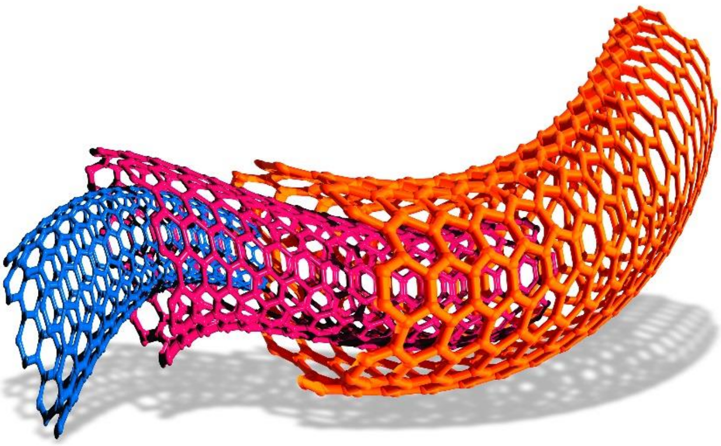
Cambridge Assessment International Education

Teaching Pack

Natural polymers – the hydrolysis of starch by acid and enzyme

Cambridge O Level

Chemistry 5070



Version 2.0

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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 practise the experiment skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.

↓

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases this also includes the opportunity 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: The hydrolysis of starch by acid and enzyme

This experiment pack focuses on the hydrolysis of starch using both an enzyme and acid.

Starch is an example of a complex carbohydrate and natural polymer – a long chain molecule made up of smaller units called monomers that can be detected after hydrolysis.

In this experiment learners will hydrolyse starch using hydrochloric acid and amylase. They will then test for the presence of simple sugars.

This experiment has links to the following syllabus content (see syllabus for detail):

- 11.5 Polymers

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

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

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- 6.1 Rate of reaction
- 11.5 Polymers

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.

Briefing lesson: Planning the experiment

Resources	• Worksheets A, B, C, D and E

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
10 min	**Starter/Introduction** Start with a formative assessment activity to assess the following prior learning points: • define polymers as large molecules built up from small units (monomers) • describe complex carbohydrates in terms of a large number of sugar units, considered as joined together by condensation polymerisation. Cut out the rectangles on Worksheet A and, if possible, laminate them. Give these cards to each pair of learners. In pairs, get learners to place the cards under three different headings: 'natural polymers', 'monomers' and 'other'. Get learners to use the cards to construct a flow diagram for the two hydrolysis reactions (acid and enzyme).
20 min 20 min	**Main lesson** Group learners into fours and give them the following information: *A starch solution needs to be hydrolysed to simple sugars using hydrochloric acid and the enzyme amylase. Remember to think about how you will hydrolyse the starch and, also test for the presence or absence of simple sugars and starch. You will also have to think about the temperature that is optimum for the enzyme to work most efficiently*. 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 group discussion with regard to 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. 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 two parts of the experiment: hydrolysis using hydrochloric acid and with amylase (use Worksheet E). Ask learners to compare their illustrations with Worksheet E 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, F and H • Equipment as outlined in the notes

Learning objectives	By the end of the lesson: • ***all*** learners should have carried out a hydrolysis reaction on starch • ***most*** learners should be able to test for the product obtained from the hydrolysis of starch • ***some*** learners will be able to start the interpretation and evaluation of their experimental data.

Timings	Activity
	Starter/Introduction
5 min	Learners should be put into groups of four. Within these groups they should decide which pair will carry out which hydrolysis reaction. Hand out Worksheet F to each group (they should already have Worksheet C, Worksheet D and Worksheet E from the briefing lesson). Inform the class of the approximate timings for each part of the experiment: (1) set-up (10 min), (2) hydrolysis reactions (10 min), (3) testing 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 boiling water.
	Main lesson
10 min	**(1) Set-up** Learners should use Worksheet E and Worksheet F to allow them to collect the correct materials and equipment.
10 min	**(2) Hydrolysis reactions and method write-up** Learners should follow the appropriate method on Worksheet F. **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) Testing and recording results** Learners need to make sure that the colour changes are recorded in the appropriate section of Worksheet H.
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.
	Plenary
10 min	Learners complete the sections in Worksheet H covering the conclusion and evaluation. Ask learners to discuss and write down, in their reports, three ways how they could improve the hydrolysis experiment. The suggested answers can be used for guidance.

Teacher notes

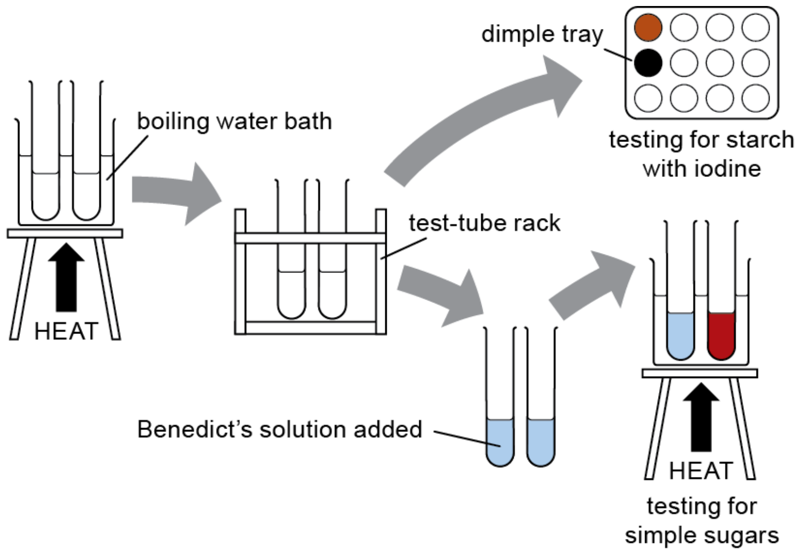
Watch the *Teacher Walkthrough video* for the hydrolysis of starch by acid and enzyme and read these notes.

