

Teaching Pack

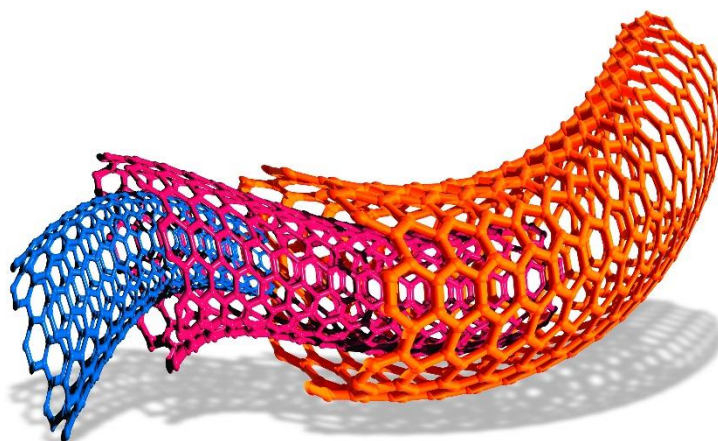
Making esters

Cambridge IGCSE™

Chemistry 0620

This *Teaching Pack* can also be used with the following syllabuses:

- Cambridge IGCSE™ (9–1) Chemistry **0971**
- Cambridge O Level Chemistry **5070**



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Icons used in this pack:



Briefing lesson



Lab lesson option 1



Lab lesson option 2



Debriefing lesson

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

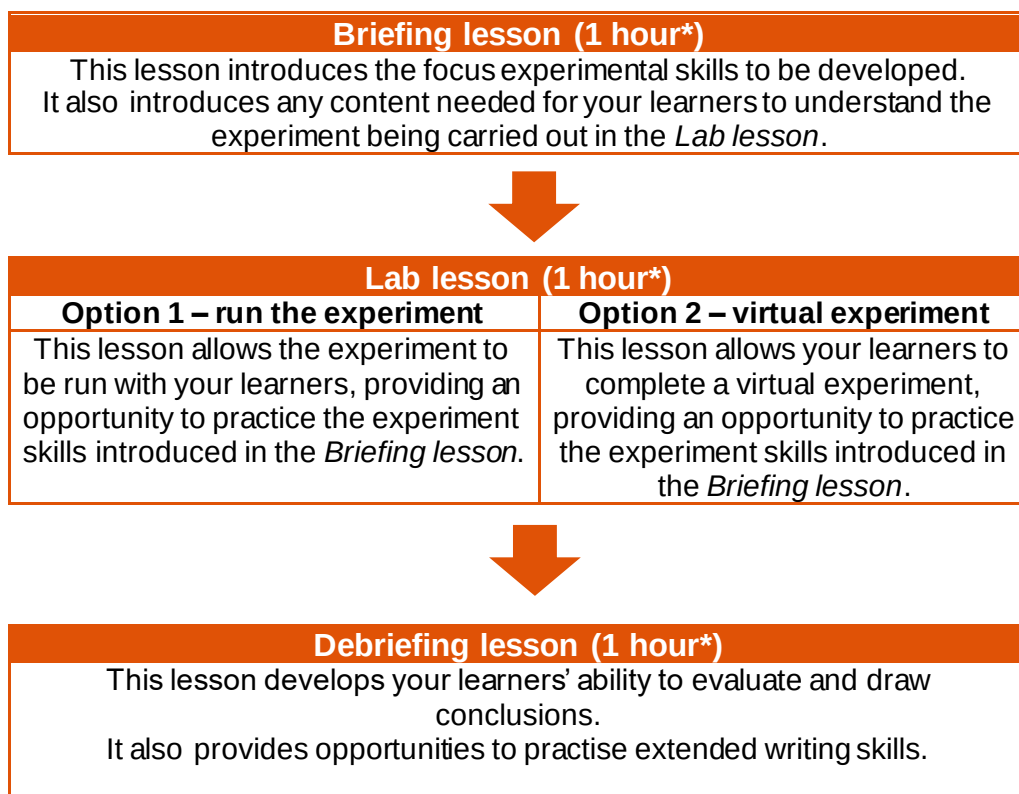
Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

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:



** 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: Making esters

This experiment pack focuses on how to make esters.

Esters are natural and synthetic carbon compounds that can be found in a range of consumer products such as foods and perfumes. They are made from a condensation reaction between an alcohol and a carboxylic acid.

In this experiment, learners will prepare an ester from a chosen alcohol and carboxylic acid.

The syllabus reference for this experiment is:

- 11.7 Carboxylic acids

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.

- 11.2 Naming organic compounds

Going forward

The knowledge and skills gained from this experiment will be useful for when you teach learners about the difference between condensation and addition polymerisation.

- 11.8 Polymers

Briefing lesson: Planning the experiment



Resources

- Worksheets A, B, C and D

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.

