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91413



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Mana Tohu Mātauranga o Aotearoa  
New Zealand Qualifications Authority

## Level 3 Earth & Space Science 2023

### 91413 Demonstrate understanding of processes in the ocean system

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of processes in the ocean system.	Demonstrate in-depth understanding of processes in the ocean system.	Demonstrate comprehensive understanding of processes in the ocean system.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

**You should attempt ALL the questions in this booklet.**

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (DO NOT WRITE IN THIS AREA). This area will be cut off when the booklet is marked.

**YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.**

Merit

TOTAL 15

## QUESTION ONE: CARBON DIOXIDE ABSORPTION AT THE POLES



**Figure 1: Global ice area since 1979**

Source: <https://tamino.wordpress.com/2011/01/14/monckton-skewers-truth/>

Deep ocean currents store carbon dioxide and reduce its concentration in the atmosphere. However, polar ice has been reducing as a result of climate change, and melting polar ice may disrupt the ocean currents that enable this removal of carbon dioxide.

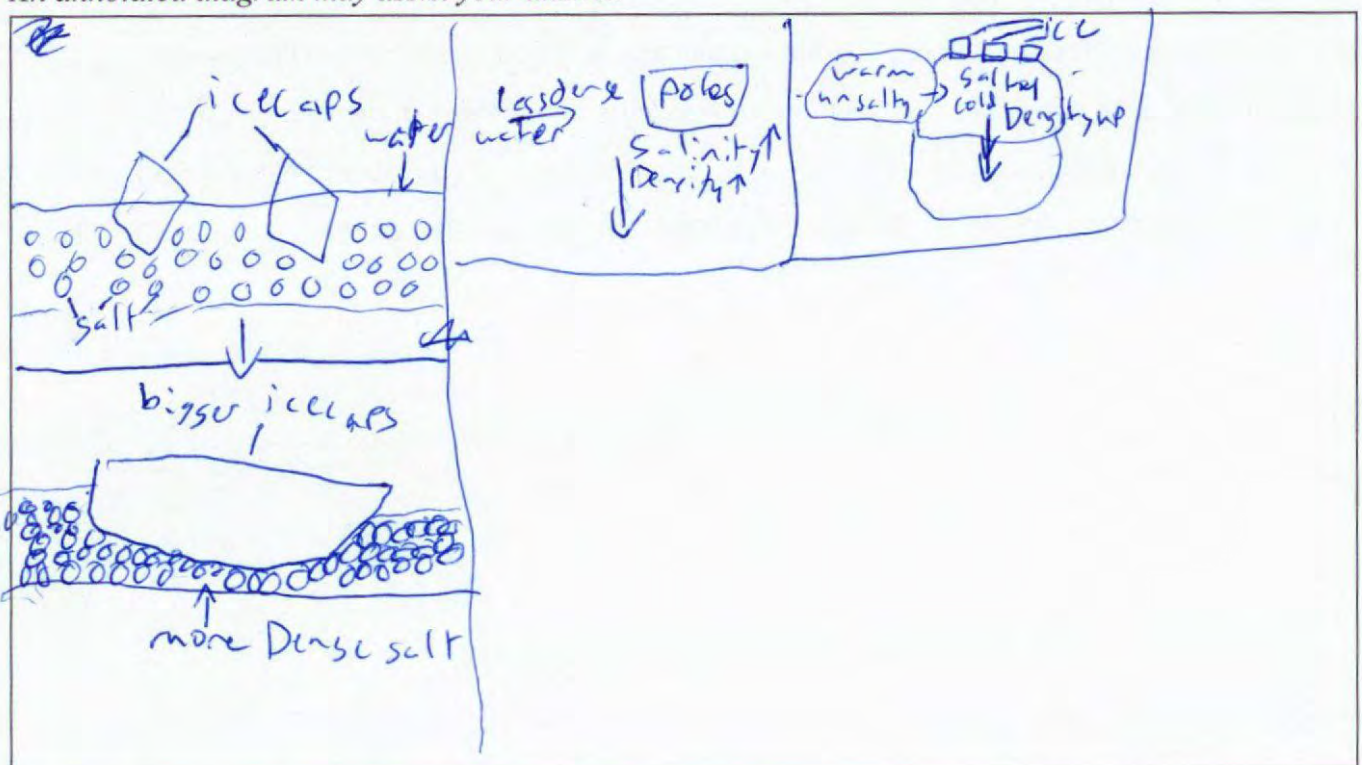
Explain the significance of melting polar ice in the removal of atmospheric carbon dioxide.

