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91414



914140



NEW ZEALAND QUALIFICATIONS AUTHORITY  
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## Level 3 Earth and Space Science, 2019

### 91414 Demonstrate understanding of processes in the atmosphere system

2.00 p.m. Thursday 28 November 2019  
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of processes in the atmosphere system.	Demonstrate in-depth understanding of processes in the atmosphere system.	Demonstrate comprehensive understanding of processes in the atmosphere 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 and clearly number the question.

Check that this booklet has pages 2–15 in the correct order and that none of these pages is blank.

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

Excellence

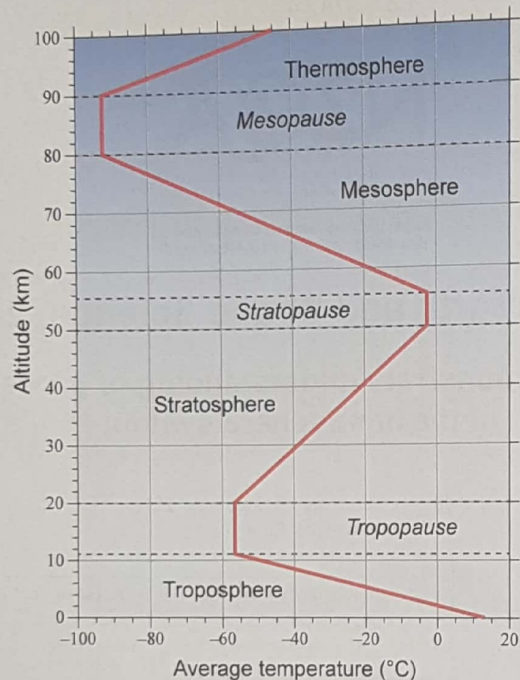
TOTAL

21

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# QUESTION ONE: TEMPERATURE WITHIN THE ATMOSPHERE

The graph below shows the **average** temperature gradient for the Earth's atmosphere.



Adapted from: [www.physicalgeography.net/fundamentals/images/atmslayers.gif](http://www.physicalgeography.net/fundamentals/images/atmslayers.gif)

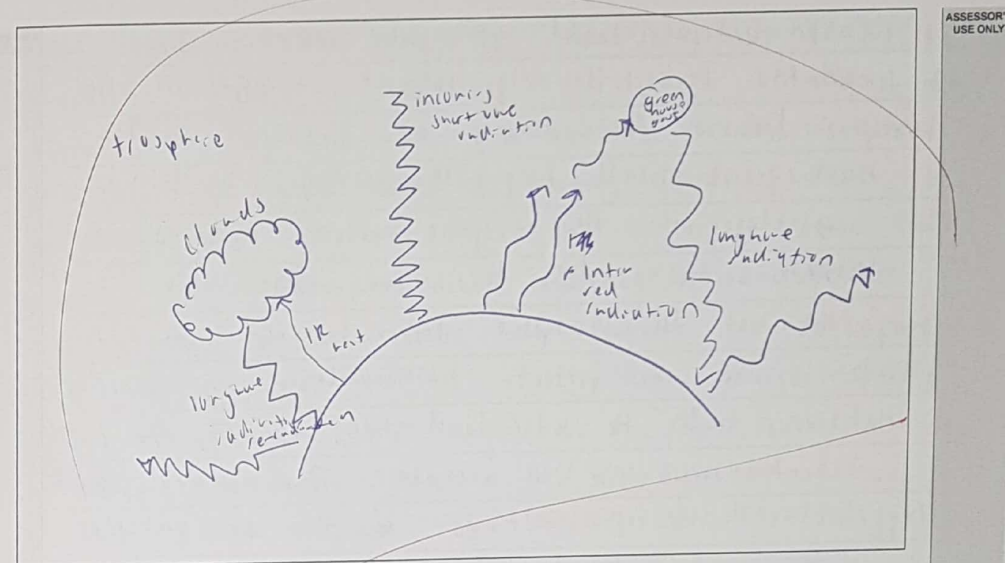
Explain the temperature gradient graph.

In your answer, you should consider:

- the heat source of each layer, and the type of radiation involved
- reasons for the temperature changes shown
- the effect of changes in latitude and seasons on the height of the troposphere.

You may use a diagram to help support your answer.

