab lesson: Option 1 – run the experiment

Resources	• Teacher notes • *Teacher Walkthrough video* • Worksheets D, E and G • Equipment as outlined in the notes
Learning objectives	By the end of the lesson: • ***all*** learners should have carried out a chromatographic separation of plant pigments • ***most*** learners should be able to calculate R_f factors for any pigments • ***some*** learners will be able to start the interpretation and evaluation of their experimental data.

Timings	Activity
5 min	**Starter/introduction** Learners should be put into pairs. Hand out Worksheet E to each group (they should already have Worksheet C and Worksheet D from the briefing lesson). Inform the class of the approximate timings for each part of the experiment: (1) set-up (10 min), (2) chromatography (10 min), (3) drying chromatography paper and recording results (10 min) and (4) clean-up (10 min).
5 min	Brief learners on basic lab safety. Start by ensuring that all learners are wearing fastened lab coats and that they are wearing goggles throughout the experiment. Learners with long hair should tie it up safely. Remind learners about spillages and the safe movement around the lab. Take care with the propanone.
10 min	**Main lesson** **(1) Set-up** Learners should use Worksheet D and Worksheet E to allow them to collect the correct materials and equipment.
10 min	**(2) Chromatography run and method write-up** Learners should follow the appropriate method on Worksheet E. **Safety** Circulate the classroom at all times during the experiment and make sure that learners are safe and that the data they are collecting is accurate.
10 min	**(3) Drying chromatography paper and recording results** Learners need to make sure that the results are recorded in the appropriate section of Worksheet G.
10 min	**(4) Clean-up** Make sure that the learners tidy up after themselves and clean up any bench spills. Finally, they should wash their hands.
10 min	**Plenary** Learners complete the sections in Worksheet G covering the conclusion and evaluation. Ask learners to discuss and write down, in their reports, three ways how they could improve the chromatography experiment.

Teacher notes

Watch the *Teacher Walkthrough video* for the chromatographic separation of plant pigments and read these notes.

Each pair will require:

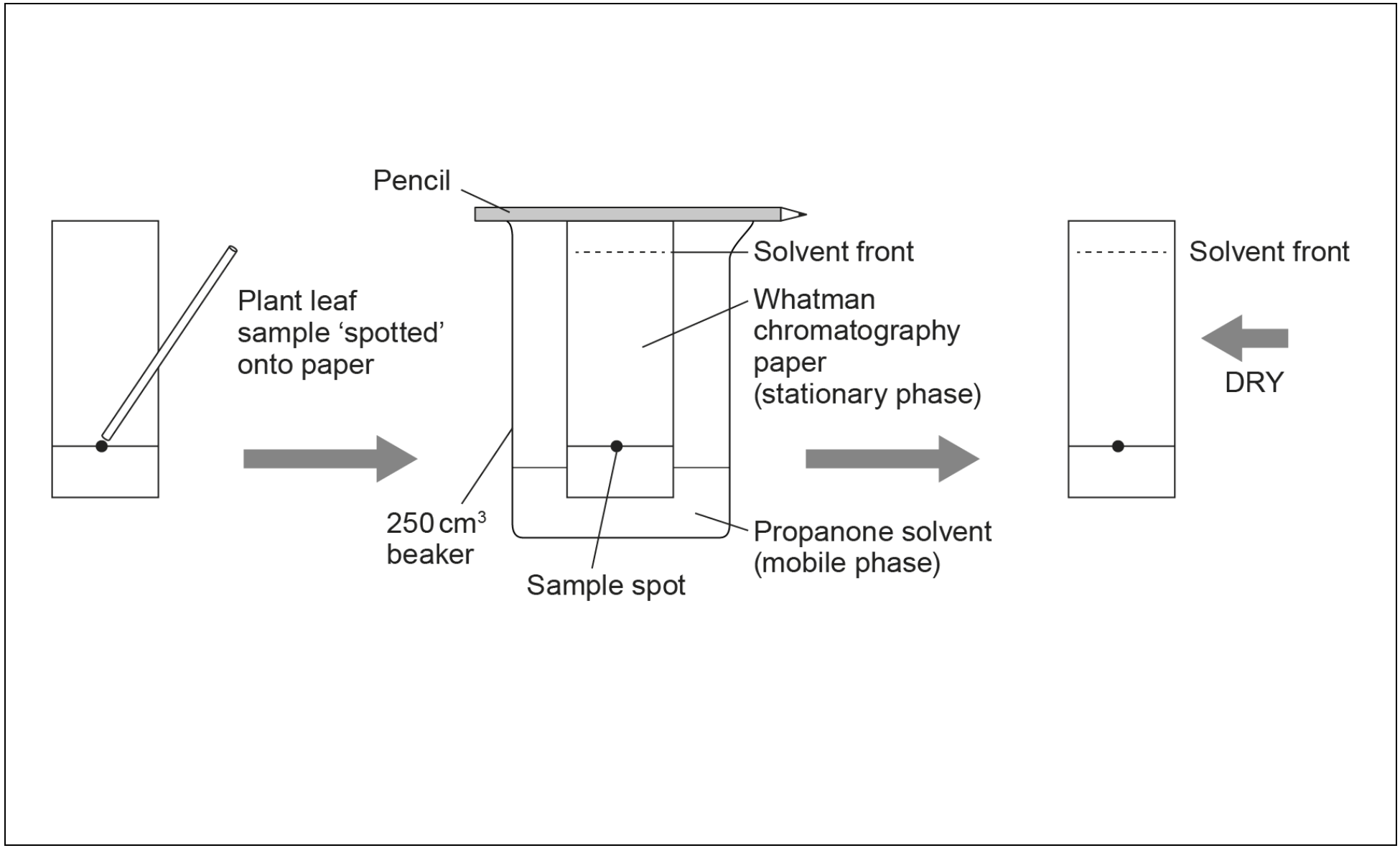
- 1 × 250 cm^3 beaker
- 1 × 10 cm^3 measuring cylinder
- 1 × very fine capillary tube
- sticky tape
- pestle and mortar
- pair of scissors
- propanone (supplied in a small bottle fitted with a pipette)
- pencil
- ruler
- spatula
- sand
- Whatman chromatography paper strip (each 10 cm in length and 2 cm wide)
- hairdryer
- 1 × green leaf (medium/large size).

Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.
It is your responsibility to carry out an appropriate risk assessment for this experiment.

Substance	Hazard	First aid
Propanone	 GHS02 (*flammable* **F**)  GHS07 (*moderate hazard* **MH**)	**In the eye:** flood the eye with gently running tap water for at least 10 minutes. See a doctor. **Swallowed:** do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Dust breathed in:** remove the casualty to fresh air. See a doctor if breathing is difficult. **Spilt on the skin or clothing:** remove contaminated clothing and rinse it. Wash off the skin with plenty of water. **Spilt on the floor, bench, etc.:** scoop up solid (take care not to raise dust). Wipe small solution spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).

Experiment set-up



Teacher method

This is your version of the method for this experiment that accompanies the teacher video.

Do not share this method with learners. Give them Worksheet E.

Before you begin

Plan how you will group your learners during the experiment.

Think about:

- the number of pairs you will need
- the amount of equipment/chemicals required.

Experiment

Circulate the classroom during the experiment in case learners encounter any difficulties.

Steps	Notes
1. Learners should collect all the equipment they need from the front of the class.	
2. Learners should place the strip of chromatography paper on a clean and dry flat surface.	
3. Learners should draw a horizontal line using a ruler and a pencil about 3 cm from the base of the paper strip.	*Remind learners they MUST use a pencil.*
4. Using a pencil, learners should add a single dot to the middle of the horizontal line.	
5. Learners should cut up a leaf into small pieces using scissors and add the leaf pieces to a mortar.	
6. Using a spatula, learners should add a small amount of sand to the mortar.	
7. Learners should measure out 10 cm^3 of propanone using a measuring cylinder and add to the mortar.	
8. Using a pestle, learners should grind the mixture in the mortar for at least two minutes.	*Remind learners to slowly grind the mixture.*
9. Learners should use a fine glass tube to transfer liquid from the mixture to the dot on the chromatography paper.	*Remind learners to keep the spot as small as possible as it will tend to spread out.*

10. Learners should use a hairdryer to dry the spot for about twenty seconds.

11. Learners should repeat the same procedure so that a total of six spots have been applied to the paper strip.

12. Learners should attach the paper to a pencil using sticky tape.

13. Using a measuring cylinder, learners should measure out 20 cm^3 of propanone and pour this into a beaker.

14. Learners should lower the paper strip into the beaker of propanone, making sure that the propanone is below the level of the horizontal line.

Remind learners that the propanone MUST be below the horizontal pencil line.

15. Learners should not move the paper or beaker once the paper is in place.

16. Learners should remove the paper when the propanone line approaches the top of the paper strip.

17. Learners should use a pencil to mark how far the propanone has moved up the paper.

Remind learners that this is the solvent front.

18. Learners should dry the paper strip with a hairdryer.

19. Learners should record the number and colour of any pigments present.

Learners should see a combination of orange, yellow or green pigments depending on the type of leaf used.