Timings Activity

	Starter/introduction Start with a formative assessment activity to assess the following prior learning points: • naming esters • drawing esters. Cut out the rectangles on Worksheet A and, if possible, laminate them. Give these cards to each pair of learners. Note: print out both sides of Worksheet A on separate pieces of paper. In pairs, get learners to match the names and structures of the esters (this could be turned into a game of bingo).
	Main lesson Group learners into pairs and give them the following information: <i>To make an ester you will be required to combine an alcohol with a carboxylic acid in a condensation reaction.</i> 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. Then learners should have a 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 of 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.
	Plenary Show the learners the experimental set-up for the experiment (use the suggested answer provided). Ask learners to compare their illustrations with the suggested answer 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 C, 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 condensation reaction to produce an ester
- **most** learners should be able to test for the production of an ester
- **some** learners will be able to start the interpretation and evaluation of their experimental data.

Timings	Activity
	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 minutes), (2) condensation reactions (10 minutes), (3) testing and recording results (10 minutes) and (4) clean-up (10 minutes).
	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 water that has just been boiled.
	Main lesson (1) Set-up Learners should use Worksheet C and Worksheet D to allow them to collect the correct materials and equipment.
	(2) Condensation reactions and method write-up Learners should follow the appropriate method on Worksheet E .
	Safety Circulate the classroom at all times during the experiment to make sure that learners are safe and that the data they are collecting is accurate.
	(3) Testing and recording results Learners need to make sure that the observations are recorded in the appropriate section of Worksheet G .
	(4) Clean-up Make sure that the learners tidy up after themselves and clean up any bench spills. Finally, they should wash their hands.
	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 they could improve the condensation experiment.

Teacher notes



Watch the *Teacher Walkthrough video* for the making of an ester and read these notes.

Each group will require:

- 1 × 250 cm³ beaker
- 1 × 50 cm³ beaker
- 1 × 50 cm³ measuring cylinder
- kettle
- 1 × test-tube rack
- 4 × small test-tubes and test-tube forceps
- sticky labels
- sodium carbonate solution (1 mol dm⁻³)
- concentrated sulfuric acid
- timer
- 4 × rubber bands and paper towels
- cotton wool
- samples of colour-coded alcohols: methanol, ethanol, propan-1-ol and butan-1-ol in bottles identified by different coloured tape or sticker; each containing a 1 cm³ pipette attached using an elastic band.
- samples of colour-coded carboxylic acids: methanoic acid, ethanoic acid, propanoic acid and butanoic acid in bottles identified by different coloured tape or stickers; each containing a 1 cm³ plastic pipette attached using an elastic band.

Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

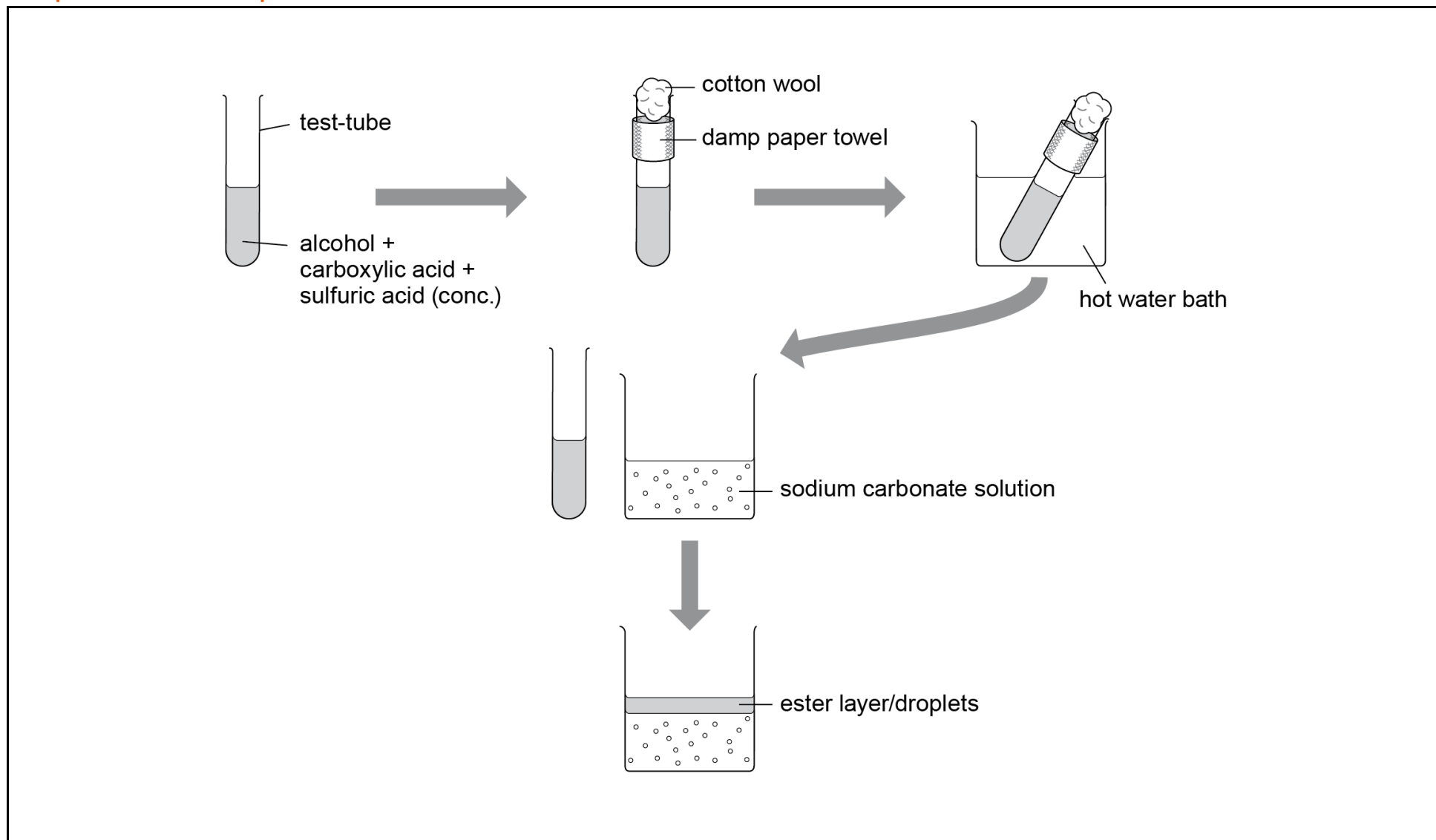
It is your responsibility to carry out an appropriate risk assessment for this experiment.

