Cambridge Assessment International Education

Teacher Pack

Investigating the effect of salinity on the density of water

Cambridge IGCSE®

Marine Science 0697

Version 1

Cambridge Pathway

® IGCSE is a registered trademark

Copyright © Cambridge University Press & Assessment 2022
Cambridge Assessment International Education is part of the Cambridge University Press & Assessment Group, which itself is a department of the University of Cambridge.

Cambridge University Press & Assessment retains the copyright on all its publications. Registered Centres are permitted to copy material from this booklet for their own internal use. However, we cannot give permission to Centres to photocopy any material that is acknowledged to a third party, even for internal use within a Centre.

Contents

Icons used in this pack:

Lab lesson: Option 1 – run the experiment

Lab lesson: Option 2 – virtual experiment

Debriefing lesson

Introduction

This pack will help you to develop your learners' practical skills as defined by assessment objective C (AOC Practical skills and investigations) in the course syllabus.

Important note
Our *Teacher Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging, particularly those that have been indicated as practical activities (PA) in the syllabus content. 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 2.

This is one of a range of *Teacher Packs* and each pack is based on one investigation. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

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 experimental skills.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experimental skills when field and lab work are not possible.

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases, it will also provide 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 pack you will find lesson plans, worksheets for learners and teacher resource sheets.

Experiment: Investigating the effect of salinity on the density of water

This *Teacher Pack* focuses on an experiment to investigate the effect of changing salinity on the density of water.

Salinity affects the density of water. This has important implications on the properties of the water and can also create or drive currents that move water all around the Earth's oceans.

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

- 2.2.7 describe salinity as the concentration of dissolved salts, using units of parts per thousand.
- 2.4.3 investigate the effect of salinity on density of water.

The experiment covers the following experimental skills, adapted from **AO3: Practical skills and investigations** (see syllabus for assessment objectives):

- demonstrate knowledge of experimental techniques, apparatus and materials and how to use them safely.
- make and record observations, measurements and estimates.
- interpret and evaluate experimental observations and data.

Prior knowledge

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

- 2.1 The water cycle
- 2.2 pH and salinity
- 2.4.1 describe density as mass per unit volume and recall and use the formula to calculate density

Going forward

The knowledge and skills gained from this experiment can be used for when you teach learners about the effects of increasing depth, and describing how abiotic factors change in an estuary during a tidal cycle.

Lab lesson: Option 1 – run the experiment

Resources (for each group)	• 2 x 10 cm3 measuring cylinders • 1 x 50 cm3 or 100 cm3 beaker • 100 cm3 of 50 ppt salt water • 100 cm3 of distilled water • an accurate electronic balance (capable of measuring to at least 0.1g – more precise results can be obtained with more precise balances) • Worksheets A and B
Learning objectives	By the end of the lesson: • ***all*** learners should record measurements of mass and volume and use these to calculate the density of a range of water samples. • ***most*** learners should be able to produce solutions of different salinities to investigate. • ***some*** learners will be able to produce repeat sets of results and calculate means for each salinity.

Timings	Activity
15 min	**Starter/Introduction** Discuss the term 'salinity' and the units for measuring this (ppt). Ask learners how many grams are in 1 kg, and how many cm^3 are in 1 dm^3 (1000 for each). Describe how we can use this to produce solutions of different salinities by dissolving *x* g of salt in 1 dm^3 of distilled water, this produces a solution of *x* ppt. Ask learners how to produce solutions of different salinities – many will suggest making 1 dm^3 of each salinity (e.g. 50 ppt, 40 ppt, 30 ppt, etc). Discuss the large volumes of water and masses of salt needed to achieve this, ask for alternative suggestions (e.g. smaller volumes and masses such as 5.0 g in 100 cm^3, or making a stock solution and diluting this down). Show learners how to produce a serial dilution from a stock solution of 50 ppt salt water. Then give learners Worksheet B (**Extend:** for more advanced learners you might want them to first design their own results table along the lines of that in Worksheet B – The *Designing Tables video* developed for AS&A Level Marine Science 9693 could be useful to show), and ask them to complete the volumes for saltwater and distilled water to make up the solutions at different salinities from the 50ppt stock solution:

Salinity (ppt)	Volume of 50 ppt saltwater to use / cm^3	Volume of distilled water to use / cm^3
50	10.0	0.0
40	8.0	2.0
30	6.0	4.0
20	4.0	6.0

10	2.0	8.0
0	0.0	10.0

Discuss the importance of precision in measuring volumes (remind how to read volumes accurately and precisely with a meniscus) and recording their results.