Each group will require:

- 2 × 250 cm^3 beaker
- 2 × tripod stand with gauze
- 2 × heat mat
- 2 × Bunsen burner
- 1 × test-tube rack
- 1 × dimple tray
- 4 × test-tubes
- 4 × test-tube forceps
- sticky labels for the test-tubes
- iodine solution (in dropper bottle)
- Benedict's solution, (in a dropper bottle)
- 1% w/v starch solution, freshly prepared
- solid sodium hydrogen carbonate
- 1% w/v amylase solution, freshly prepared
- hydrochloric acid [2 mol/dm^3]
- 2 × 5 cm^3 syringe
- 4 × 1 cm^3 syringe
- a spatula
- 4 × 1 cm^3 plastic dropper
- 2 × timer
- water bath set at 37 °C (with thermometer in the water)

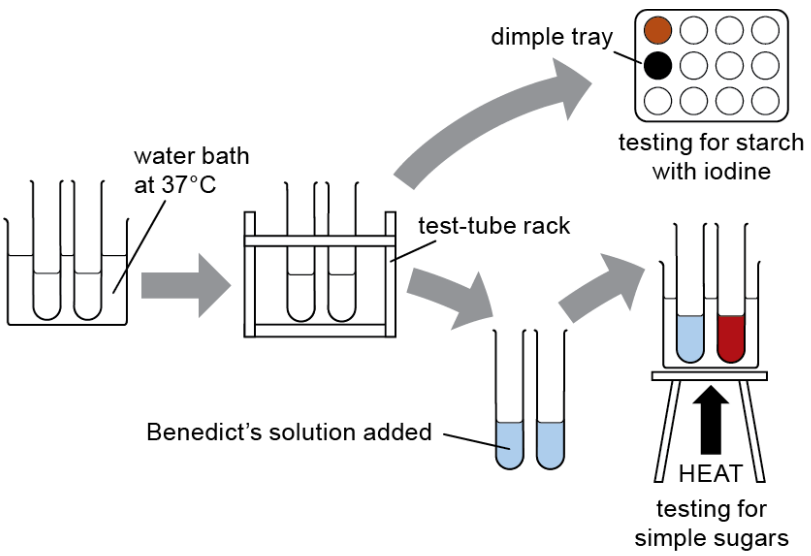
Experiment set-up

1. Acid hydrolysis experiment



Test-tube 1: 5 cm^3 starch solution + 1 cm^3 HCl [2 mol/dm^3]
Test-tube 2: 5 cm^3 starch solution + 1 cm^3 water

2. Enzyme hydrolysis experiment



Test-tube 3: 5 cm^3 starch solution + 1 cm^3 amylase solution [1% w/v]
Test-tube 4: 5 cm^3 starch solution + 1 cm^3 water

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 hydrogen carbonate (solid)	LOW HAZARD	**In the eye:** flood the eye with gently-running tap water for at least 10 min. 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 up small solution spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).
Dilute amylase solution [1% w/v]	 GHS08 (*health hazard* **HH**)	**In the eye:** flood the eye with gently-running tap water for at least 10 min. See a doctor. **Swallowed:** do no more than wash out the mouth with water. Do **n**ot 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.:** wipe up small solution spills with cloth; for larger spills use mineral absorbent (e.g. cat litter).
Concentrated hydrochloric acid [2.0 mol/dm^3]	 GHS07 (*moderate hazard* **MH**)	**In the eye:** flood the eye with gently-running tap water for 10 min. 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. Then drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. **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 up small amounts with a damp cloth and rinse it well.
Benedict's reagent solution	LOW HAZARD	**In the eye:** flood the eye with gently-running tap water for 10 min. 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.

Substance	Hazard	First aid
		Spilt on the skin or clothing: remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. **Spilt on the floor, bench, etc.:** Wipe up small amounts with a damp cloth and rinse it well. For larger amounts, cover with mineral absorbent (e.g. cat litter) and scoop into a bucket. Neutralise alkali with citric acid. Rinse with water.
Iodine solution [0.1 mol/dm^3]	 GHS09 (*hazardous to the aquatic environment* **N**)	**In the eye:** Flood the eye with gently-running tap water for 10 min. See a doctor. **Vapour breathed in:** remove the casualty to fresh air. Call a doctor if breathing is even slightly affected. **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. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. **Spilt on the floor, bench, etc.:** ventilate the room. For small amounts, use a damp cloth. Rinse well. For larger amounts, cover with mineral absorbent (e.g. cat litter) and scoop into a bucket.
Starch [1% w/v solution]	LOW HAZARD	**In the eye:** flood the eye with gently-running tap water for at least 10 min. 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.:** wipe up small solution spills with cloth and rinse well. For larger spills use mineral absorbent (e.g. cat litter).

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 F.

Before you begin
Plan how you will group your learners during the experiment.

Think about:

- the number of groups you will need (group size 2–4 learners) and which of the hydrolysis reactions they will be carrying out
- the amount of equipment/chemicals required.