Substance	Hazard	First aid
Sodium carbonate solution	 GHS07 (<i>moderate hazard MH</i>)	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. Spilt on the skin or clothing: remove contaminated clothing and rinse it. Wash off the skin with water. Spilt on the floor, bench, etc.: scoop up solid (take care not to raise dust). Wipe small spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).
Concentrated sulfuric acid	 GHS05 (<i>corrosive C</i>)	In the eye: flood the eye with gently-running tap water for 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. Spilt on the skin or clothing: remove contaminated clothing and quickly wipe as much liquid as possible off the skin with a dry cloth before drenching the area with a large excess of water. If a large area is affected or blistering occurs, seek medical attention. Spilt on the floor, bench, etc.: for large spills, and especially for (moderately) concentrated acid, cover with mineral absorbent (e.g. cat litter) and scoop into a bucket. Neutralise with sodium carbonate. Rinse with plenty of water. Wipe small spills with a damp cloth and rinse it well.
Methanol	 GHS02 (<i>flammable F</i>)  GHS07 (<i>moderate hazard MH</i>)  GHS08 (<i>health hazard HH</i>)	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. 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 spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).

Substance	Hazard	First aid
Ethanol	 GHS02 (<i>flammable F</i>)  GHS07 (<i>moderate hazard MH</i>)  GHS08 (<i>health hazard HH</i>)	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. 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 up small spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).
Propan-1-ol	 GHS02 (<i>flammable F</i>)  GHS07 (<i>moderate hazard MH</i>)	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. 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 spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).
Butan-1-ol	 GHS02 (<i>flammable F</i>)  GHS07 (<i>moderate hazard MH</i>)	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. 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 spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).
Methanoic acid	 GHS05 (<i>corrosive C</i>)	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. 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 spills or

Substance	Hazard	First aid
Ethanoic acid	 GHS02 (<i>flammable F</i>)  GHS05 (<i>corrosive C</i>)	any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter). 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. 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 spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).
Propanoic acid	 GHS05 (<i>corrosive C</i>)	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. 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 spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).
Butanoic acid	 GHS05 (<i>corrosive C</i>)	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. 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 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 and whether you or the learners should add the concentrated sulfuric acid
- 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. | ----- | Remind learners they need to wear gloves throughout this experiment. |
| 2. Learners should label, near the neck, four test-tubes 1–4, then place these into a test-tube rack. | ----- | Remind learners that the labels must be near the neck of the test-tube otherwise they will fall off during boiling. |
| 3. Learners should add 1 cm ³ of methanol to test-tube 1 using the pipette attached to the methanol bottle. | | |
| 4. Learners should then add 1 cm ³ of ethanoic acid to test-tube 1 using the pipettes attached to the bottle. | ----- | Remind learners to re-attach the plastic pipettes to the correct bottles using the elastic bands. This will stop any cross contamination. |
| 5. Learners should repeat the same procedure for the other combinations required for their results table. | | |
| 6. Learners should carefully add five drops of concentrated sulfuric acid to each test-tube. | ----- | Remind learners they need to be wearing gloves. |
| 7. Learners should place a piece of cotton wool into the mouth of each test-tube. | | |
| 8. Learners should soak a paper towel in cold water, then fold it up several times, wrap it around the neck of test-tube 1 and secure it with a rubber band. | ----- | Remind learners that this acts as a condenser. |
| 9. Learners should repeat this for the other test-tubes. | | |

10. Learners should set up a water-bath by pouring boiled water from a kettle up to the 100 cm³ mark in a beaker.
11. The learners should carefully transfer the labelled test tubes into the water bath and start their timers.
12. While the condensation reactions are proceeding, learners should label four small beakers 1–4.
13. Learners should measure out 20 cm³ of sodium carbonate solution and pour into beaker 1.
14. Learners should repeat this for all the other beakers.
15. After 10 minutes, learners should transfer the test-tubes to a test-tube rack using forceps and leave to cool for one minute.
16. Learners should remove the cotton wool from the mouth of each test-tube, pour the reaction mixtures into their correspondingly labelled small beaker and gently swirl each beaker.

