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Draw a cross through the box (☒) if you have NOT written in this booklet

NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Earth & Space Science 2023

91414 Demonstrate understanding of processes in the atmosphere system

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.

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 (). 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 17

QUESTION ONE: FLYING HIGH

Pilots of jet aircraft that fly long distances prefer to fly in the lower stratosphere. In the stratosphere, atmospheric conditions have less turbulence which is caused by the vertical movement of air. Aircraft also have better fuel efficiency, as the air is thinner. However, jet engines need sufficient oxygen to work. Sometimes pilots make use of jet streams in the upper troposphere.

Figure 1: Jet stream locations **Figure 2: The stratosphere and troposphere**

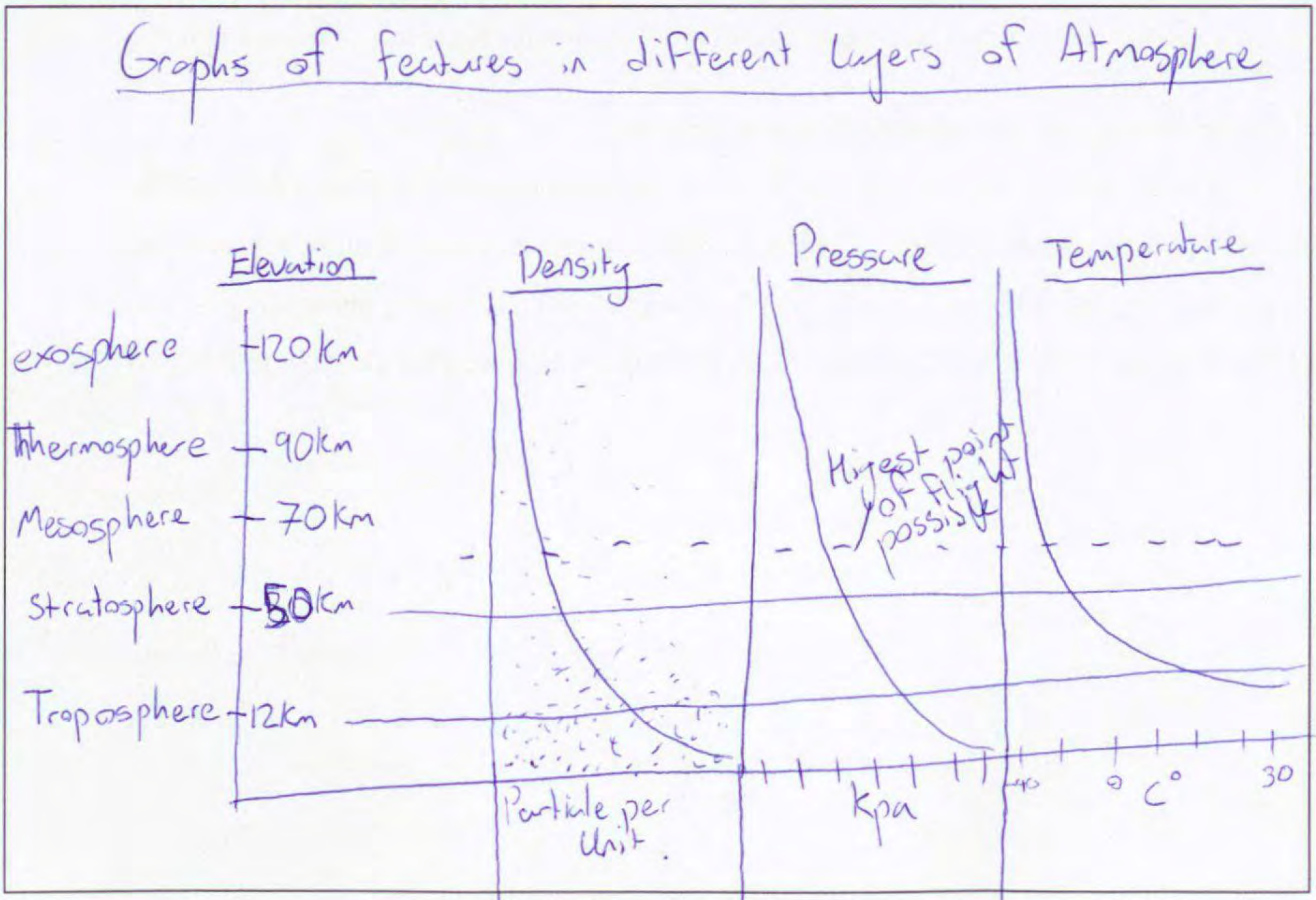
Source: www.weather.gov/jetstream/jet Source: https://geoengineering.global/stratospheric-aerosol-injection/

Discuss why pilots prefer to fly in the stratosphere, instead of the troposphere.