Recall how to measure density – learners need to measure the mass (in g) and volume (in cm^3) of the water samples. Discuss how to record the mass of only the water and not the water and container (e.g. using a 'tare' button).

Main lesson

Safety

Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe and that the data they are collecting is accurate.

Give learners Worksheet A. Learners work in pairs or small groups to produce samples of water of different salinities.

Learners record the masses and volumes of these samples and calculate the density of each sample, completing Worksheet B as they proceed.

Plenary

Discuss the results found and identify any trends – most learners should have results showing an increase in density as the salinity increases.

Discuss any anomalous results and reasons for these occurring – any anomalous results are most likely due to be errors in measuring the volumes of solutions.

Teacher notes

Watch the salinity and density video and read these notes.

Each group will require:

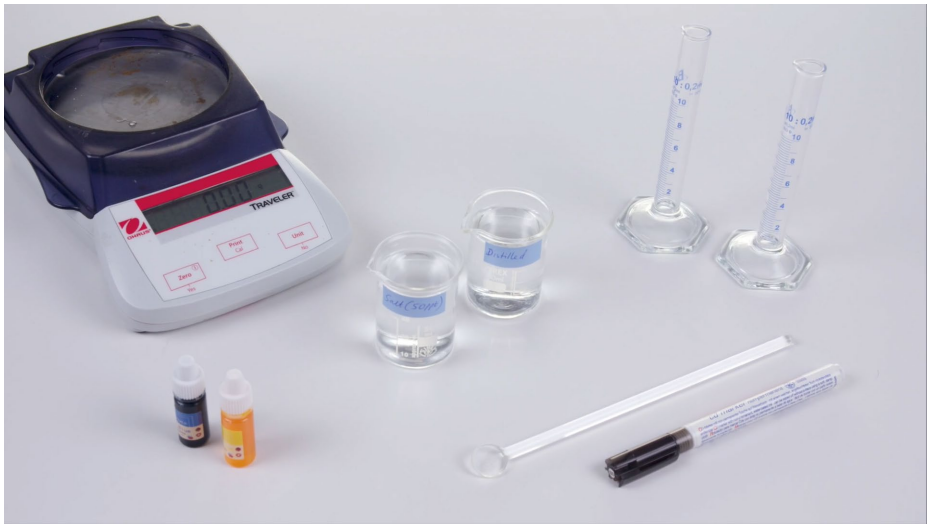
- 2 x 10 cm3 measuring cylinders
- 1 x 50 cm3 or 100 cm3 beaker
- 100 cm3 of 50 ppt salt water
- 100 cm3 of distilled water
- access to an accurate electronic balance (capable of measuring to at least 0.1g – more precise results can be obtained with more precise balances)

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.

Hazard	First aid
Risk of cuts due to sharps, e.g. broken glass. Wounds can lead to infection, especially if the point is contaminated.	**Minor cuts:** Rinse the wound with water. Get the casualty to apply a small, sterile dressing. **Severe cuts**: Lower the casualty to the floor. Raise the wound as high as possible. If feasible, ask the casualty to apply pressure on or as close to the cut as possible, using fingers, a pad of cloth or, better, a sterile dressing (adding further layers as necessary). If the casualty is unable to do so, apply pressure yourself, protecting your skin and clothes from contamination by blood if possible. Leave any embedded large bodies and press around them. Send for a first aider.

Experiment set-up



Teacher method

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

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

Before you begin

Plan how you will group your learners during the experiment session.

Think about:

- the number of groups you will need (group size 2–4 learners).
- the amount of equipment/volume of salt water samples required.

Experiment

Walk around the learners during the experiment in case they encounter any difficulties.

Step	Notes
Measuring volumes of water	Check learners are reading the meniscus correctly – offer guidance if they are not making their eyes level with the meniscus
Using the balance	Check learners are using the tare button (if available) or know how to record the mass of the beaker and subtract this from the mass of the beaker containing the water.
Calculating density	Check learners are carrying out the correct calculation (mass divided by volume).