In your answer, you should consider:

- the causes of downwelling at the poles
- the physical ocean carbon pump at high latitudes
- the significance of melting ice to the polar ocean surface.

*You do not need to discuss carbon chemistry or thermohaline circulation.*

*An annotated diagram may assist your answer.*





the melting polar ice caps are very significant in the removal of atmospheric carbon dioxide. the first reason to this is the cause of the massive downwells at the poles. this is the ice caps themselves. when water comes to the poles at the surface it becomes cold eventually it becomes so cold that it begins to freeze ~~and it sticks to~~ onto the polar ice caps causing them to grow. this results in a number of things most importantly an increased salinity. because the water has frozen the amount of water in the ocean has decreased however salt does not freeze with the ice so it builds up in the surrounding water. this increases the density of the ~~water~~ remaining water causing it to ~~sink~~ sink below the less dense water flowing to the poles from the warmer regions of the earth. ~~this effect is furthered by~~ this effect works to absorb carbon from the atmosphere. this is because water absorbs carbon dioxide ~~by combining with it to form~~ bicarbonate and carbonic acid. so when the water ~~absorbs the carbon dioxide~~ that has absorbed carbon dioxide sinks due to increased salinity and colder ~~temperatures~~ ~~some of these~~

There is more space for your answer to this question on the following pages.



the absorbed carbon sinks with it stopping it from being released back into the atmosphere. This is the physical carbon pump and is one of the major ways that carbon leaves the atmosphere. ~~The next~~

The melting icecaps will pose a significant issue to the physical carbon pump. This is because it will slow or stop the large increases in salinity that occur to create the pump by slowing the freezing of ice at the poles. The lack of increasing salinity means that the density of water at the poles will not be high enough for the water ~~to sink~~ and absorb carbon to sink into the ocean where the carbon cannot be released, ~~stopping~~ stopping the physical carbon pump.





## QUESTION TWO: MARINE HEATWAVES

When the surface ocean temperature is unusually high for a period of time, scientists consider this to be a marine heatwave. These events cause habitat destruction due to coral bleaching, seagrass destruction, and loss of kelp forests, as well as the death of fish and other marine species.



**Figure 2: 2021–2022 marine heatwave in Fiordland, southwest New Zealand**

Adapted from: [www.odt.co.nz/regions/southland/bleaching-fiordland-sea-sponges-may-be-largest-its-kind](http://www.odt.co.nz/regions/southland/bleaching-fiordland-sea-sponges-may-be-largest-its-kind)

In recent years, the coastal waters around New Zealand have experienced some of the most extreme and persistent marine heatwaves on record, with Fiordland reaching 6 °C higher than previously recorded maximum temperatures. The warm water was likely caused by a mixture of climate change and the prolonged La Niña conditions.

Discuss how climate change and La Niña may contribute to the increasing frequency and severity of marine heatwaves around New Zealand.