20. Using a ruler, learners should measure the distance travelled by the propanone and any pigments, from the horizontal pencil line.

21. Once finished, learners should complete their results table with results from the other members of the class and start to evaluate their findings.

Clean-up

After the experiment learners should:

- clean all glassware, tidy up their work space and ensure any spillages are mopped up
- empty their chemical waste into the main chemical waste bottle in a central location
- return all equipment and any unused chemicals to you
- wash their hands with soap and water.

Lab lesson: Option 2 – virtual experiment

Resources	• *Virtual Experiment video* for chromatography: pigments in leaves • Worksheets C, D, F, G, H and I
Learning objectives	By the end of the lesson: • ***all*** learners should know how to extract plant pigments and separate them using paper chromatography • ***most*** learners should be able to measure the R_f factors from the results of paper chromatography experiments • ***some*** learners will be able to start the interpretation and evaluation of their experimental data.

Timings	Activity
15 min	**Starter/introduction** Instruct learners that they need to look at Worksheet C and Worksheet D from the previous lesson to remind themselves of what they planned. Ask learners to review Worksheet D so they can look at the experimental set-up before the *Virtual Experiment video* is shown.
25 min 10 min	**Main lesson** Introduce the video by stating: 'Plant leaves contain a mixture of different pigments, some of which help with the process of photosynthesis. Today you will try to separate the individual pigments found in a variety of different plant leaves, using paper chromatography.' Give learners Worksheet F and Worksheet G. Inform learners that they should complete the method in Worksheet F as they watch the video. Also inform learners that they should fill in results and conclusions in Worksheet G as they watch the video. After the video has finished ask learners to discuss and write down, in their report sheets, three ways they could improve the chromatography experiment. Tell them they need to think about: • the effectiveness of the method • the limitations of equipment • the possible sources of errors/uncertainties.
10 min	**Plenary** Get the learners to answer questions on the theory and practice behind the experiment. Give learners Worksheet H and Worksheet I. Ask them to answer the questions using the information in their report and encourage them to use a glossary from a textbook.

Debrief lesson: Reviewing and evaluating a report

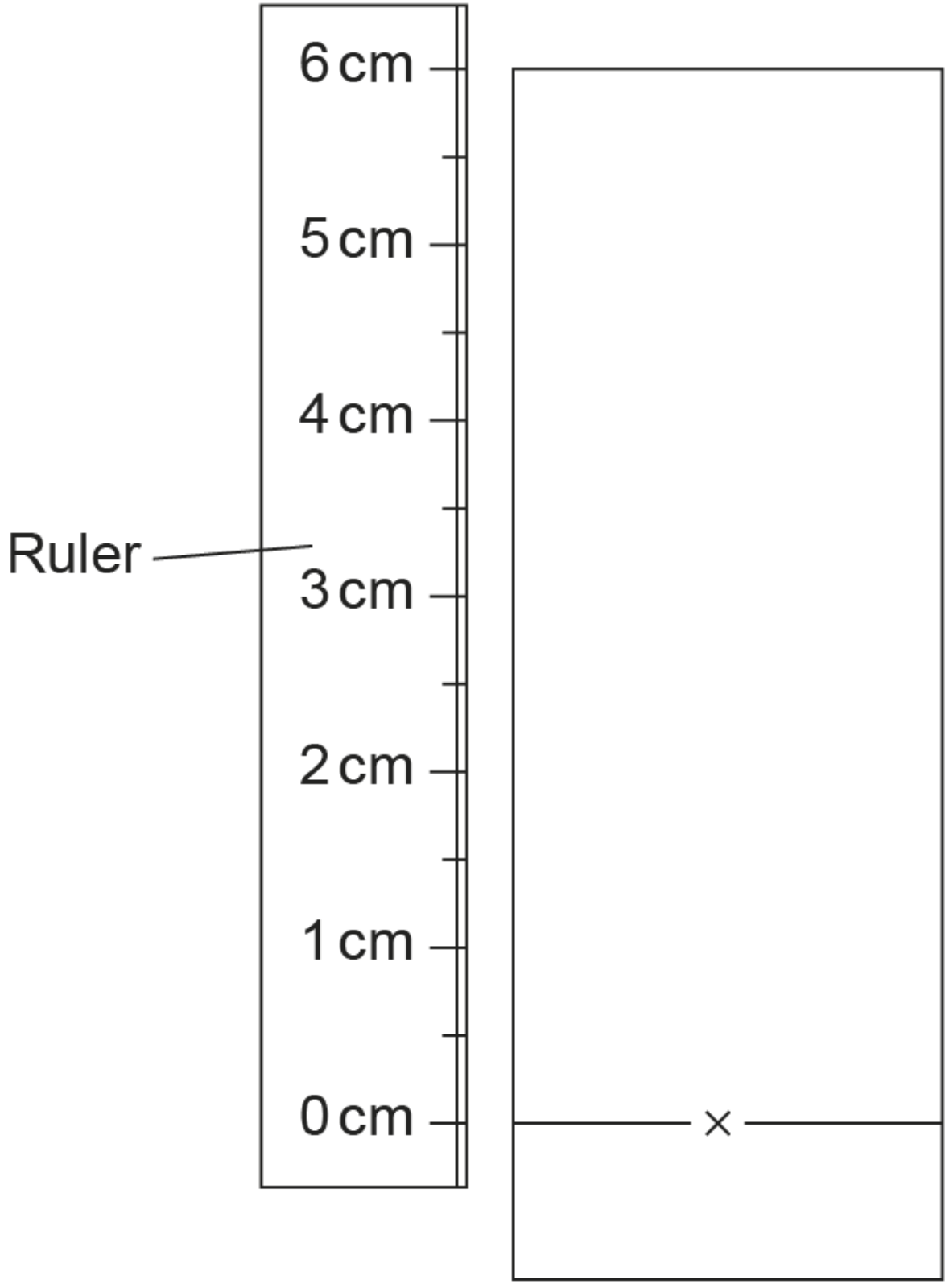
Resources	• Worksheets J
Learning objectives	By the end of the lesson: • ***all*** learners should be able to write a conclusion based on their findings • ***most*** learners should be able to evaluate the experiment • ***some*** learners will be able to review their finished report in line with success criteria and offer improvements.