Clean-up

After the experiment learners should:

- clean all glassware
- tidy up their work space
- ensure any spillages have been mopped up
- return all equipment and any unused solutions to you.

The salt water solutions should be flushed down the sink with tap water.

Lab lesson: Option 2 – virtual experiment

Resources	• Experiment video • Making a stock solution of salt water video
Learning objectives	By the end of the lesson: • ***all*** learners should record measurements of mass and volume and use these to calculate the density of a range of water samples • ***most*** learners should be able to use repeat sets of results and calculate means for each salinity • ***some*** learners will be able to describe how to produce solutions of different salinities

Timings	Activity
15 min	**Starter/Introduction** Discuss the term 'salinity' and the units for measuring this (ppt). Ask learners how many grams are in 1 kg, and how many cm^3 are in 1 dm^3 (1000 for each). Describe how we can use this to produce solutions of different salinities by dissolving *x* g of salt in 1 dm^3 of distilled water, this produces a solution of *x* ppt. Ask learners how to produce solutions of different salinities – many will suggest making 1 dm^3 of each salinity (e.g. 50 ppt, 40 ppt, 30 ppt, etc). Discuss the large volumes of water and masses of salt needed to achieve this, ask for alternative suggestions (e.g. smaller volumes and masses such as 5.0 g in 100 cm^3, or making a stock solution and diluting this down). Show learners the *Making a stock solution of salt water* video. This shows how a stock solution of 40ppt salt water can be made up. The ask learners how to produce a serial dilution from a stock solution of 50 ppt salt water. Use Worksheet B, which shows how the 50ppt stock solution is made up for this experiment, and ask learners to complete the columns for volumes of salt water and distilled water to make up the dilutions:

Salinity (ppt)	Volume of 50 ppt saltwater to use / cm^3	Volume of distilled water to use / cm^3
50	10.0	0.0
40	8.0	2.0
30	6.0	4.0
20	4.0	6.0
10	2.0	8.0
0	0.0	10.0

Discuss the importance of precision in measuring volumes (remind how to read volumes accurately and precisely with a meniscus) and recording their results.

	Recall how to measure density – learners need to measure the mass (in g) and volume (in cm^3) of the water samples.
	**Main lesson** Learners watch the *virtual experiment video* showing the masses and volumes of each sample of water of different salinities. At various points in the video, it will pause and ask the learner to enter the sample mass values onto their results table. They should do this using Worksheet B. Learners record the masses and volumes of these samples and calculate the density of each sample on the worksheet. Learners can compare their results to what is shown on screen and/or you can give them a copy of the completed table on Worksheet B answers.
	**Plenary** Discuss the results found and identify any trends – most learners should have results showing an increase in density as the salinity increases. Discuss any anomalous results and reasons for these occurring – any anomalous results are most likely due to be errors in measuring the volumes of solutions.

Debriefing lesson: Investigating the effect of salinity on the density of water

Resources	• graph paper • two contrasting food dyes (to colour distilled water and salt water)
Learning objectives	By the end of the lesson: • ***all*** learners should plot a line graph of the data collected • ***most*** learners should be able to draw a suitable line of best fit • ***some*** learners will be able to explain their results using ideas about particles and dissolving

Timings	Activity
10 min	**Starter/Introduction** Recall the practical and ask learners to describe how to prepare 5 solutions of different salinity from a stock solution of 50 ppt salt water. Discuss the trend in the results collected (you can share Worksheet B answers again) and the most appropriate form of graph to show the trend (a line graph). The *Drawing Graphs video* developed for AS&A Level Marine Science 9693 may be useful here. Discuss the orientation of the axes (the independent variable is plotted on the x-axis and the dependent variable on the y-axis). Discuss using the space available to choose an appropriate scale (try to use increments of 1, 2, 5 or 10 for ease of plotting and checking plots). If plots will all fit in less than half the scale, then consider doubling the scale so the plots occupy more than half the scale.
30 min	**Main lesson** Learners plot graphs of their data. Check the scales are appropriate as they do this and encourage learners to re-draw graphs with inappropriate scales or axes to make best use of the space available. Use this exercise as an opportunity for learners to develop and improve their graph drawing skills. Encourage learners to swap their graphs with another learner and check each others plotting and graph skills – provide feedback to each other on the accuracy of the plotting and use of space available. If the experiment was carried out precisely enough there should be a trend in the data showing a linear increase in density as the salinity increases. Encourage learners to draw a straight or smooth curve of best fit most appropriate for the data collected – avoid a 'dot-to-dot' for joining the plots.