Remind learners that this is to neutralise any unreacted acid left in the test-tube. They should do this for each test-tube.

Ask learners what gas is produced (CO₂).

17. Once no more bubbling is seen, learners should gently waft any vapour from the beaker towards their nose in order to identify any smells.

Remind learners that they shouldn't put their nose near the top of the beaker and that they shouldn't lift the beaker up to their noses.

18. Learners should look for the presence of oily droplets floating on the surface or on the side of the beakers.

Remind learners that they will need to gently swirl the beaker and look carefully for signs of the droplets.

19. Learners should record all their observations in their results table and evaluate their findings.

Learners should be able to smell distinct odours and see oily droplets on the surface.

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 making esters
- Worksheets C, D, F, G, H, I

Learning objectives

By the end of the lesson:

- **all** learners should have learned how to set up a condensation reaction between an alcohol and a carboxylic acid.
- **most** learners should know how to test for the presence of an ester.
- **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 have a look at Worksheet C and Worksheet D from the previous planning 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 <i>Virtual Experiment video</i> is shown.
 25 min	Main lesson Introduce the video by stating: ‘An ester is a natural or synthetic compound that is used as a flavouring in food and, as a scent in perfumes. Today you will try to prepare an ester from a condensation reaction between an alcohol and a carboxylic acid.’ Give learners Worksheet F and Worksheet G. Inform the learners that they should complete the method in Worksheet F. Also inform learners that they should fill in results and conclusions in Worksheet G as they watch the video.
 10 min	After the video has finished, ask learners to discuss and write down, in their report sheets, three ways they could improve the condensation experiment. Tell them they need to think about: • the effectiveness of the method • limitations of equipment • 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

- Worksheet 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.

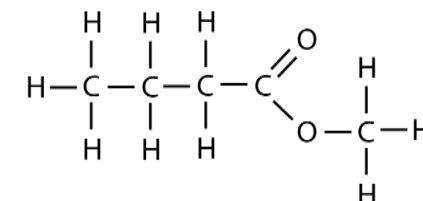
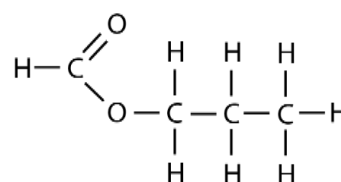
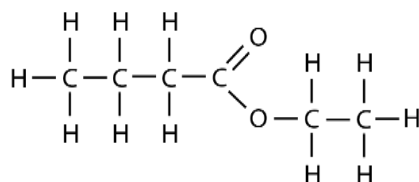
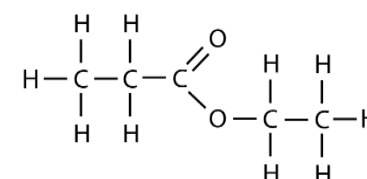
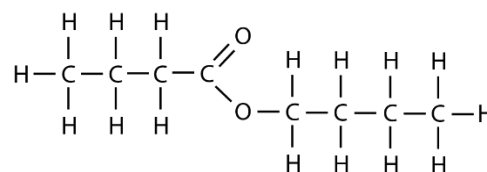
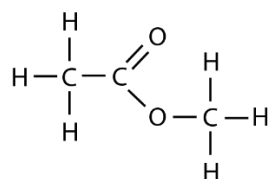
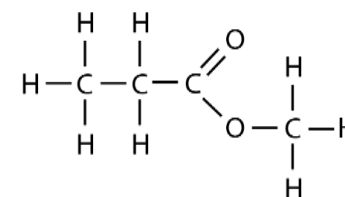
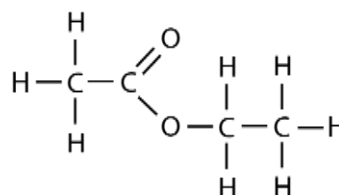
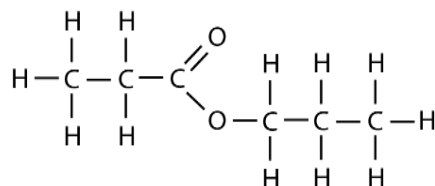
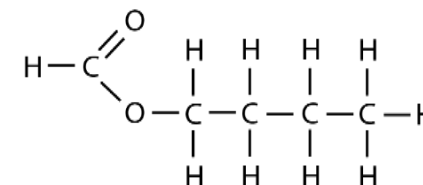
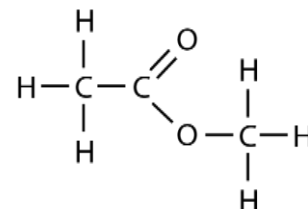
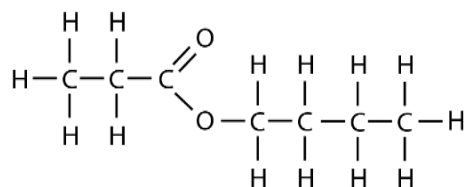
Timings	Activity
 10 min	Starter/introduction Ask learners to complete and review their findings from the experiment. Encourage them to share their findings with other learners.
 15 min	Main lesson Ask learners to discuss the characteristics of a good scientific report. Get them to write out the suggestions and ask them to 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.
 20 min	Show learners the suggested answers for the ideal report. Note: Worksheet J should also be shown to learners who have completed the virtual practical. Learners should then swap their report with a member of another group they haven't been involved with. 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 <i>Briefing lesson</i>:		
A: Ester structures	18	33
B: Choosing the correct equipment	20	—
C: Experiment report – introduction	21	34
D: Your experiment set-up and materials	23	35
For use in <i>Lab lesson: Option 1</i>:		
E: Method	24	—
G: Experiment report – results and analysis	26	37
For use in <i>Lab lesson: Option 2</i>:		
F: Your method	25	36
G: Experiment report – results and analysis	26	37
H: Virtual experiment questions	28	39
I: Applying your knowledge	29	40
For use in the <i>Debriefing lesson</i>:		
J: Assessing a scientific report	30	—