Timings	Activity
10 min	**Starter/introduction** Ask learners to complete and review their findings from the experiment. Encourage them to share their findings with other learners.
15 min 20 min	**Main lesson** Ask learners to discuss the characteristics of a good scientific report. They should write out the suggestions and stick these on the board. Use this as the focal point of a classroom discussion. They are likely to suggest things like: explains processes, uses clear language, writing is concise, uses technical language or presents data clearly. Show them the suggested answers to worksheets C, D and G, which provide an exemplar scientific report. **Note:** Worksheet F should also be shown to learners who have completed the virtual practical. Leaners should then swap their report with another member of the class. Using the success criteria in Worksheet J, they should assess the report they have been given. You can guide their progress using the ideal report.
10 min	**Plenary** Learners should return the work they have assessed. Each learner should read the feedback given by their partners and act on the feedback by rewriting a section of their work, incorporating the improvements that has been suggested.

Worksheets and answers

	Worksheets	Answers
For use in the *Briefing lesson*:		
A: Prior learning activity	**16**	**—**
B: Choosing the correct equipment	**18**	**—**
C: Experiment report – introduction	**19**	**33**
D: Your experiment set-up and materials	**21**	**34**
For use in *Lab lesson: Option 1*:		
D: Your experiment set-up and materials	**21**	**34**
E: Method	**22**	**—**
G: Experiment report – results and analysis	**24**	**37**
For use in *Lab lesson: Option 2*:		
C: Experiment report – introduction	**19**	**33**
F: Your method	**23**	**35**
G: Experiment report – results and analysis	**24**	**36**
H: Virtual experiment questions	**26**	**38**
I: Applying your knowledge	**28**	**39**
For use in the *Debrief lesson*:		
J: Assessing a scientific report	**30**	**—**

Worksheet A: Prior learning activity



Worksheet A: Prior learning activity, continued

Analysis 1

Component	Order of affinity for stationary phase
A	3
B	2
C	1

Order of affinity: High (1) to Low (4)
Three spots were present on the chromatogram at: 3.5 cm, 2.5 cm and 0.5 cm from the origin.

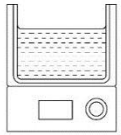
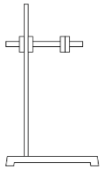
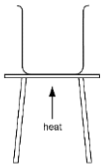
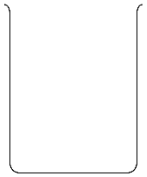
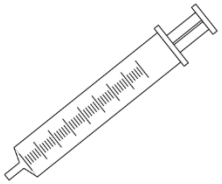
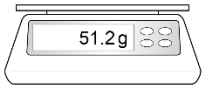
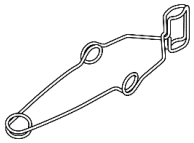
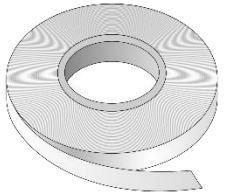
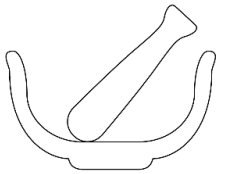
Analysis 2

Component	Order of affinity for mobile phase
W	1
X	2
Y	3
Z	4

Order of affinity: High (4) to Low (1)
Four spots were present on the chromatogram at: 5.5 cm, 4.0 cm, 2.5 cm and 1.0 cm from the origin.