Plenary

Discuss reasons for changes in salinity in sea water – examples include precipitation (e.g. rain), melting sea ice and run-off from land adding fresh water to the oceans reducing salinity, and the evaporation and freezing of sea water increasing salinity. The Investigating the effect of salinity on the freezing point of water video produced for AS&A Level Marine Science 9693 could be a useful resource to watch, as it highlights the effect of salinity on ocean currents.

Demonstrate (or allow learners to try for themselves) how less saline water of a lower density floats above more saline water due to their difference in density (this is also demonstrated in the video).

Ask learners to suggest why more saline water is denser – some learners may realise that dissolved salts occupy some of the space between the water molecules so there are more particles (and therefore more mass) in the same volume of solution.

Worksheets and answers

	Worksheets	Answers
For use in *Lab lesson: Option 1: Run the experiment*		
A: Method	**15**	
B: Results	**16**	17
For use in *Lab lesson: Option 2: Virtual experiment*		
B: Results	**16**	**17**

Worksheet A: Method

1. Collect all your equipment from the front of the class.
2. Use a measuring cylinder (label this measuring cylinder ’50 ppt salt water’) to measure exactly 10 cm^3 of 50 ppt salt water.
3. Place the beaker on to the balance and zero (‘tare’) the balance.
4. Add all of the salt water from the measuring cylinder into the beaker – take care not to spill any as this will affect the results.
5. Record the mass of the 10 cm^3 sample of 50 ppt salt water.
6. Repeat steps 2–5 two more times to give you three results for 50 ppt salt water.
7. Use the measuring cylinder to measure exactly 8 cm^3 of 50 ppt salt water.
8. Use the second measuring cylinder (label this ‘distilled water) to measure exactly 2 cm^3 of distilled water. When this is added to the 8 cm^3 of 50 of salt water in the beaker, it will produce a total volume of exactly 10 cm^3 (this will be 40 ppt salt water).
9. Place the beaker on to the balance and zero the balance.
10. Carefully add the salt water measured in step 7 and the distilled water measured in step 8 into the beaker.
11. Record the mass of the 10 cm^3 sample of 40 ppt salt water in your results table.
12. Repeat steps 7–11 two more times to give you three results for 40 ppt salt water.
13. Repeat steps 7–12 for: 30 ppt (6 cm^3 of 50 ppt salt water and 4 cm^3 of distilled water)
    i. 20 ppt (4 cm^3 of 50 ppt salt water and 6 cm^3 of distilled water)
    ii. 10 ppt (2 cm^3 of 50 ppt salt water and 8 cm^3 of distilled water)
    iii. 0 ppt (10 cm^3 of distilled water only).

Worksheet B: Results

Volume of 50 ppt salt water used / cm^3	Volume of distilled water used / cm^3	Salinity of water produced / ppt	Mass of water sample / g				Density of water sample / g cm^{-3}
			Trial 1	Trial 2	Trial 3	Mean	
10	0	50					
		40					
		30					
		20					
		10					
		0					

Worksheet B Answers: Results

Volume of 50 ppt salt water used / cm^3	Volume of distilled water used / cm^3	Salinity of water produced / ppt	Mass of water sample / g				Density of water sample / g cm^{-3}
			Trial 1	Trial 2	Trial 3	Mean	
10	0	50	10.32	10.36	10.34	10.34	1.034
8	2	40	10.28	10.27	10.28	10.28	1.028
6	4	30	10.20	10.22	10.19	10.20	1.020
4	6	20	10.13	10.13	10.15	10.14	1.014
2	8	10	10.08	10.07	10.06	10.07	1.007
0	10	0	9.92	10.02	10.02	9.99	0.999

Cambridge Assessment International Education
The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA, United Kingdom
t: +44 1223 553554
e: **info@cambridgeinternational.org** **www.cambridgeinternational.org**

Copyright © Cambridge University Press & Assessment 2022