In your answer, you should explain:

- differences in density, pressure, temperature, and composition of the troposphere and stratosphere
- atmospheric conditions in both layers, and how this may impact on flights
- how jet streams may help or hinder flights.

An annotated diagram may assist your answer.



Temperature in the Atmosphere decreases in elevation as earth is the heat sorce. As the Sun heats the earths surface the Air in the troposphere is closer to the heat source and therefore warmer closer to earth.
Density messured in particles per areea are again higher in the Troposphere then the Stratosphere. This is because there is more gas both natural and man made like CO_2 and O_2 in the troposhere than compeered to decreasing amounts the higher you go; as seen in the diagram. This also directly interacts with pressure as with more particles there is more pressure in a certian area unlike higher in the atmosphere.

What this results in is higher pressure, density, temperature closer to earth/in the troposphere as a result of gravitys influence and the sun heating the earths surface. This means weather, high winds all occur most commonly in the troposphere and not higher up in the Stratosphere.
This is why pilots prefer flying in the Stratosphere, there is no localised common weather and winds creating turbulence and uncomfortable fly conditions that make the plane less efficent

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

It also eliminates the need to fly around storms and other undesirable weather systems as planes in the Stratosphere can fly over them. The Stratosphere also still has enough density and pressure to create flight; with enough oxygen for the engines to combust and density to create lift under the wings. Any higher and these factors become to low and dont support flight as seen in the diagram.

Aswell as this on the edge of troposphere and Stratosphere Jetstreams are located. Jetstreams are caused by high pressure air rushing to fill low pressure areas around the ferrel cell 30° N & S to 60° N & S. These move west to east, so for a plane flighing east they can use the jetstreams wind for a quicker and more efficent flight as it help move the plane. For planes travelling from the east these are avoided as head on wind can seriously slow the effeciecy and speed of a plane

QUESTION TWO: AEROSOLS

The highest concentrations of sea spray aerosols occur in the lower troposphere near 50 °S. The spray is transported towards New Zealand by strong prevailing westerly surface winds. This contributes to the west coast of the South Island being the wettest area in New Zealand.

Figure 3: Production of sea spray aerosols

Figure 4: Sea-spray concentration at Earth's surface

Adapted from: www.mdpi.com/2072-4292/13/4/614

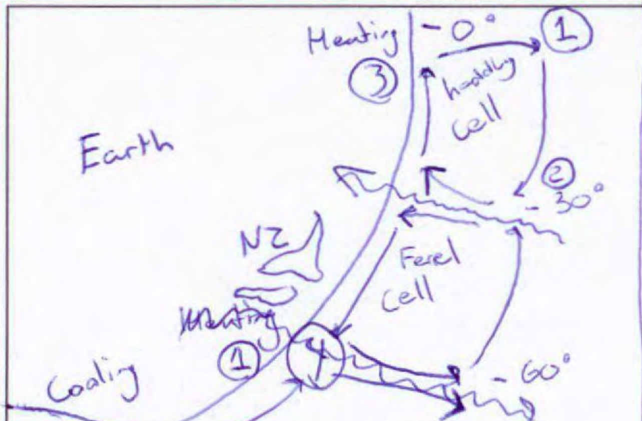
Source: https://pdfs.semanticscholar.org/8eb9/33a0e3594e9c6f13ad6b17d020acea94b138.pdf?_ga=2.189352232.2063430432.1658545364-1415782361.1658545364

Explain the processes that lead to cloud formation and high rainfall on the west coast of the South Island.

In your answer, you should consider:

- the formation of the Ferrel cell and surface winds around 50 °S latitude
- the production of salt spray aerosols and the role they play in cloud formation.

An annotated diagram may assist your answer.