Worksheet B: Choosing the correct equipment

Here is a range of some common lab equipment.

			
water bath	**measuring cylinder**	**boss, clamp and stand**	**timer**
			
Bunsen burner	**beaker**	**syringe**	**balance**
			
pipette	**test-tube holder**	**thermometer**	**chromatography paper**
			
capillary tube	**conical flask**	**distilled water**	**pestle and mortar**

Worksheet C: Experiment report – introduction

Title	…….
Background information	…… …… ……
Aim	…… …… …… ……

Worksheet C: Experiment report – introduction

Experimental variables	**Changed (independent) variables** …….. …….. **Measured (dependent) variables** …….. …….. **Fixed variables** …….. …….. ……..
What will happen? (hypothesis)	…….. ……..

Worksheet D: Your experiment set-up and materials

Materials and method: In the space provided, draw your experiment set-up. Make sure you annotate your diagram showing the decisions you have made.

Experiment set-up: preparation of plant leaf sample

Experiment set-up: chromatography of plant leaf sample

Worksheet E: Method

1. Place a strip of chromatography paper on a clean and dry flat surface.
2. Draw a horizontal line using a ruler and a pencil about 3 cm from the base of the paper strip.
3. Using a pencil, learners add a single dot to the middle of the horizontal line.
4. Cut up a leaf into small pieces using scissors and add the leaf pieces to a mortar.
5. Use a spatula to add a small amount of sand to the mortar.
6. Measure out 5 cm^3 of propanone using a measuring cylinder and add to the mortar.
7. Use a pestle to grind the mixture in the mortar for at least two minutes.
8. Use a fine glass tube to transfer liquid from the mixture to the dot on the chromatography paper.
9. Use a hairdryer to dry the spot for about 20 seconds.
10. Repeat the same procedure so that a total of six spots have been applied to the paper strip.
11. Attach the paper to a pencil using sticky tape.
12. Use a measuring cylinder, learners to measure out 20 cm^3 of propanone and pour this into a beaker.
13. Lower the paper strip into the beaker of propanone, making sure that the propanone is below the level of the horizontal line.

Do not move the paper or beaker once the paper is in place.

14. Remove the strip when the propanone line approaches the top of the paper.
15. Use a pencil to mark how far the propanone has moved up the paper.
16. Dry the paper strip with a hairdryer.
17. Record the number and colour of any pigments present.
18. Use a ruler to measure the distance travelled by the propanone and any pigments, from the horizontal pencil line.

Worksheet F: Your method

Method: Watch the virtual experiment video and fill in the gaps of the method.

1. Place a strip of chromatography paper on a clean and dry flat surface.
2. Draw a horizontal line using a ruler and a pencil about 3 cm from the base of the paper strip.
3. ……

   ……
4. Cut up a leaf into small pieces using scissors and add the leaf pieces to a mortar.
5. Use a spatula to add a small amount of sand to the mortar.
6. ……

   ……
7. Use a pestle to grind the mixture in the mortar for at least two minutes.
8. Use a fine glass tube to transfer liquid from the mixture to the dot on the chromatography paper.
9. Use a hairdryer to dry the spot for about 20 seconds.
10. ……

    ……
11. Attach the paper to a pencil using sticky tape.
12. Use a measuring cylinder, learners to measure out 20 cm^3 of propanone and pour this into a beaker.
13. ……

    ……

Do not move the paper or beaker once the paper is in place.

14. Remove the strip when the propanone line approaches the top of the paper.
15. Use a pencil to mark how far the propanone has moved up the paper.
16. Dry the paper strip with a hairdryer.
17. ……

    ……
18. Use a ruler to measure the distance travelled by the propanone and any pigments, from the horizontal pencil line.

Worksheet G: Experimental report – results and analysis

Results:

Type of plant leaf	Number of pigments identified	Colour of identified pigments	Distance travelled by the solvent front (cm)	Distance travelled from the pencil line by each pigment (cm)	Retention factor (if applicable)

Conclusion(s): What were the results of your experiment? Mention the aim of the experiment in your answer.

……

……

……

……

……

Worksheet G: Experimental report – results and analysis

Evaluation: Assess whether the experiment you carried out was fair and whether you can make a reliable conclusion based on the data collected.