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

Part 1: Acid hydrolysis of starch

Steps	Notes
1. Learners should collect all the equipment they need from the front of the class.	
2. Learners should half-fill a 250 cm^3 beaker with water and heat to boiling using a Bunsen burner (blue flame).	
3. Whilst the water is being heated, learners should label two test-tubes **1 and 2** and place these in 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.*
4. Learners should add 5 cm^3 of the starch solution to each of the test-tubes using the 5 cm^3 syringe.	*Remind learners to wash out the syringe with water after it has been used.*
5. Learners should add 1 cm^3 of dilute hydrochloric acid to test-tube **1 ONLY** using the 1 cm^3 syringe.	*Remind learners that hydrochloric acid only goes into test-tube 1.* *Learners should wash out the syringe with water after it has been used.*
6. Using another syringe, the learner should add 1 cm^3 of water to test-tube **2**.	*Remind learners that this is the control.*
7. The learners should carefully transfer the labelled test-tubes into the boiling water bath and start their timers.	*Remind learners that if the water is boiling too much, close the Bunsen air-hole a little to control the level of boiling.*

8. After 10 min learners should transfer the test-tubes to a test-tube rack using forceps and leave to cool for 1 min.

Remind learners to leave the water boiling as they will need it again. Get them to top-up the water in the beaker.

9. Using a spatula, the learners should add tiny amounts of sodium hydrogen carbonate to test-tube **1** only until no more bubbles of gas are produced.

If too much sodium bicarbonate (sodium hydrogen carbonate) is added the contents of the reaction tube will froth up.

10. Once no more bubbling is seen, learners should use separate plastic droppers to transfer some of the sample from each test-tube to an individual dimple in their dimple tray.

Remind learners that this is to neutralise any unreacted acid left in test-tube 1.

Ask learners what gas is produced (CO_2).

11. They should then add five drops of the red/brown iodine solution to each sample in the dimple tray and note down the colour in their results table.

Learners should observe:

- *a blue/black colour indicating the presence of starch for test-tube 2*
- *a red/brown colour for test-tube 1 indicating the absence of starch as it has all been hydrolysed.*

12. Learners should add enough Benedict's solution to each of the labelled test-tubes to give a blue colour (20–30 drops) and add these to the boiling water bath which can now be turned off.

Benedict's solution tests for the presence of simple sugars. The presence of a brick-red colour precipitate indicates the presence of simple sugars.

The absence of the precipitate indicates the absence of simple sugars and, by implication, the continuing presence of starch.

13. Learners should carefully remove the test-tubes with forceps, when any colour change becomes apparent and note down the colour in their results table.

Learners should see:

- *a brick-red colour precipitate in test-tube 1 indicating the presence of simple sugars*
- *a blue colour in test-tube 2 indicating the absence of simple sugars.*

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

Part 2: Enzymatic hydrolysis of starch

Steps	**Notes**
1. Learners should collect all the equipment they need from the front of the class.	
2. Learners should set up an electronic water bath at 37 °C.	
3. Whilst the water bath is being heated, learners should label two test-tubes, **3** and **4**, and place these in a test-tube rack.	
4. Learners should add 5 cm^3 starch solution to each of the test-tubes using the 5 cm^3 syringe.	
5. Using a syringe add 1 cm^3 of the amylase solution to test-tube **3**.	
6. Then add 1 cm^3 of water to test-tube **4** using another syringe this will be the control.	
7. Place both test-tubes to the 37 °C water bath for 10 min.	
8. While you are waiting, use the Bunsen burner and beaker to set-up a boiling water-bath to test for the simple sugars like you did earlier.	
9. After 10 min use the plastic droppers to transfer some of the sample from each test-tube to the dimples in the dimple tray.	
10. Add 5 drops of red/brown iodine solution to each and note down the colour.	*The presence of a blue/black colour indicates the presence of starch.*
11. As before, test for the presence of simple sugars, by adding enough Benedict's solution to each of the labelled test-tubes to give a blue colour (20–30 drops) and transfer to the boiling water bath.	

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 hydrolysis of starch • Worksheets E, G, H, J and K

Learning objectives	By the end of the lesson: • ***all*** learners should have carried out a hydrolysis reaction on starch • ***most*** learners should be able to test for the product obtained from the hydrolysis of starch • ***some*** learners will be able to start the interpretation and evaluation of their experimental data.

Timings	Activity
10 min	**Starter/Introduction** Instruct learners that they need to have a look at worksheets C and D from the previous planning lesson to remind themselves of what they planned. Ask learners to review Worksheet E so they can look at the experimental set-up before the *Virtual Experiment video* is shown.
25 min	**Main lesson** Introduce the video by stating: 'Starch is an example of a condensation polymer and is made up of smaller glucose monomer units. Today you will try to find out what happens when starch is hydrolysed using an acid or an enzyme called amylase.' Give learners Worksheet G and Worksheet H. Inform the learners that they should complete the method in Worksheet G as they watch the video. Also inform learners that they should fill in results and conclusions in Worksheet H 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 how they could improve the hydrolysis 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 J and Worksheet K. Ask them to answer the questions using the information in their report and encourage them to use a glossary from a textbook.

Debriefing lesson: Evaluating a report

Resources	• Worksheets E and I • Suggested answers to Worksheets C, D, E and H

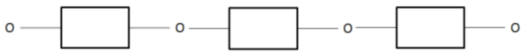
Learning objectives	By the end of the lesson: • ***all*** learners should be able to write a conclusion based on their findings • ***most*** learners should be able to evaluate the experiment • ***some*** learners will be able to review their finished report in line with success criteria and offer improvements.