The earth's atmosphere is the layer of air around the earth. It is divided into five layers: the troposphere, stratosphere, mesosphere & thermosphere. The troposphere & mesosphere decrease in temperature with altitude whereas the stratosphere & thermosphere increase in temperature when altitude increases. This is a result of the various heat sources for each of the



layers, which produce the temperature gradient seen on the graph. The tropopause, stratopause & mesopause demonstrate a change in layer & are characterised by rather rapid temperature change.

The thermosphere temperature increases with an increase in altitude because the particles in the thermosphere are closer to the sun. The type of radiation involved include UV rays, x-rays, and gamma rays. When the air particles in the thermosphere receive massive amounts of heat energy & UV rays, these UV rays rip protons of the air particles to form the ionosphere. This also produces an extreme amount of heat energy warming the top of the thermosphere. The ionosphere then acts to protect the earth from gamma & x-rays. Even though the particles in the thermosphere

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



receive an extreme amount of solar radiation the temperature is still only about  $-45^{\circ}\text{C}$  in the thermosphere because the density of particles is low so therefore, the overall temperature reading will be low. The next layer is the mesosphere where meteoroids & asteroids burn up due to friction. ~~Here~~ The temperature of the mesosphere decreases with increase altitude because the particles don't undergo any reaction or relationship with the solar radiation. Therefore, there is no heat source for the mesosphere. This means that temperature will decrease altitude as the air particles get further and further away from the heat of the below layers.

The next layer is the stratosphere. The temperature of this layer increases with an increase in altitude because of the ozone layer acting as a heat source. The ozone layer is found in the upper stratosphere which is why the temperature of the stratosphere increases with increased altitude. The ozone layer acts to protect the earth's surface from harmful UV rays. ~~then the temperature then~~ So therefore, the type of radiation involved is UV. When the UV light hits the ozone layer it transforms  $\text{O}_2$  into  $\text{O}_3$  molecules. This process causes the particles in the ozone layer to gain kinetic energy and therefore, produce heat. This causes the ozone layer to release heat into the upper stratosphere warming this layer, which is why the temperature of the stratosphere increases with increase altitude.

The troposphere ~~then~~ temperature decreases with an increase in altitude because the base of the atmosphere (the part closest to earth) is the warmest part of the earth. ~~then~~ Incoming shortwave solar radiation from the sun hits the earth's surface warming it. The earth then absorbs this radiation and emits it as infra red longwave radiation. This IR longwave radiation then warms the lower layers of the troposphere and acts as a heat source. ~~then~~ Greenhouse gases and clouds also act to warm the troposphere by absorbing this returning IR radiation and re-radiating back to earth as longwave radiation. These processes act to warm the lower troposphere. This heat is then slowly lost as altitude increases in the troposphere causing the temperature to decrease as the altitude increases. Changes in latitude sun input the amount of height of the troposphere. This is because different latitudes receive different amounts of solar radiation. For example the equator receives more sunlight than the poles because the solar radiation has a shorter distance to travel so there is less scattering by dust & water vapour meaning more heat energy reaches the surface at the equator than at the poles. At the equator the sun also hits on a higher angle so more radiation reaches the surface. Because of this the air is warmer at the equator than at the poles which causes the air to expand because less dense which increased the height.

## QUESTION TWO: THE ROARING FORTIES AND THE WEST COAST OF NEW ZEALAND

Sailors call the latitudes between  $40^\circ$  and  $50^\circ$  south the 'Roaring Forties'. New Zealand lies in the 'Roaring Forties', represented by the green band on the map below.

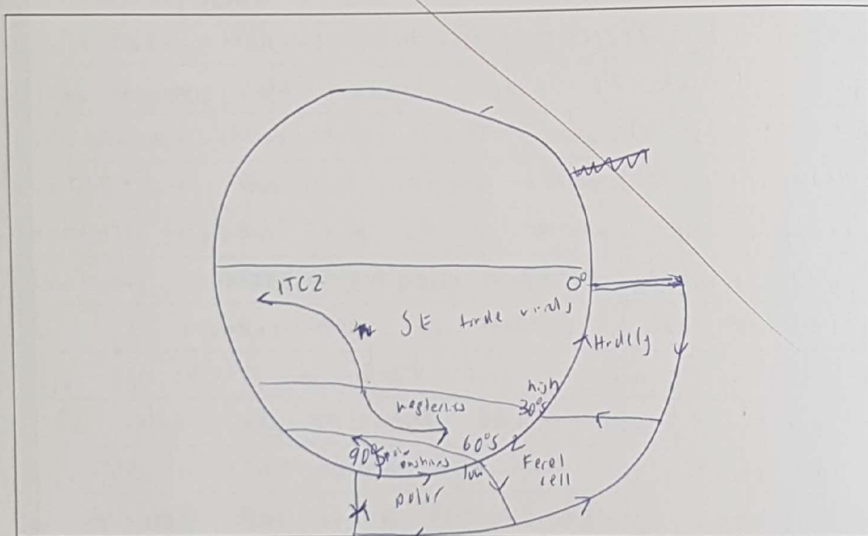
Source: [http://www.thesuperfins.com/wp-content/uploads/2017/02/001-the-Roaring-Forties-TheSuperfins.com\\_.jpg](http://www.thesuperfins.com/wp-content/uploads/2017/02/001-the-Roaring-Forties-TheSuperfins.com_.jpg)