Overall fairness of experiment	…… ……
Accuracy and reliability of results	…… ……
Sources of error/uncertainties	…… ……
Improvements	…… ……

Worksheet H: Virtual experiment questions

Use your notes to answer the questions below. Use full sentences.

1. What is the name given to the variable that is measured in an experiment?

……..

2. Why was the plant leaf cut up and sand added?

……..

……..

……..

3. Why was propanone used in the experiment?

……..

……..

4. Why was a pencil used to draw the line on the chromatography paper and not a pen?

……..

……..

5. The propanone level in the beaker must be lower than the spot on the chromatography paper. Explain why this is the case.

……..

……..

……..

Worksheet H: Virtual experiment questions

6. What are the two phases present in any chromatography experiment?

……..

……..

7. What are the two phases in this particular chromatography experiment?

……..

……..

8. Why do you think some pigments move further up the paper than others?

……..

……..

……..

……..

9. Can you think of any way of improving the separation between the different plant pigments?

……..

……..

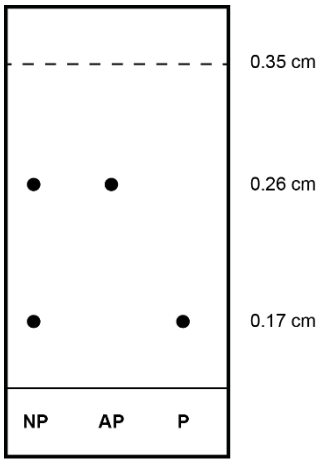
……..

……..

Worksheet I: Applying your knowledge

Answer the following questions by applying the knowledge you have learned from this experiment.

1. The pain-killer paracetamol can be synthesised from 4-aminophenol (AP). To assess the purity of a batch of paracetamol (new paracetamol), chromatography was carried out. The results can be seen below.

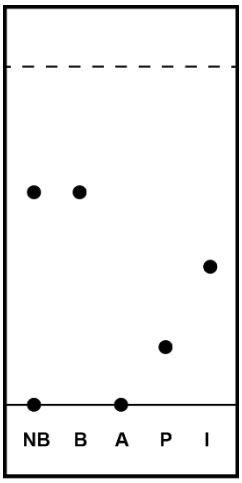


Key
NP = new paracetamol
AP = 4-aminophenol
P = paracetamol

Which one of the following is the R_f value for the 4-aminophenol (AP) contaminant in the new paracetamol?

A. 0.74
B. 0.49
C. 0.10
D. 0.35

2. A batch of the local anaesthetic, benzocaine (new benzocaine), was manufactured by a pharmaceutical company and its purity tested using chromatography. The results of this purity test can be seen below.



Key
NB = new benzocaine
B = benzocaine
A = aspirin
P = paracetamol
I = ibuprofen

From the chromatogram it can be stated that:

A. New benzocaine is pure
B. New benzocaine is contaminated with aspirin
C. New benzocaine is contaminated with paracetamol
D. New benzocaine is contaminated with ibuprofen

Worksheet I: Applying your knowledge

3. You have been given a water-soluble black marker pen that is actually made up of a mixture of dyes.

a. Describe how you would separate and identify each dye using paper chromatography.

……..

……..

……..

……..

b. What is the stationary phase in this experiment?

……..

c. What is the mobile phase in this experiment?

……..

d. Explain why the ink from a permanent marker pen could not be analysed using this same experiment. How could you get it to separate?

……..

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4. Chromatography can be used in forensic science to determine if money has been forged. An investigator can carry out an analysis on the inks used to print money. If you were an expert witness in a jury trial, how would you explain your ink analysis evidence to a jury?

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……..

Worksheet J: Assessing a scientific report

Report section	Success criteria	✓ or ×	Comments
Title	Does the report contain a simple and informative title?		
Background	Is there a brief explanation of a theory or concept linked to the experiment?		
Aim(s)	Does this section say what will be investigated?		
Variables	Does the report state what variables were changed, what variables were measured and what were fixed?		
Hypothesis	Does the report contain a clear hypothesis? For example, “vitamin C in orange juice oxidises over time when exposed to the air".		