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. 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. Show them the suggested answers to worksheets C, D, and H, which combine to provide an exemplar scientific report. **Note:** Worksheet E should also be shown to learners who have completed the virtual practical. Leaners should then swap their report with a member of another group they haven’t been involved with. Using the success criteria in Worksheet I, they should assess the report they have been given. You can guide their progress using the ideal report.
15 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

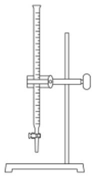
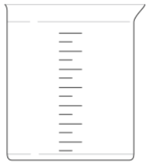
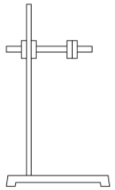
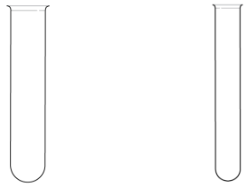
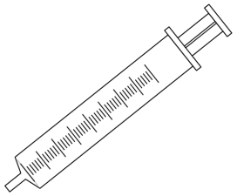
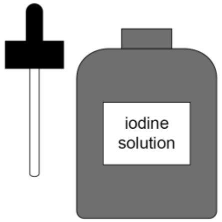
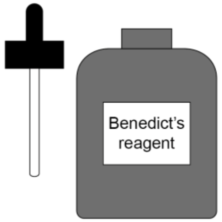
	Worksheets	Answers
For use in the *Briefing lesson*:		
A: Prior learning card game	**18**	**—**
B: Choosing the correct equipment	**19**	**—**
C: Experiment report – Introduction	**20–21**	**38**
D: Your experiment set-up and materials	**22–23**	**39–40**
E: Experimental set-up	**24–25**	**—**
For use in *Lab lesson: Option 1*:		
C: Experiment report – Introduction	**20–21**	**38**
D: Your experiment set-up and materials	**22–23**	**39–40**
E: Experimental set-up	**24–25**	**—**
F: Method	**26–27**	**—**
H: Experiment report – Results	**30–31**	**43-44**
For use in *Lab lesson: Option 2*:		
E: Experimental set-up	**24–25**	**—**
G: Your method (acid/enzymatic hydrolysis)	**28–29**	**41–42**
H: Experiment report – Results	**30–21**	**43–44**
J: Virtual experiment questions	**35–36**	**45**
K: Applying your knowledge	**37**	**46**
For use in the *Debriefing lesson*:		
E: Experimental set-up	**24–25**	**—**
I: Assessing a scientific report	**32–34**	**—**

Worksheet A: Prior learning card game

	used to test for starch
	glucose
starch	
polymerisation	condensation
boiling water	optimum temperature 37 °C
Benedict’s solution	maltose
use to test for simple sugars	amylase
hydrochloric acid	
hydrolysis	iodine solution
turns brick-red	turns blue/black

Worksheet B: Choosing the correct equipment

Here is a range of some common lab equipment.

			
burette	**beaker**	**boss, clamp and stand**	**boiling-tube and test-tube**
			
conical flask	**syringe**	**measuring cylinder**	**water bath**
			
iodine solution	**thermometer**	**Benedict's reagent**	**pipette**

Worksheet C: Experiment report – Introduction

Title	………………………………………………………………………………………………
Background information	……………………………………………………………………………………………… ……………………………………………………………………………………………… ………………………………………………………………………………………………
Aims	**Aim 1:** ……………………………………………………………………………………………… ……………………………………………………………………………………………… **Aim 2:** ……………………………………………………………………………………………… ………………………………………………………………………………………………

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.

Experimental set-up: Acid hydrolysis of starch

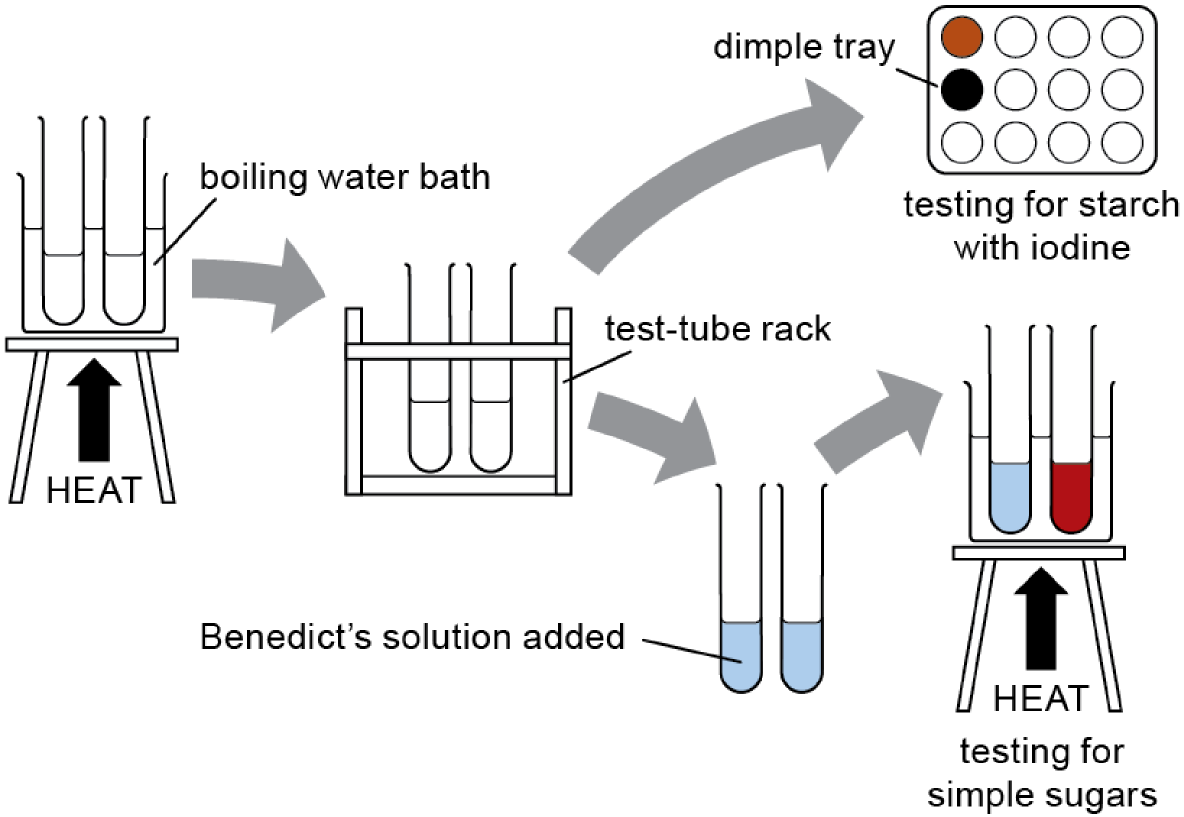
Worksheet D: Your experiment set-up and materials