Worksheet A: Ester structures



Note: do not print the continuation of this worksheet on the reverse, use a separate sheet of paper.

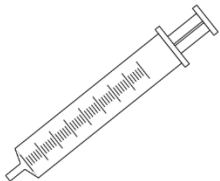
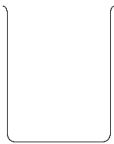
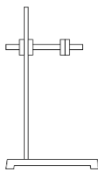
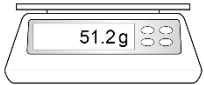
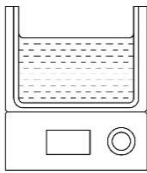
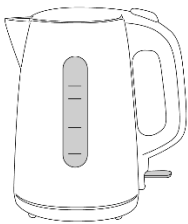
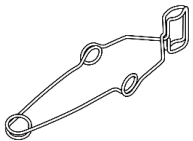
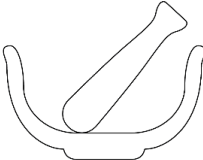
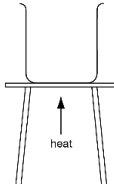
Worksheet A: Ester structures, continued

Butyl propanoate	Methyl ethanoate	Butyl methanoate
Propyl propanoate	Ethyl ethanoate	Methyl propanoate
Methyl ethanoate	Butyl butanoate	Ethyl propanoate
Ethyl butanoate	Propyl methanoate	Methyl butanoate

Worksheet B: Choosing the correct equipment



Here is a range of some common lab equipment. Select what you would use in this experiment.

			
syringe	beaker	boss, clamp and stand	test-tube
			
conical flask	balance	measuring cylinder	water bath
			
kettle	thermometer	timer	pipette
			
distilled water	test-tube holders	pestle and mortar	Bunsen burner and tripod

Worksheet C: Experiment report – introduction



Title	
Background information	
Aims	

Worksheet C: Experiment report – introduction, continued



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

Worksheet D: 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



Worksheet E: Method

Making an ester

1. Collect all the equipment from the front of the class.
2. Label four test-tubes (1–4), at the neck, then place these into a test-tube rack.
3. Measure out 1 cm³ of methanol and transfer to test-tube 1 using the pipette attached to the methanol bottle.
4. Measure out 1 cm³ of methanoic acid and add to test-tube 1 using the pipette attached to the bottle.
5. Repeat the same procedure for the other combinations required.
6. Carefully add five drops of concentrated sulfuric acid to each test-tube.
7. Place a piece of cotton wool into the mouth of each test-tube.
8. Soak a paper towel in cold water, fold it up several times, wrap it around the neck of test-tube one and secure it with a rubber band.
9. Repeat this for the other test-tubes.
10. Set up a water-bath by pouring boiled water from a kettle up to the 100 cm³ mark in a beaker.
11. Place the test-tubes in the water and start the timer.
12. While the condensation reactions are proceeding label four small beakers, 1–4.
13. Measure out 20 cm³ of sodium carbonate solution and pour into labelled beaker 1.
14. Repeat this for all the other labelled beakers.
15. After 10 minutes, transfer the test-tubes to a test-tube rack using forceps and leave to cool for 1 minute.
16. Remove the cotton wool from the mouth of each test-tube, pour the reaction mixtures into their correspondingly labelled small beaker and gently swirl each beaker.
17. Once no more bubbling is seen, gently waft any vapour from the beaker towards the nose to identify any smells.
18. Look for the presence of oily droplets floating on the surface or on the side of the beakers.
19. Record all your observations in your results table and evaluate your findings.