Worksheet J: Assessing a scientific report

Report section	Success criteria	✓ or ✗	Comments
Materials and method(s)	• Is there a list of equipment and chemicals used? • Does this section have a sequence of steps or commands that show how a task should be carried out? • Is it written using impersonal language? • Is there a clear labelled diagram of the experiment? • Is the language clear so that someone could repeat the experiment without mistakes?		
Results	This section should be made up of what can be measured or observed, not guessed. For example, if bubbles were observed, then this is all that can be stated in this section (unless gas produced was tested). • Is this section well-presented and clear? • Have observations been made as accurately as possible? • Is the data in the form of a table and/or graph? • Have correct headings and units been used? • Has an average mean been worked out from repeat readings?		
Conclusion(s)	• Have the results been described? • Are any conclusions related to the aims? • Are there any comments on whether the results agree with the hypothesis?		

Worksheet J: Assessing a scientific report

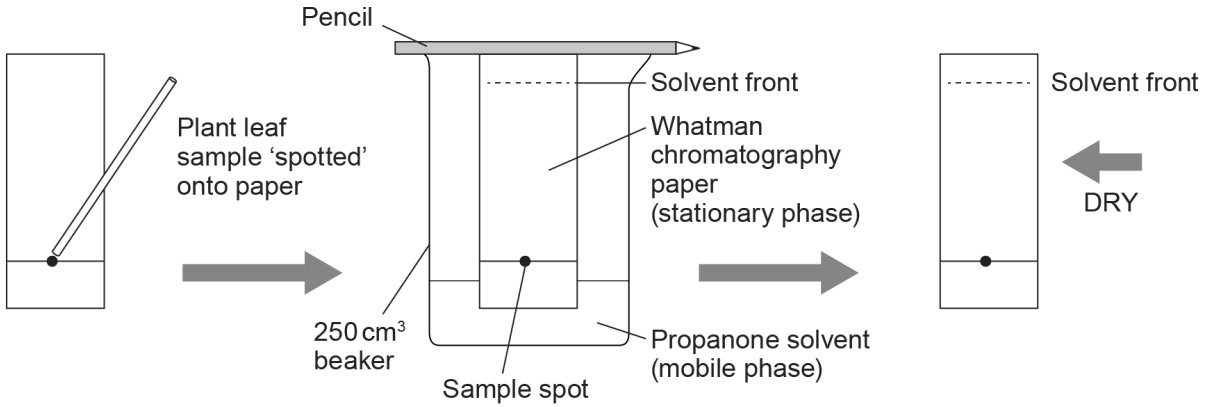
Report section	Success criteria	✓ or ✗	Comments
Evaluation	The evaluation is an opportunity to discuss both the strengths and weaknesses of an experiment. It should be specific and explain why the experiment did or did not work well and how it could be improved. • Has the fairness of the experimental design been evaluated? • Is there any mention about the accuracy and reliability of the results? • Does the report mention possible sources of error/uncertainty? • Does the report contain **three** improvements?		
Overall quality of the report	Look at the whole of the report and decide on its quality. • Does the report follow clearly from start to finish? • Is the vocabulary used in the report precise? • Has technical language been used throughout? • Has impersonal language (no 'I' or 'we') been used?		

Worksheet C: Answers (ideal report – introduction)

Title	*Chromatography: pigments in leaves*
Background information	*Chromatography is a technique that can be used to separate and identify components in a mixture. The individual components are separated based on their affinity for either a stationary phase (paper) or a mobile phase (solvent the mixture was dissolved in).*
Aims	*To demonstrate that paper chromatography can be used to separate the pigments in a variety of plant leaves.*
Experimental variables	**Changed (independent) variables** — *Different types of leaves* **Measured(dependent) variables** — *Number of plant pigments on each chromatogram* *Colour of plant pigments on each chromatogram* **Fixed variables** — *Final volume of solvent (propanone) used* *Length and thickness of chromatography paper*
What will happen? (hypothesis)	*Different leaves will contain different numbers of plant pigments.*

Worksheet D: Answers (ideal report – experiment set-up)

Materials and experiment set-up:



Materials (list of chemical and equipment)

- 1 × 250 cm^3 beaker
- 1 × 10 cm^3 measuring cylinder
- 1 × very fine capillary tube
- sticky tape
- pestle and mortar
- pair of scissors
- propanone (supplied in a small bottle fitted with a teat pipette)
- pencil
- ruler
- spatula
- sand
- Whatman chromatography paper strip (each 10 cm in length and 2 cm wide)
- hairdryer
- 1 × green leaf (medium/large size)

Worksheet F: Answers

Method(s)