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

Experimental set-up: Enzymatic hydrolysis of starch

Worksheet E: Experimental set-up

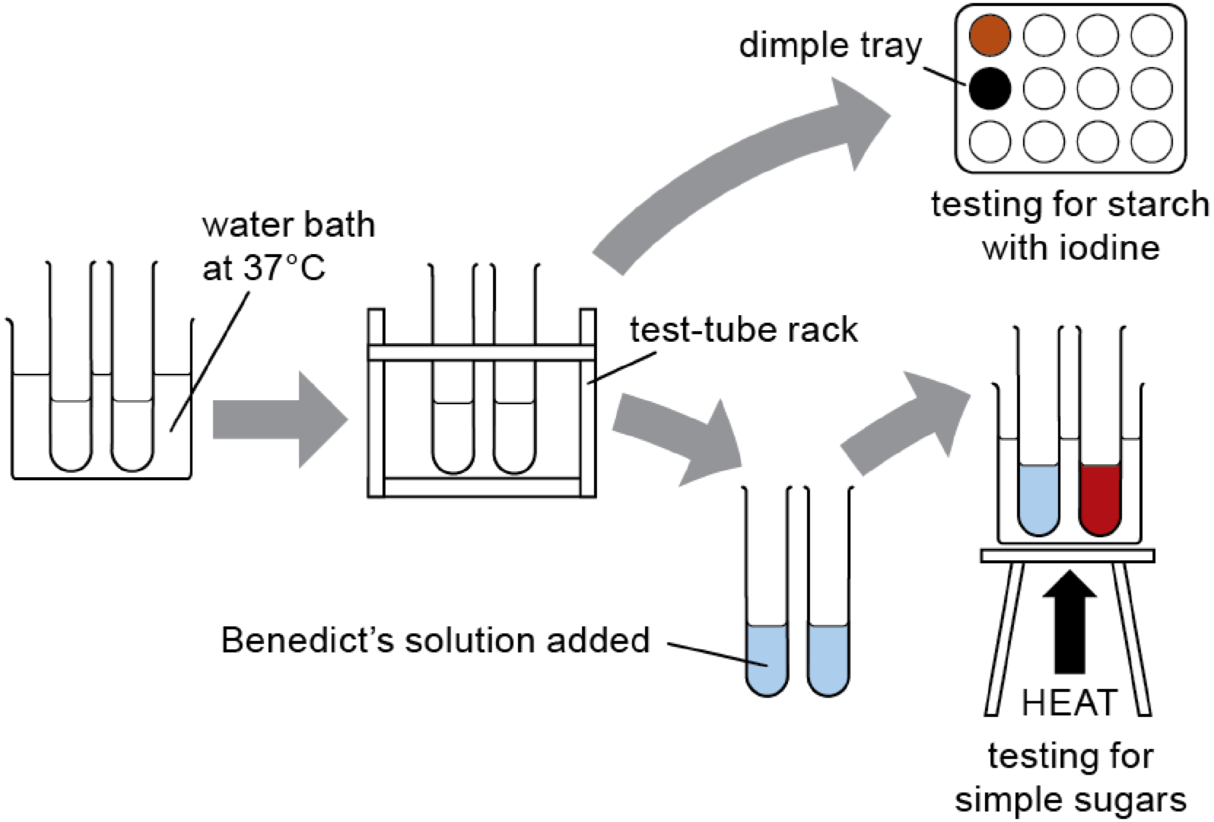
Acid hydrolysis of starch



Test-tube 1: 5 cm^3 starch solution + 1 cm^3 HCl [2 mol/dm^3]
Test-tube 2: 5 cm^3 starch solution + 1 cm^3 water

Worksheet E: Experimental set-up

Enzymatic hydrolysis of starch



Test-tube 3: 5 cm^3 starch solution + 1 cm^3 amylase solution [1% w/v]
Test-tube 4: 5 cm^3 starch solution + 1 cm^3 water

Worksheet F: Method

Acid hydrolysis of starch

1. Half-fill a 250 cm^3 beaker with water and heat to boiling using a Bunsen burner (blue flame).
2. Whilst the water is being heated, label two test-tubes **1** and **2** (near the top). Place these in a test-tube rack.
3. Add 5 cm^3 of starch solution to each of the test-tubes using a 5 cm^3 syringe.
4. Using a syringe add 1 cm^3 of dilute hydrochloric acid to test-tube **1**.
5. Using another syringe, add 1 cm^3 of water to test-tube **2**, this will be the control.
6. Carefully transfer the labelled test-tubes into the boiling water bath, start the timer and boil for 10 minutes.

If the water is boiling too much, close the Bunsen air-hole a little to control the boiling.

7. After 10 minutes, transfer the test-tubes to a test-tube rack using forceps and leave to cool for 1 min.

Leave the water boiling; you will need it again. You may have to add some water.

8. Using a spatula, add a tiny amount of sodium hydrogen carbonate to only test-tube **1** (acid–starch mixture). This is to neutralise any unreacted acid. Continue adding tiny amounts of sodium hydrogen carbonate until no more bubbles of gas are produced in the test-tube.