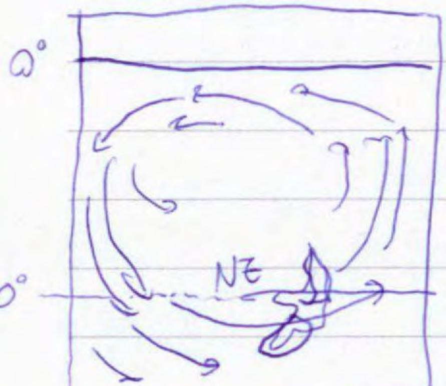
Aerosals are small minute particles both soild and Liquid suspended in Air, like sea spray particles, clouds and rain.

At 0°, equater the sunlight is more direct, heating the surface more then other places, this surface then heats the air above and causes it to rise as it expands and becomes warmer ①. As it get higher the air begins to cool and fall ~~[illegible] pressure~~ back to the earths surface ② this creates a high pressure that then races to fill the low pressure at ③ 0° where the Air escaped and rised. This is the creation of wind on surface, the high pressure air rushing to fill low pressure. This is The hadley cell. This process is similer in the polar cell but rather driven by the cooling of Air at the poles.

Right inbetween at the same latitudes of New Zealand is the Ferrel cell, unlike the other cells the fereel cell is created by the drag of the other cells and why it travels in the oppisite direction. These arrows on the diagram show where the other cell pull on the ferrel cell. This convection cycle of the Ferrel cell of high pressure air filling low pressure spots is how in New Zealand we get wind.

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

The reason for these wind mainly coming from the west is because of the corriolis effect.
As the earth is a sphere that spins, its spins faster at 0° equator when compared to the poles. This difference in speed in the air creates winds going anti clock wise in the southern hemisphere.



As seen in this diagram it creates a prevailing westerly wind that blows over 70% of the time on the west coast.

At around 60° Lat you can see on the map that both the Ferrel and polar cell rush to fill the low pressure at (4). This creates some of the strongest winds in the world and in turn pushes on the water creating huge waves. These waves of the southern ocean create large amounts of sea spray around 45 ng/m³. These are aerosols and if light enough are picked up by the Ferrel cell and polar cell and taken up at around 50° Lat (4). As these large quantities of water rise and cool they condense and form clouds in the moist environment that then due to the corriolis effect and westerly trade winds are pushed to NZ west coast before condensing even more on land against the southern alps, creating high amounts of Rainfall all year round.

QUESTION THREE: GLOBAL CLIMATE TIPPING POINTS

An estimated 28 trillion tons of ice disappeared from the Earth's surface between 1994 and 2017. Over the same period, the average global temperature increased by 0.7 °C. Climate scientists consider this to be a potential "tipping point", which is a small change in the climate system that could lead to much greater irreversible changes. This is also referred to as a positive feedback loop.

Figure 5: Global change in ice mass (1994–2017)

Figure 6: Average global surface temperature, (1994–2017)

Adapted from: https://www.researchgate.net/figure/Global-ice-mass-change-between-1994-and-2017-partitioned-into-the-different-floating_fig4_348753744)

Adapted from: https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/global/time-series/globe/land_ocean/12/1/1994-2017