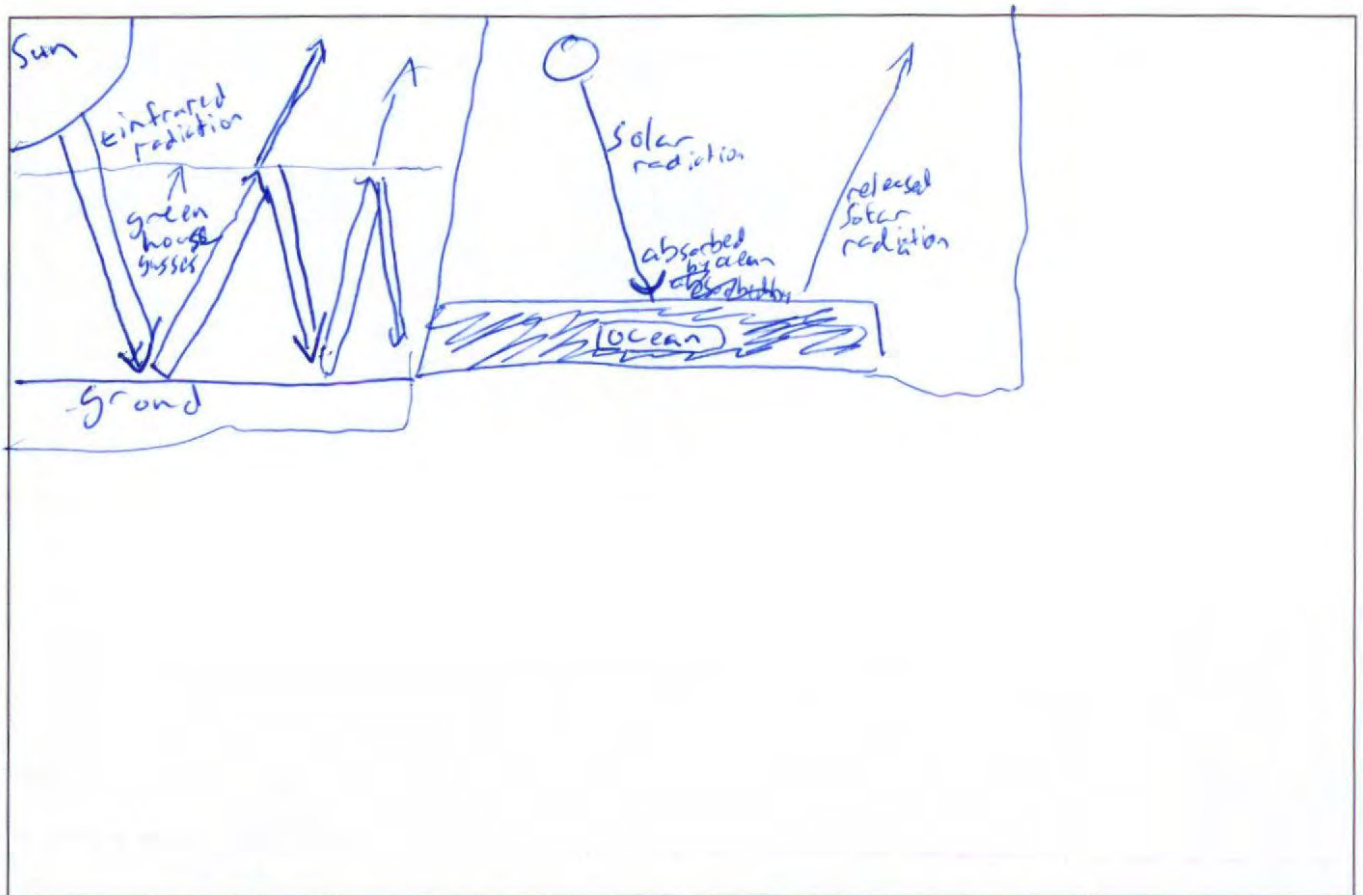
In your answer, you should consider:

- how the surface layer of the ocean is heated
- the effects of climate change on surface water temperature
- the effect of La Niña on the surface water temperature around New Zealand.