9. Using separate plastic droppers transfer some of the sample from each test-tube to an individual dimple in the dimple tray.

10. Add five drops of the red/brown iodine solution to each sample in the dimple tray and note down the colour.

The presence of a blue/black colour indicates the presence of starch.

11. To test for the presence of simple sugars, add enough blue Benedict's solution to each of the labelled test-tubes to give a blue colour (25 drops) and add these to the boiling water bath which can now be turned off.

12. Carefully, remove the test-tubes with the forceps when any colour change becomes apparent. Don't leave them in the water bath.

The presence of a red/orange precipitate indicates the presence of simple sugars.

Worksheet F: Method

Enzymatic hydrolysis of starch

1. Set up a water bath at 37 °C.

Make sure the temperature of the water bath is not higher than 37 °C.

2. Label two test-tubes **3** and **4** and place these in the test-tube rack.
3. Add 5 cm^3 of starch solution to each of the test-tubes using the 5 cm^3 syringe.
4. Using a syringe add 1 cm^3 of the amylase solution to test-tube **3**.
5. Then add 1 cm^3 of water to test-tube **4** using another syringe- this will be the control.
6. Place both test-tubes into the 37 °C water bath for 10 minutes.
7. Whilst you are waiting, use the Bunsen burner and beaker to set up a boiling water-bath to test for the simple sugars like you did earlier.
8. After 10 minutes, use the plastic droppers to transfer some of the sample from each test-tube to dimples in the dimple tray.
9. Add 5 drops of red/brown iodine solution to each and note down the colour.

The presence of a blue/black colour indicates the presence of starch.

10. As before, test for the presence of simple sugars, by adding enough Benedict's solution to each of the labelled test-tubes to give a blue colour (25 drops) and transferring these to the boiling water bath.

The presence of a red/orange precipitate indicates the presence of simple sugars.

Worksheet G: Your method (acid hydrolysis)

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

Acid hydrolysis of starch

1. Half-fill a 250 cm^3 beaker with water and heat to boiling using a Bunsen burner.
2. Label two test-tubes **1** and **2** (near the top) and place in a test-tube rack.

3. ……………………………………………………………………………………………………

……………………………………………………………………………………………………

4. Add 1 cm^3 of dilute hydrochloric acid to test-tube **1**.

5. ……………………………………………………………………………………………………

……………………………………………………………………………………………………

6. Carefully transfer the test-tubes into a boiling water bath for 10 min.

7. ……………………………………………………………………………………………………

……………………………………………………………………………………………………

8. Using a spatula, add a tiny amount of sodium hydrogen carbonate to test-tube **1 ONLY**. Continue adding tiny amounts of sodium hydrogen carbonate until no more bubbles of gas are produced in the test-tube.
9. Use a separate plastic dropper to transfer some of the sample from each test-tube to an individual dimple in the dimple tray.
10. Add 5 drops of the iodine solution to each sample in the dimple tray and note down the colour

11. ……………………………………………………………………………………………………

……………………………………………………………………………………………………

12. Carefully, remove the test-tubes with the forceps when any colour change becomes apparent. Do not leave in the water bath. Note down the colour of the solution.

Worksheet G: Your method (enzymatic hydrolysis)

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

Enzymatic hydrolysis of starch

1. ....

....

2. Label two test-tubes **3** and **4** and place in a test-tube rack.
3. Add 5 cm^3 of starch solution to each of the test-tubes.

4. ....

....

5. Add 1 cm^3 of water to test-tube **4**.

6. ....

....

7. Set up a boiling water-bath to test for the simple sugars.

8. ....

....

9. Add 5 drops of iodine solution to each and note down the colour.
10. Add 25 drops of Benedict's solution to each of the remaining solutions in the test-tubes and transfer these to the boiling water bath. Remove when a colour change becomes apparent. Note down the colour of the solution.

Worksheet H: Experimental report

Results:

Test-tube	Colour with iodine solution	Colour with Benedict's solution
1	…………………………………………………	…………………………………………………
2	…………………………………………………	…………………………………………………
3	…………………………………………………	…………………………………………………
4	…………………………………………………	…………………………………………………

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

……

……

……

……

……

Worksheet H: Experimental report

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 I: 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 I: 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 I: 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 J: Virtual experiment questions

Use your notes to answer, in sentences, the questions below.

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

……..

2. Why were test-tubes **3** and **4** placed in a water bath at 37 °C?

……..

3. What was the purpose of the presence of hydrochloric acid in test-tube **1**?

……..

4. What was the purpose of using Benedict's solution?

……..

5. **(a)** At the end of the experiment, what substance was present in tubes **1** and **3** that was not there at the start?

……..

(b) What evidence do you have that this substance was not present at the start of the experiment?

……..

6. What was the iodine solution used to test for?

……..

Worksheet J: Virtual experiment questions

Use your notes to answer, in sentences, the questions below.

7. What name is given to the experiments carried out in test-tubes **2** and **4**?

………..

8. What was the purpose of adding the sodium hydrogen carbonate to test-tube **1**?

………..

9. What would be the outcome if a test-tube was set up with **BOTH** hydrochloric acid and amylase present in a water bath at 37 °C?

………..

10. Does the hydrolysis of starch require the presence of hydrochloric acid?

………..

11. How was the experiment made a ‘fair’ test?

………..

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

………..