Worksheet F: Your method

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

Making an ester

1. Collect all the equipment from the front of the class.
2. Label four test-tubes (1–4), at the neck, then place these into a test-tube rack.
3.
.....
4. Measure out 1 cm³ of methanoic acid and add to test-tube 1 using the pipette attached to the bottle.
5. Repeat the same procedure for the other combinations required.
6. Carefully add five drops of concentrated sulfuric acid to each test-tube.
7.
.....
8.
.....
9. Repeat this for the other test-tubes.
10. Set up a water-bath by pouring boiled water from a kettle up to the 100 cm³ mark in a beaker.
11. Place the test-tubes in the water and start the timer.
12. While the condensation reactions are proceeding label four small beakers, 1–4.
13.
.....
14. Repeat this for all the other labelled beakers.
15. After 10 minutes, transfer the test-tubes to a test-tube rack using forceps and leave to cool for 1 minute.
16. Remove the cotton wool from the mouth of each test-tube, pour the reaction mixtures into their correspondingly labelled small beaker and gently swirl each beaker.
17.
.....
18. Look for the presence of oily droplets floating on the surface or on the side of the beakers. Record all your observations in your results table and evaluate your findings.

Worksheet G: Results and analysis



Results:

Test-tube	Name of carboxylic acid used	Name of alcohol used	Description of smell	Evidence of 'oily droplets'	Name of the ester formed
1					
2					
3					
4					

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

.....
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Worksheet G: Results and analysis, continued



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, in sentences, the questions below.

1. What would be suitable controls for this experiment?

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.....

2. Why wasn't a Bunsen burner used to create the water-bath?

.....

.....

3. What was the purpose of the presence of concentrated sulfuric acid in each test-tube?

.....

.....

4. What was the purpose of the cotton wool and the wet paper towel?

.....

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5. At the end of the experiment, the contents of the test-tubes were added to sodium carbonate solution in beakers. Why?

.....

.....

6. How was the experiment made a 'fair' test?

.....

.....

7. How could the results from the experiment be made more reliable?

.....

.....



Worksheet I: Applying your knowledge

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

1. An ester has the following structural formula $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_3$. What is the name of the ester?

.....

2. Esters are formed from the reaction between which two functional groups?

.....

.....

3. Name and draw the full structural formula for the ester formed from the condensation reaction between ethanol and butanoic acid.

.....

4. Esters can be broken down (hydrolysed) into the individual alcohol and carboxylic acid used to make it. A hydrolysis reaction was carried out on an ester and gave an alcohol and carboxylic acid both with the same gram formula mass of 60. Which one of the following was the original ester?

- A. $\text{CH}_3\text{COOCH}_2\text{CH}_3$
B. $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_3$
C. $\text{CH}_3\text{CH}_2\text{COOCH}_3$
D. $\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3$

5. The ester methyl salicylate is found in medicines used to relieve muscular aches and pains. A learner prepared this ester from methanol and stearic acid during an experiment. Describe how this ester could be prepared in the classroom.

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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

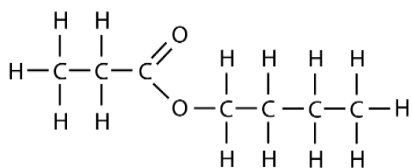
Report section	Success criteria	✓ or ✗	Comments
Materials and method(s)	- Is there a list of equipment and chemicals used? - Does this section have a sequence of steps or commands that show how a task should be carried out? - Is it written using impersonal language? - Is there a clear labelled diagram 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?		



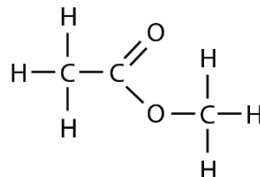
Worksheet J: Assessing a scientific report

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?		