Explain how the westerly winds of the 'roaring forties' are formed, AND how these contribute to the high annual precipitation rates found on the west coast of the South Island of New Zealand.

In your answer, you should consider:

- the role of solar heating and air pressure on wind formation
- the role of the Coriolis effect on the westerly wind belt
- the role of the Southern Alps in the South Island on precipitation rates.

You may use a diagram to help support your answer.



The factors which influence wind formation are the uneven solar heating of the earth and air pressure. The earth's surface is heated unevenly.

because the distance between the sun & the equator is shorter than the distance between the sun & poles. The poles receive little solar radiation as it has to travel a long distance to reach the surface at the poles so more of the ~~heat~~ solar energy is reflected by dust & water vapour before it can reach the surface. The solar radiation also hits the earth's surface at a low angle at the poles which means this small amount of radiation is spread over a large surface area. Because of this  $40^\circ\text{S}$  will be much colder than  $60^\circ\text{S}$ . At  $60^\circ\text{S}$  the air is warmer than the surrounding polar air so it is less dense and because it is less dense than the surrounding air it will rise and cool. Forming an area of low pressure at  $60^\circ\text{S}$ . As the air rises it travels across to  $30^\circ\text{S}$ . The air has lost a lot of heat from rising and then travelling across to  $30^\circ\text{S}$  so therefore, it is cooler than the surrounding air. Because the air is cooler than the surrounding air it is also denser which means the air will sink at  $30^\circ\text{S}$  forming an area of high pressure at  $30^\circ\text{S}$ . The difference in pressure between  $30^\circ\text{S}$  and  $60^\circ\text{S}$  will cause the air to flow from an area of high pressure to an area of low pressure. This produces winds. However, these winds don't travel directly from  $30^\circ\text{S}$  to  $60^\circ\text{S}$  the air is instead deflected by the Coriolis effect. The

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



Coriolis effect is the deflection of winds or objects from their original path of travel as a result of the rotation of the earth on its axis. It impacts the winds between  $30^\circ$  +  $60^\circ$  because of the large distance which they travel.

Because the winds are in the Southern Hemisphere the winds will be deflected anticlockwise causing the winds to blow in a westerly direction forming the prevailing winds.

These strong westerly winds contribute to the high precipitation rates in New Zealand.

Because as the wind blows towards NZ across the Tasman sea it picks up moisture from the water.

The friction on the water leads to the evaporation of water which is then carried by the wind. When this moisture dense wind

hits the ~~south~~ west coast of the South Island of NZ it is forced to rise due to the

presence of the Southern Alps. As this air rises it cools. This causes the water to

cool to its dew point. When the water reaches its dew point it will condense around aerosols

releasing latent heat into the environment. These

water saturated aerosols will then combine to form clouds. The clouds will eventually become very heavy

with water vapour until they reach the point where they can no longer hold any more. This causes

heavy rain to fall often along the west coast of the South Islands. Because the air has lost all

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of its moisture when it travels over the ~~south~~ Southern Alps to the Canterbury plains the

dry is very dry. Therefore, there is <sup>consequently</sup> little to no rain fall at this ~~part~~ region of NZ.

This phenomenon is known as a rain shadow.