1. Place a strip of chromatography paper on a clean and dry flat surface.
2. Draw a horizontal line using a ruler and a pencil about 3 cm from the base of the paper strip.
3. *Using a pencil, learners add a single dot to the middle of the horizontal line.*
4. Cut up a leaf into small pieces using scissors and add the leaf pieces to a mortar.
5. Use a spatula to add a small amount of sand to the mortar.
6. *Measure out 5 cm^3 of propanone using a measuring cylinder and add to the mortar.*
7. Use a pestle to grind the mixture in the mortar for at least two minutes.
8. Use a fine glass tube to transfer liquid from the mixture to the dot on the chromatography paper.
9. Use a hairdryer to dry the spot for about 20 seconds.
10. *Repeat the same procedure so that a total of six spots have been applied to the paper strip.*
11. Attach the paper to a pencil using sticky tape.
12. Use a measuring cylinder, learners to measure out 20 cm^3 of propanone and pour this into a beaker.
13. *Lower the paper strip into the beaker of propanone, making sure that the propanone is below the level of the horizontal line.*

Do not move the paper or beaker once the paper is in place.

14. Remove the strip when the propanone line approaches the top of the paper.
15. Use a pencil to mark how far the propanone has moved up the paper.
16. Dry the paper strip with a hairdryer.
17. *Record the number and colour of any pigments present.*
18. Use a ruler to measure the distance travelled by the propanone and any pigments, from the horizontal pencil line.

Worksheet G: Answers (ideal report – results and analysis)

Results:

Plant leaf	Number of pigments identified	Colour of identified pigments	Distance travelled by the solvent front (cm)	Distance travelled from the pencil line by each pigment (cm)	Retention factor (if applicable)
Maple	2	green / yellow	3.7	Green: 3.0 Yellow: 3.1	Green: 0.81 Yellow: 0.83
Laurel	2	green / yellow	3.2	Green: 2.5 Yellow: 2.5	Green: 0.78 Yellow: 0.78
Rose	2	green / yellow	3.5	Green: 2.7 Yellow: 2.7	Green: 0.77 Yellow: 0.77
Lime	3	green / yellow	3.5	Green: 2.9 Yellow: 3.0	Green: 0.83 Yellow: 0.86
Ash	3	green / yellow	3.5	Green: 2.8 Yellow: 3.0	Green: 0.80 Yellow: 0.86

Worksheet G: Answers (ideal report – results and analysis)

Conclusion(s):

Different types of leaf contain differing numbers of pigments. Some of these pigments can be separated using paper chromatography and individual retention factors calculated for them.

Evaluation:

Overall fairness of experiment	• *Only one variable changed, so experimental results are valid.*
Accuracy and reliability of results	• *Accuracy – Results were obtained through correct and careful measurement of volumes and identification of colours.* • *Reliable – Results were reliable as several over groups in the class got the same type of results.*
Sources of error/uncertainties	• *Plant leaf sample spot not fully dried before applications applied.*
Improvements	• *Each individual experiment should be carried out a minimum of three times and an average taken.*

Worksheet H: Answers

1 Chlorophyll.

2 To allow the release of plant pigments from inside plant cells (the sand is an abrasive and helps smash open the cells).

3 Plant pigments are soluble in propanone.

4 Dyes in the pen would dissolve in the solvent and travel up the paper.

5 The propanone has to travel up the paper and dissolve the substances in the plant extract before they travel up the paper.

6 Mixtures.

7 Mobile phase = propanone Stationary phase = chromatography paper

8 The extent to which any particular component moves up the paper is dependent not only on its solubility in propanone, but also on its attraction for the cellulose in the chromatography paper.

9 Use a different solvent or mixture of solvents.

Worksheet I: Answers

Answer the following questions by applying the knowledge you have learned from this experiment.

1. **A** *0.26 cm / 0.35 cm = 0.74*

2. **B** *Sample has two spots, one of which is similar to the 'Aspirin' sample that has one spot at the origin.*

3. a. *Cut a thin strip of paper and using a pencil draw a line across the paper, about 1cm up from the bottom. Use the pencil to place a dot or cross in the middle of the line. Apply the mixture of dyes to the spot and dry (air or hairdryer). Then place the paper in a beaker and add water to a level just below the pencil line. Leave the paper until the solvent line has travelled about ¾ of the way up the paper. Take out of the beaker and mark the solvent line using a pencil. Leave to dry, then measure the distances travelled by the individual spots/lines. Work out individual retention factors for each.*

b. *Paper.*

c. *Water.*

d. *Dyes in the permanent marker are not soluble in water. Use an organic solvent.*

4. *A specific mixture of inks is used to print money. Paper chromatography can be used to separate and identify individual inks in a mixture giving it a unique 'fingerprint'.*

A sample of paper containing ink from the forged money was placed in a solvent to dissolve the inks. The same procedure was carried out for a sample from some legitimate money. Samples from both types of money were analysed using paper chromatography and a chromatogram produced. The unique 'fingerprint' produced by each ink mixture can be compared.

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