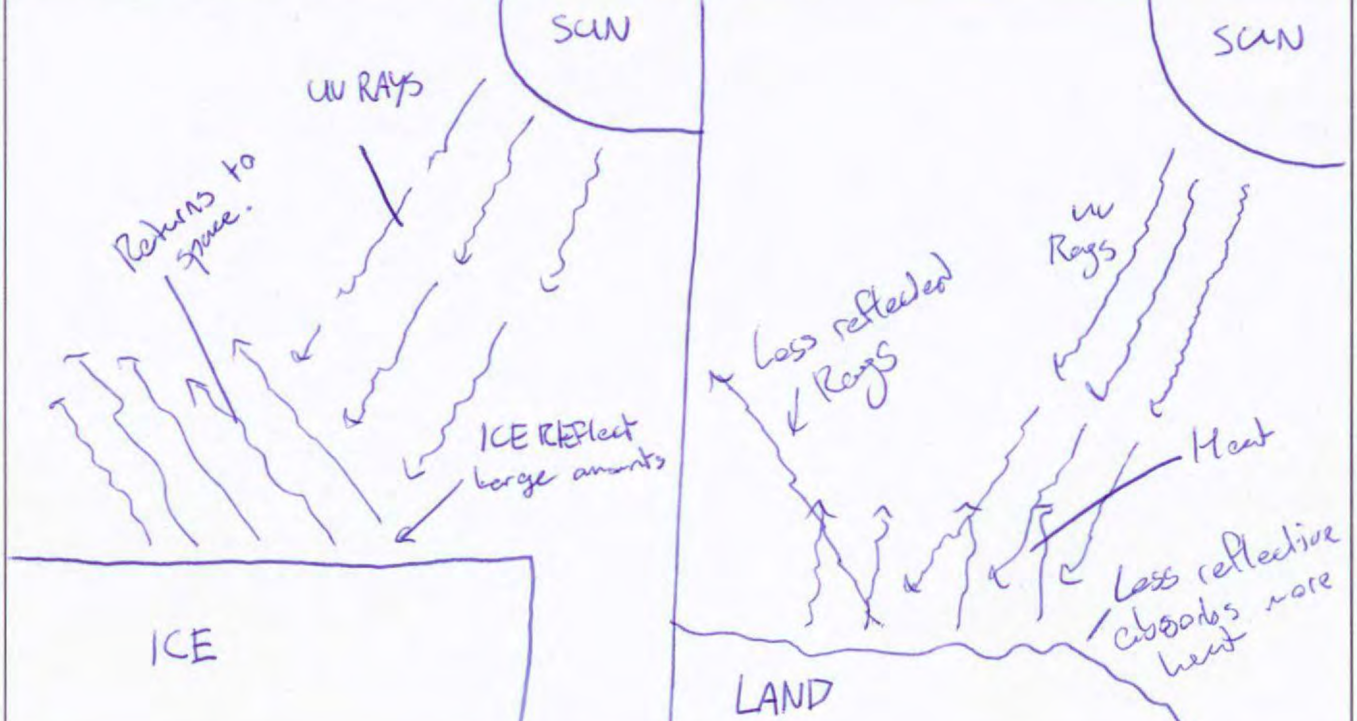
Discuss the causes and effects of a decline in polar ice on the atmosphere and global climate.

In your answer, you should explain:

- the greenhouse effect, including changes due to human activity
- how surface ice regulates atmospheric temperature
- how change in surface ice may lead to faster climate change.

You do not need to discuss sea level change or ocean processes.

An annotated diagram may assist your answer. Comparison of ICE vs LAND Reflection