It is because of this ~~process~~ process that the west coast of the South Island receive such

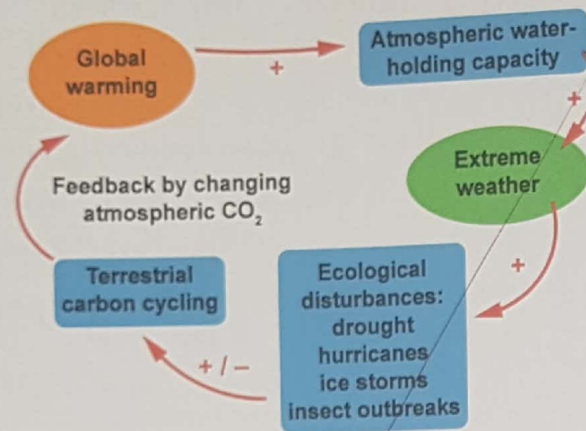
high precipitation rates and the east coast of the New Zealand receive such low precipitation

rates

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### QUESTION THREE: THE CARBON AND WATER CYCLES

The carbon and water cycles are closely linked, and help to regulate the Earth's temperature. One example of this is shown in the diagram below.



Adapted from: <https://iopscience.iop.org/article/10.1088/1748-9326/10/7/070201/pdf>

Explain how changes to the carbon AND water cycles can **influence** climate change.

In your answer, you should consider:

- how the Earth's temperature affects the water cycle
- the role of the carbon cycle in the Earth's temperature regulation
- how human activities have changed the carbon and water cycles.

You may use a diagram to help support your answer.



The carbon cycle decreases the ~~temperature~~ earth's temperature regulation through the ability of the oceans to absorb <sup>CO<sub>2</sub></sup> water & the amount of greenhouse gases in the earth's atmosphere. Recently a global industrial revolution has led to the vast increase in the amount of greenhouse gases in the earth's atmosphere, by increasing the amount of CO<sub>2</sub> in the atmosphere. Increasing the amount of CO<sub>2</sub> in the atmosphere acts to warm the planet because the greenhouse gases ~~absorb~~ absorb and re-radiate the energy as long wave radiation back to earth causing warming. This temperature increase is leading to climate change. One of the reasons for this is the strong influence the increased temperatures have had on the earth's water cycle. The higher temperatures influence the earth's water cycle because it ~~also~~ with causes more ice melt at the poles. This can be seen as a positive feedback cycle because the increased temperature leads to a decrease in the amount of ice at the poles through melting. And because of the decrease in polar ice there is less reflection of solar energy by the white ice caps leading to an increase in warming leading to an increase in ice cap melt and so on. It can also influence the earth's climate because warmer temperatures will lead to more evaporation especially at the poles. This will

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



lead to greater amount of cloud formation than the increase in ~~precipitation~~ evaporation leading to an increase in the precipitation <sup>& more extreme weather</sup> ~~rate~~. This could act in both a negative and positive feedback system. It could act negatively by increasing the amount of reflection of solar radiation by the clouds leading to a decrease in the amount of warming. Or it could act in a positive feedback loop by trapping ~~the~~ and re-radiating longwave radiation back down to earth increasing the global warming & climate change.

The increase in temperature as a result of the increase greenhouse gases could also cause climate change as there would be an earlier onset of spring conditions as a result of earlier snow melt coming on off.

So overall the human activities of increasing the concentration of CO<sub>2</sub> in the atmosphere have changed the carbon cycle by increasing the amount of CO<sub>2</sub> present increasing the temperature of the globe. This temperature increase is having a massive impact on the water cycle of the earth leading to climate change.

Another example of a potential negative feedback system through changes in the water cycle is the higher evaporation rates leading to desertification, then the deserts will have a higher albedo increasing ~~on~~ <sup>the</sup> amount of

of deflection of solar rays leading to a cooling effect ~~leading to climate change~~.

m6

Extra paper if required.  
Write the question number(s) if applicable.

QUESTION  
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of the troposphere at the equator compared to at the poles. The height of the troposphere can also be altered due to seasons because during summer that particular section of the earth will be receiving a greater amount of solar radiation causing the gases to expand and become less dense increasing the height of the troposphere. Compared to winter months where less heat energy is received.

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## ESS 91414 Annotated exemplars 2019

Subject	ESS	Standard	91414	Total score	21
Q	Grade score	Annotation			
1	E8	Has explained how each layer is heated and why there are differences in the height of the troposphere at different times of the year.			
2	E7	Has explained all Merit points with minor error/lack of clarity with the wording in the explanation of the wind direction.			
3	M6	Has explained an implication of increase in carbon dioxide on the climate. Has also explained the implication of increased carbon dioxide, therefore higher temperature on the water cycle in terms of ice melting. Final explanation of the implications of increased clouds on the water cycle linked to climate change. Excellence required further links to the carbon and water cycles.			

Confirmation of check	Y / N
This exemplar has been checked for similarities with current online exemplars.	Y