*An annotated diagram may assist your answer.*

the ocean is heated mostly by a combination of solar radiation from the sun and surrounding air temperature. Solar radiation heats up the ocean because water absorbs it at a high rate due to its dark ~~color~~ colour. This solar radiation heats up the water when it is absorbed and





is eventually released by the ocean back into the atmosphere. ~~the atmosphere is a temperature~~  
~~change is a process that is slowly warming the earth this is due to greenhouse gasses like carbon dioxide and methane, greenhouse gasses in the atmosphere cause solar radiation that is leaving the earth to bounce back towards the surface this causes a build up of solar radiation in the earth's system warming up the earth. Climate change is causing surface water temperatures to rise because it increases the amount of energy that is in the ocean at any given time by bouncing back some of the solar~~ climate change is a process that is slowly warming the earth this is due to greenhouse gasses like carbon dioxide and methane, greenhouse gasses in the atmosphere cause solar radiation that is leaving the earth to bounce back towards the surface this causes a build up of solar radiation in the earth's system warming up the earth. Climate change is causing surface water temperatures to rise because it increases the amount of energy that is in the ocean at any given time by bouncing back some of the solar

There is more space for your answer to this question on the following pages.



radiation that had already been released by the ocean back towards the ocean to be reabsorbed in addition to new solar radiation from the sun.





### QUESTION THREE: THE MOST PLASTIC-POLLUTED ISLAND ON EARTH

Henderson Island is a tiny uninhabited island in the Pitcairn Islands, and lies within the South Pacific Gyre. Beaches on Henderson Island contain an estimated 38 million items of plastic debris. On the island, researchers have found plastic rubbish from South America, Australia, and even as far away as Europe.



**Figure 3: Ocean currents around Henderson Island and plastic rubbish on its beaches**

Source: [www.weforum.org/agenda/2017/05/the-untouched-south-pacific-island-choking-on-38-million-bits-of-plastic/](http://www.weforum.org/agenda/2017/05/the-untouched-south-pacific-island-choking-on-38-million-bits-of-plastic/)

Discuss how surface ocean circulation has led to such a large accumulation of plastic debris on Henderson Island.

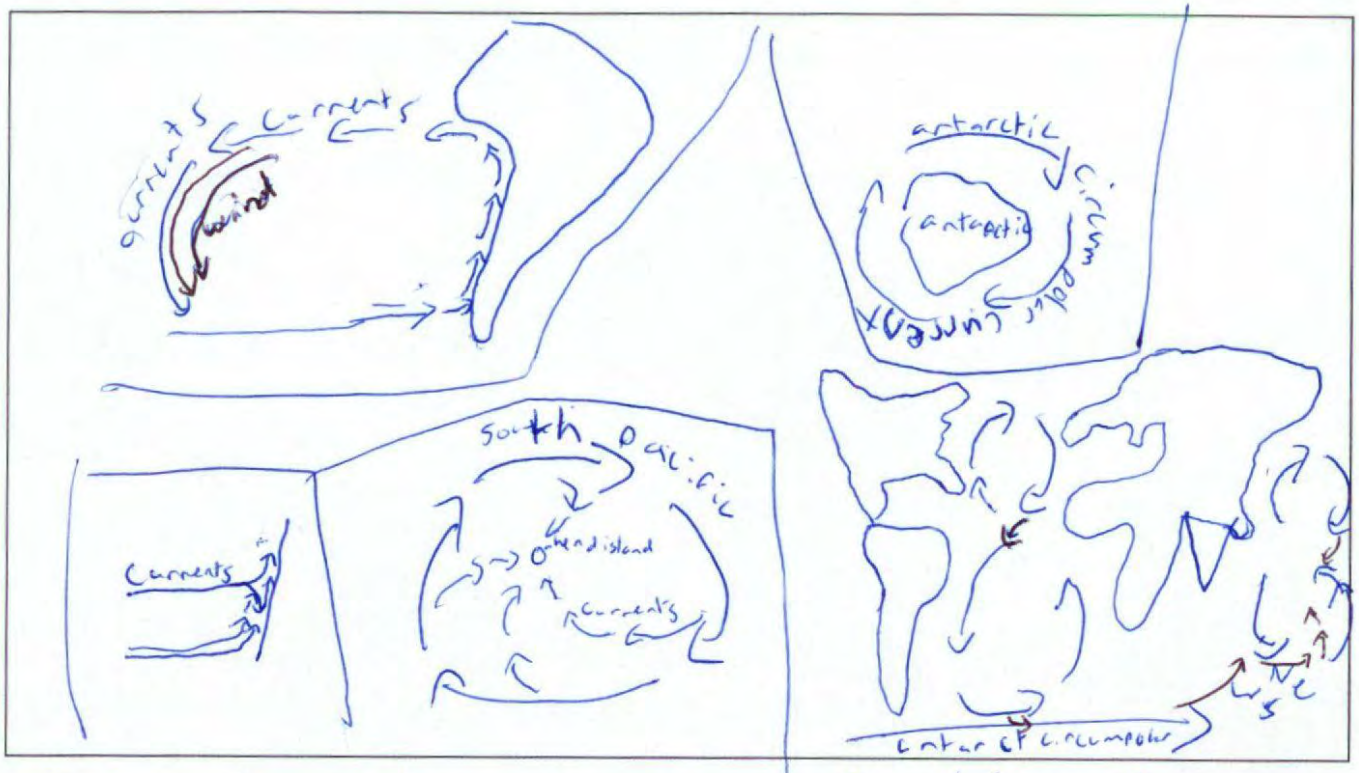
In your answer, you should consider:

- how the South Pacific Gyre is formed
- how the Antarctic Circumpolar Current is formed
- how plastic debris travels thousands of kilometres from around the globe to accumulate on Henderson Island.

An annotated diagram may assist your answer.

The South Pacific gyre is a current that is ~~in the South Pacific~~ flows throughout the South Pacific. It is created by large flows of water being pushed by the wind hitting South America where ~~the~~ to ~~the~~ it is pushed into the continent. This pushes the water in both directions however.





due to the shape of the landmass most of the water is forced to go north where it will eventually hit a large outcroppings in the continent that forces the water to head ~~east~~ west again. after moving east it is then slowly turned by the wind more south again before ~~east~~ meeting the antarctic circumpolar current and heading east again towards south america. the antarctic circumpolar current is created by the high winds that surround the antarctic. ~~in addition to~~ within the South Pacific gyre Henderson island is the and the surrounding area is where the most debris builds up this is because it is near the centre where ~~currents~~ <sup>smaller</sup> currents from every side of the gyre push towards this results in Henderson island

There is more space for your answer to this question on the following pages.



building up incredible amounts of debris. the debris from places very far away from the Pacific also makes sense European and American debris would travel through the Atlantic gyres until ~~the~~ the debris is picked up by the Antarctic circumpolar current it is then carried until it is passed to the ~~the~~ South Pacific gyre. ~~the~~





## Merit

**Subject:** Earth & Space Science

**Standard:** 91413

**Total score:** 15

Q	Grade score	Marker commentary
One	M6	<p>The candidate explains the process of ice formation leading to increased salinity and denser water, and how this results in downwelling.</p> <p>They also explain and link how melting ice reduces the salinity, therefore the density, causing a reduction in downwelling.</p> <p>Finally, they link how warmer waters at lower latitudes reduces the dissolving of carbon dioxide compared to the poles.</p>
Two	M5	<p>The candidate describes absorption of solar energy by the surface layer of the ocean.</p> <p>They link the warming of the atmosphere due to greenhouse gases and to the warming of the surface layer of the ocean.</p>
Three	A4	<p>The candidate states that South America deflects surface currents, and links the circular direction of the SPG to bordering landmasses and the ACC.</p> <p>They describe how ocean currents are linked together to transfer debris to the SPG, and how the circular motion of the SPG draws debris into the middle where Henderson Island is located. The explanation lacks details of the cause and effect to meet the Merit criteria.</p>