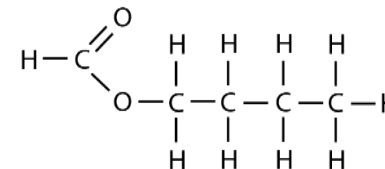
Worksheet A: Answers



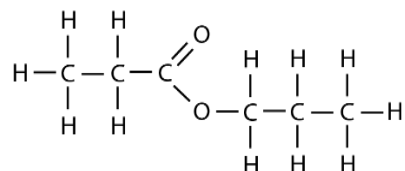
Butyl propanoate



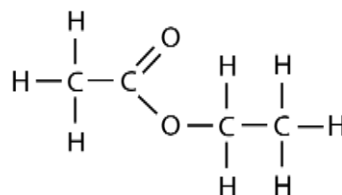
Methyl ethanoate



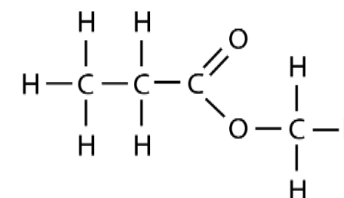
Butyl methanoate



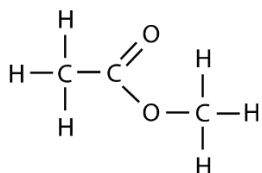
Propyl propanoate



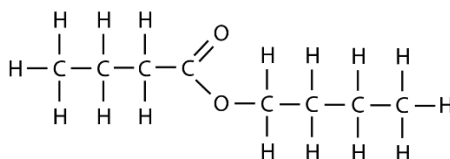
Ethyl ethanoate



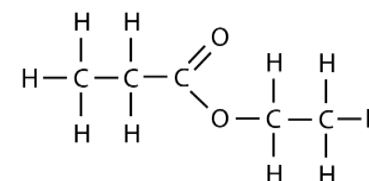
Methyl propanoate



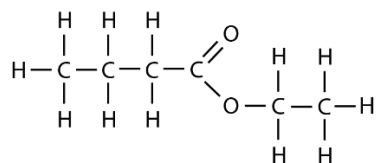
Methyl ethanoate



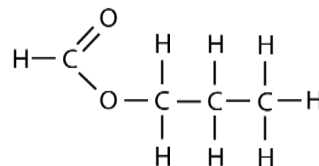
Butyl butanoate



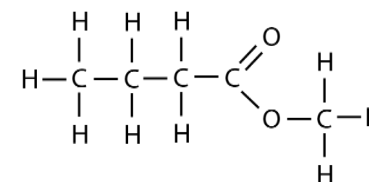
Ethyl propanoate



Ethyl butanoate



Propyl methanoate



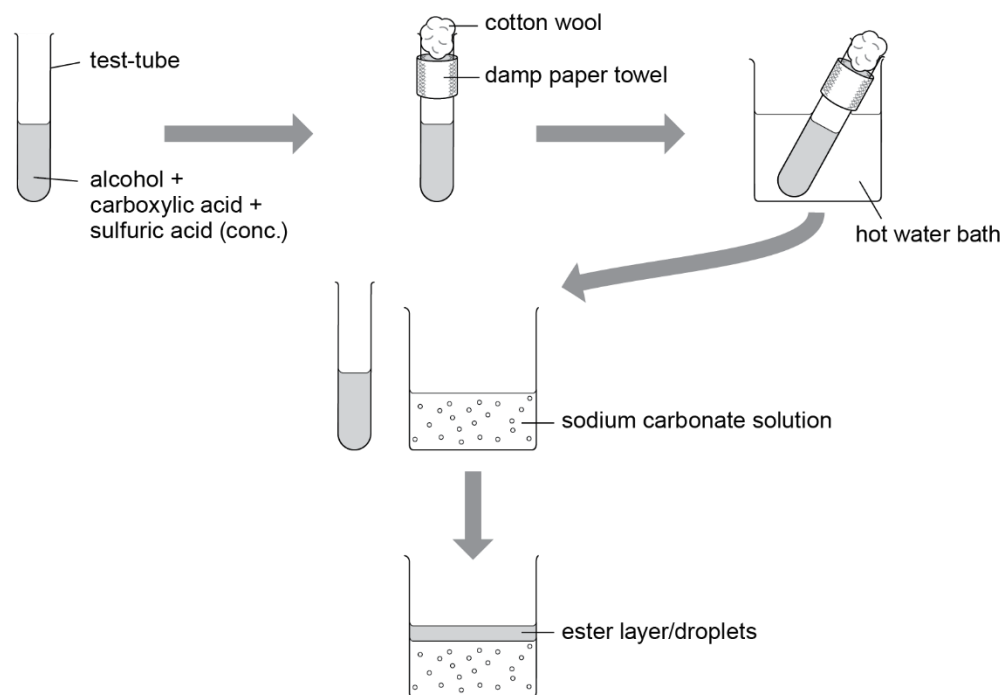
Methyl butanoate

Worksheet C: Answers (ideal report – introduction)



Title	<i>Making esters</i>	
Background information	<i>An ester is a compound made from a condensation reaction between an alcohol and a carboxylic acid.</i>	
Aims	<i>To prepare four esters and test for their presence.</i>	
Experimental variables	Changed (independent) variables	<i>The combination of alcohol and carboxylic acid in the condensation reaction.</i>
	Measured(dependent) variables	<i>Distinctive odour (sweet and pleasant) Presence of oily droplets</i>
	Fixed variables	<i>Final volume of reaction solutions / temperature / concentration of reactants / particle size of reactants.</i>
What will happen? (hypothesis)	<i>An ester will only form in the presence of an alcohol and carboxylic acid.</i>	

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



Materials (list of chemicals and equipment)

- 1 × 250 cm³ beaker
- 1 × 50 cm³ beaker
- 1 × 50 cm³ measuring cylinder
- kettle
- 1 × test-tube rack
- 4 × small test-tubes and test-tube forceps
- sticky labels
- sodium carbonate solution [1 mol/dm³]
- concentrated sulfuric acid
- timer
- 4 × rubber bands and paper towels
- cotton wool
- samples of colour-coded alcohols: methanol, ethanol, propan-1-ol, and butan-1-ol in bottles identified by different coloured tape or stickers; each with a 1 cm³ pipette.
- samples of colour-coded carboxylic acids: methanoic acid, ethanoic acid, propanoic acid and butanoic acid in bottles identified by different coloured tape or stickers; each with a 1 cm³ plastic pipette.