Worksheet K: Applying your knowledge

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

1. During digestion humans break down (hydrolyse) complex carbohydrates like starch.

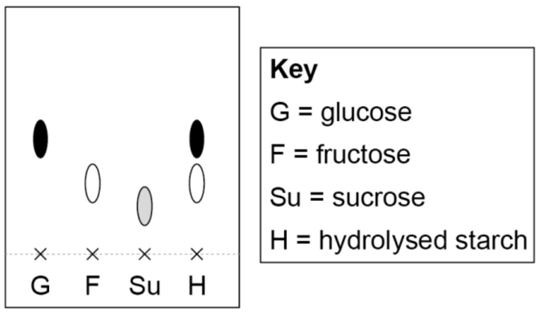
Why does a starch molecule need to be hydrolysed during digestion?

………

2. During the hydrolysis of starch many different simple sugars can be formed.

Chromatography is a technique that can be used to identify the products of hydrolysed starch reactions. Different sugars move up chromatography paper at different rates, so they separate out and can be identified after the application of Benedict's solution to the paper, at 100 °C.

The products of a hydrolysis reaction were analysed using chromatography and the results can be seen below. What does this chromatogram tell us about the original starch molecule?



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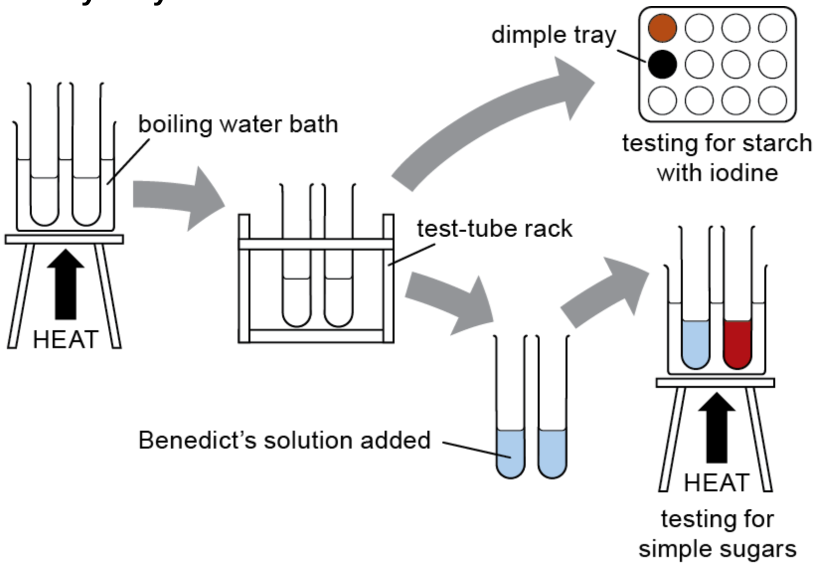
Worksheet C: Answers (ideal report)

Title	*Starch hydrolysis*	
Background information	*Starch is an example of a complex carbohydrate and natural polymer – a long chain molecule made up of smaller units called monomers. The monomer units that make up starch are called simple sugars. Complex carbohydrates like starch are formed by joining lots of simple sugars together by condensation polymerisation.*	
Aims	**Aim 1:** *To demonstrate that an acid (hydrochloric) can hydrolyse starch into simpler monomer units.* **Aim 2:** *To demonstrate that an enzyme (amylase) can hydrolyse starch into simpler monomer units.*	
Experimental variables	**Changed (independent) variables**	*Presence or absence of hydrochloric acid* *Presence or absence of amylase*
	Measured(dependent) variables	*Colour of iodine solution* *Colour of Benedict's solution*
	Fixed variables	*Final volume of reaction solutions/temperature/concentration of reactants/particle size of reactants*
What will happen? (hypothesis)	*Starch will only be hydrolysed when boiled in the presence of an acid or when an enzyme like amylase is present.*	

Worksheet D: Answers (ideal report)

Materials and experimental set-up:

Acid hydrolysis



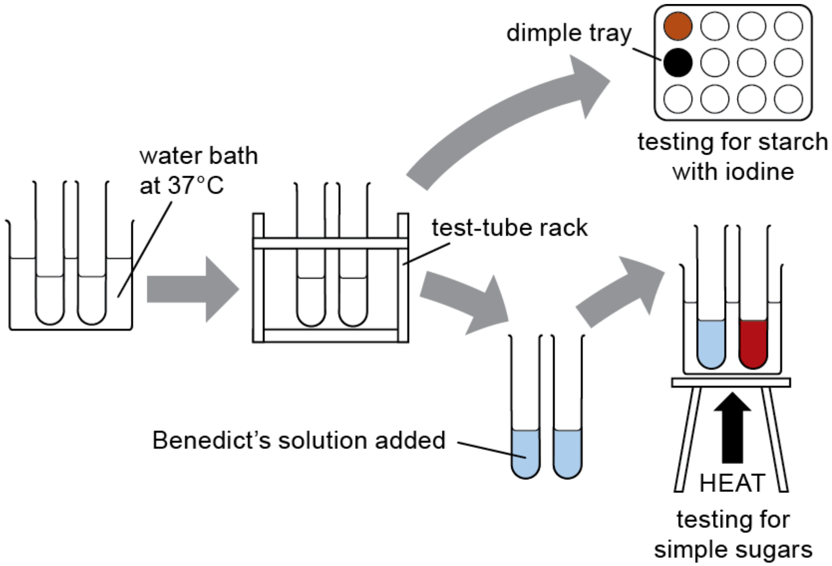
Test-tube 1: 5 cm^3 starch solution + 1 cm^3 HCl [2 mol/dm^3]
Test-tube 2: 5 cm^3 starch solution + 1 cm^3 water

Materials required:

- a 250 cm^3 beaker
- a tripod stand with gauze
- a heatproof mat
- a Bunsen burner
- a test-tube rack
- a dimple tray
- 2 × test-tubes
- test-tube forceps
- sticky labels for the test-tubes
- iodine solution (in dropper bottle)
- Benedict's solution, (in a dropper bottle)
- 1% (w/v) starch solution, freshly prepared
- solid sodium hydrogen carbonate
- hydrochloric acid [2 mol/dm^3]
- a 5 cm^3 syringe
- 2 × 1 cm^3 syringe
- a spatula
- plastic droppers
- timer

Worksheet D: Answers (ideal report)

Enzymatic hydrolysis



Test-tube 3: 5 cm^3 starch solution + 1 cm^3 amylase solution [1% w/v]
Test-tube 4: 5 cm^3 starch solution + 1 cm^3 water

Materials required:

- a 250 cm^3 beaker
- a tripod stand with gauze
- a heatproof mat
- a Bunsen burner
- a test-tube rack
- a dimple tray
- 2 × test-tubes
- test-tube forceps
- sticky labels for the test-tubes
- iodine solution (in dropper bottle)
- Benedict's solution, (in a dropper bottle)
- 1% (w/v) starch solution, freshly prepared
- a 5 cm^3 syringe
- 2 × 1 cm^3 syringe
- a spatula
- plastic droppers
- timer
- water bath (set at 37 °C)
- 1% (w/v) amylase solution, freshly prepared

Worksheet G: Answers (ideal report)

Method(s)

Acid hydrolysis of starch

1. Half-fill a 250 cm^3 beaker with water and heat to boiling using a Bunsen burner.
2. Label two test-tubes **1** and **2** (near the top) and place in a test-tube rack.
3. *Add 5 cm^3 of starch solution to each of the test-tubes.*
4. Add 1 cm^3 of dilute hydrochloric acid to test-tube **1**.
5. Add 1 cm^3 of water to test-tube **2**.
6. Carefully transfer the test-tubes into a boiling water bath for 10 min.
7. *After 10 min transfer the test-tubes to a rack using forceps and leave to cool for 1 min. Leave the water bath boiling.*
8. Using a spatula, add a tiny amount of sodium hydrogen carbonate to test-tube **1** ONLY. Continue adding tiny amounts of sodium hydrogen carbonate until no more bubbles of gas are produced in the test-tube.
9. Use a separate plastic dropper to transfer some of the sample from each test-tube to an individual dimple in the dimple tray.
10. Add five drops of the iodine solution to each sample in the dimple tray and note down the colour.
11. *Add 25 drops of Benedict's solution to each of the remaining solutions in the test-tubes and add to the boiling water bath which can now be turned off.*
12. Carefully, remove the test-tubes with the forceps when any colour change becomes apparent. Don't leave in the water bath. Note down the colour of the solution.

Worksheet G: Suggested answers (ideal report)

Enzymatic hydrolysis of starch

1. *Set up a water bath at 37 °C.*

2. Label two test-tubes **3** and **4** and place in a test-tube rack.
3. Add 5 cm^3 of starch solution to each of the test-tubes.

4. *Add 1 cm^3 of the amylase solution to test-tube **3**.*

5. Add 1 cm^3 of water to test-tube **4**.

6. *Place both test-tubes into the 37 °C water bath for 10 min.*

7. Set up a boiling water-bath to test for the simple sugars.

8. *After 10 min use the plastic droppers to transfer some of the sample from each test-tube to dimples in the dimple tray.*

9. Add 5 drops of iodine solution to each and note down the colour.
10. Add 25 drops of Benedict's solution to each of the remaining solutions in the test-tubes and transfer these to the boiling water bath. Remove when a colour change becomes apparent. Note down the colour of the solution.

Worksheet H: Answers (ideal report)

Results:

Test-tube	Colour with iodine solution	Colour with Benedict's solution
1	Red/brown	Brick-red
2	Blue/black	Blue
3	Red/brown	Brick-red
4	Blue/black	Blue

Conclusion(s):

Acid hydrolysis of starch

A sample tested after boiling with hydrochloric acid gave a positive test (brick-red) for simple sugars. A sample without acid tested positive for the presence of starch (blue/black colour). Therefore, starch was only hydrolysed in the presence of hydrochloric acid.

Enzymatic hydrolysis of starch

A starch sample incubated with the enzyme amylase gave a positive test (brick-red) for simple sugars. Another sample without amylase tested positive for starch. Therefore, starch was hydrolysed only in the presence of amylase.

Worksheet H: Answers (ideal report)

Evaluation:

Overall fairness of experiment	• Hydrolysis using acid-Only one variable changed, so experimental results are valid. • Hydrolysis using amylase-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	• Volumes measured using the syringes due to lack of meniscus.
Improvements	• Each individual experiment should be carried out a minimum of three times and an average taken.

Worksheet J: Answers

1. The name given is the dependent variable.

2. This was done to allow the enzyme (amylase) to hydrolyse the starch whilst not denaturing.

3. The hydrochloric acid acted as a catalyst (to speed up the hydrolysis of starch).

4. To test for the presence of simple sugars like maltose and glucose.

5. (a) Simple sugars (like glucose, fructose or maltose)
(b) Negative results for test-tubes 2 and 4.

6. To test for the presence or absence of starch.

7. Controls.

8. To neutralise any hydrochloric acid.

9. No simple sugars would be present because the acid would denature the amylase.

10. Yes, as test-tube 2 took place in its absence and no simple sugars were formed.

11. The final reaction volumes in the test-tubes were the same (6 cm^3). Same method and apparatus used.

12. Repeat the experiments to see if the same results are obtained. See if the results can be obtained by other researchers.

Worksheet K: Answers

1. The starch molecule is too large to pass into the bloodstream.

2. The original starch must have been made of glucose and fructose molecules joined together.

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