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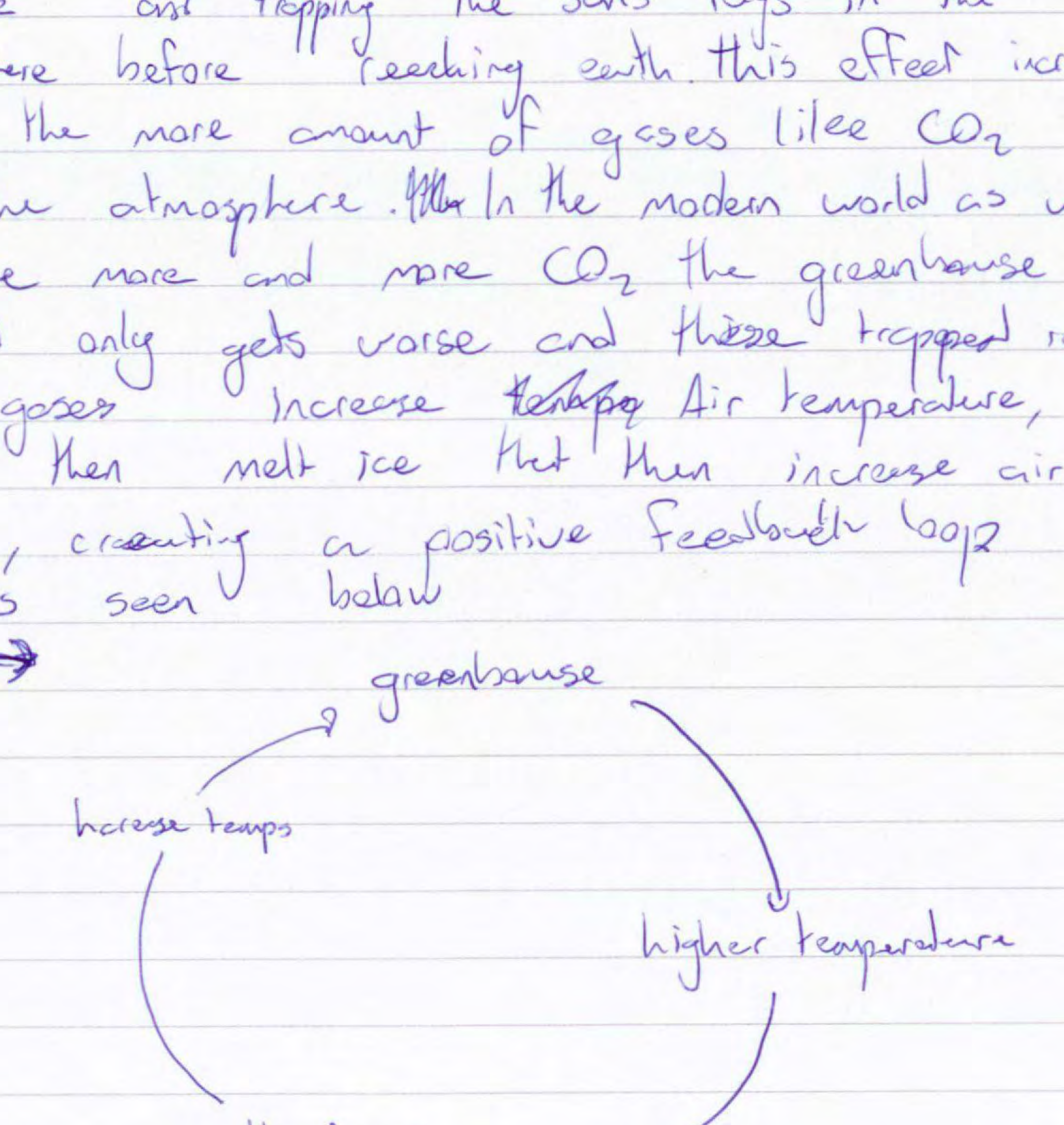
(✳) As ~~surface~~ Ice melts, Average global temperature increases.
Ice being shinny white has a high albedo aspect. Meaning it is more reflective, This means that less UV Rays and heat is absorbed from the sun and is rather reflected back out to space. This means ~~that~~ cool air around the ice and therefore becomes a cold air producer that regulates atmospheric temerature ~~the~~ as this air travels all over the world.
In contrast, Land like Forrest, ~~at~~ polar dessert, wastland beneath the ice has lower albedo. Meaning it aborbs more Rays and heat from the sun and as seen in the diagram reflects way less when compared to ice. What this means is the land can heat up and in turn heat the air above it as it becomes a huge heat source. this New hot air then rises to travel all over the world and leads to climite change as there is No ice regulating temperatures with cold air. These show there is a direct Link between the amount of surface ice and how quick the climate will change, with going from Lossing 0 to -30 trillion tons in ice mass and global temperature increasing almost a degree from 1995 – 2017 it shows that if the greenhouse effect isnt stop ice will continue to melt and increase the

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

global warming as this positive feedback loop continues

* The greenhouse effect is the result of more gases in the atmosphere stopping both reflected rays to escape and trapping the suns rays in the atmosphere before reaching earth. this effect increses with the more amount of gases like CO_2 in the atmosphere. ~~the~~ In the modern world as we produce more and more CO_2 the greenhouse effect only gets worse and these trapped rays and gases increase ~~temp~~ Air temperature, that then melt ice that then increase air temp, creating a positive feedback loop As seen below

(*) ~~[illegible]~~ →



Merit

Subject: Earth & Space Science

Standard: 91414

Total score: 17

Q	Grade score	Marker commentary
One	M5	Good explanation of how jet streams can be used from west to east to speed up flight. Other statements are at an achieved level as causes are not explained for gradients or properties of the layers.
Two	M5	Thorough explanation for causes of strong wind and how this creates more sea spray aerosols at 50S latitude is provided. Detailed explanation of Hadley cell formation provided but answer doesn't extend to the explanation of Ferrell cell.
Three	E7	Candidate provides a Merit level explanation for the impacts of human activities on the greenhouse effect. The answer comprehensively explains the role that surface ice plays in regulating global temperature, when compared to land.