Worksheet F: Answers

Method

1. Collect all the equipment from the front of the class.
2. Label four test-tubes (1–4), at the neck, then place these into a test-tube rack.
3. *Measure out 1 cm³ of methanol and transfer to test-tube 1 using the pipette attached to the methanol bottle.*
4. Measure out 1 cm³ of methanoic acid and add to test-tube 1 using the pipette attached to the bottle.
5. Repeat the same procedure for the other combinations required.
6. Carefully add five drops of concentrated sulfuric acid to each test-tube.
7. *Place a piece of cotton wool into the mouth of each test-tube.*
8. *Soak a paper towel in cold water, fold it up several times, wrap it around the neck of test-tube 1 and secure it with a rubber band.*
9. Repeat this for the other test-tubes.
10. Set up a water-bath by pouring boiled water from a kettle up to the 100 cm³ mark in a beaker.
11. Place the test-tubes in the water and start the timer.
12. While the condensation reactions are proceeding label four small beakers, 1–4.
13. *Measure out 20 cm³ of sodium carbonate solution and pour into labelled beaker 1.*
14. Repeat this for all the other labelled beakers.
15. After 10 minutes, transfer the test-tubes to a test-tube rack using forceps and leave to cool for 1 minute.
16. Remove the cotton wool from the mouth of each test-tube, pour the reaction mixtures into their correspondingly labelled small beaker and gently swirl each beaker.
17. *Once no more bubbling is seen, gently waft any vapour from the beaker towards the nose to identify any smells.*
18. Look for the presence of oily droplets floating on the surface or on the side of the beakers. Record all their observations in their results table and evaluate their findings.

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



Results:

Test-tube	Name of carboxylic acid used	Name of alcohol used	Description of smell	Evidence of 'oily droplets' (yes/no)	Name of ester formed
1	<i>ethanoic acid</i>	<i>methanol</i>	<i>glue, chemical</i>	<i>yes</i>	<i>methyl ethanoate</i>
2	<i>propanoic acid</i>	<i>ethanol</i>	<i>pineapple, sweet</i>	<i>yes</i>	<i>ethyl propanoate</i>
3	<i>butanoic acid</i>	<i>propan-1-ol</i>	<i>pear, sweet</i>	<i>yes</i>	<i>propyl butanoate</i>
4	<i>methanoic acid</i>	<i>butan-1-ol</i>	<i>raspberry, sweet</i>	<i>yes</i>	<i>butyl methanoate</i>

Conclusion(s):

Four different esters were made from four different condensation reactions.

The presence of the esters was confirmed by the presence of oily droplets and distinct odours.

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



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	Some of the reactants may have escaped the reaction test-tube.
Improvements	Control experiments should also be conducted to assess the integrity of the alcohols, carboxylic acid and concentrated sulfuric acid i.e. test-tubes set up without each present.



Worksheet H: Answers

1.

- Test-tube containing water (instead of carboxylic acid) + alcohol + concentrated sulfuric acid.

OR

- Test-tube containing water (instead of alcohol) + carboxylic acid + concentrated sulfuric acid.

OR

- Test-tube containing water (instead of concentrated sulfuric acid) + alcohol + carboxylic acid.

2. Due to the flammability of the alcohols used in the condensation reaction.

3. It acts as a catalyst.

4. To stop the reactants leaving the test-tube, as they become gaseous when placed in the boiled water. The wet paper towel acts a condenser.

5. To react with and neutralise any concentrated sulfuric acid.

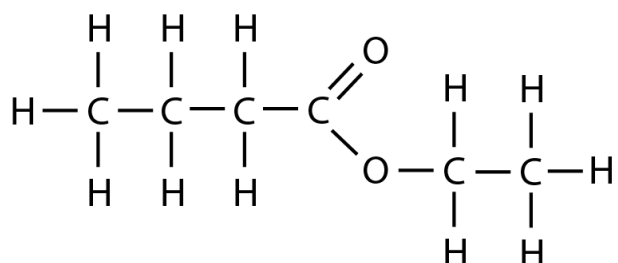
6. The only change made to the reactions was the combination of carboxylic acids and alcohols. The volumes and concentrations of the reactants remained constant.

7. Repeat each individual experiment a minimum of three times.



Worksheet I: Answers

1. *Ethyl butanoate*
2. *Carboxyl and hydroxyl*
3. *Ethyl butanoate*



4. *B (it gives $\text{CH}_3\text{COOH} + \text{HOCH}_2\text{CH}_2\text{CH}_3$)*
5. **All of the points below (or a labelled diagram)**
 - *Non-flame water bath.*
 - *Condenser of some type.*
 - *Methanol and salicylic acid in a test-tube.*
 - *Presence of concentrated sulfuric acid catalyst in test-tube.*
 - *Pour reaction mixture into a carbonate solution or solid carbonate added after esterification.*

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