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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 (DO NOT WRITE IN THIS AREA DO NOT WRITE). 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.

Excellence TOTAL 23

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

Source: www.weather.gov/jetstream/jet

Figure 2: The stratosphere and troposphere

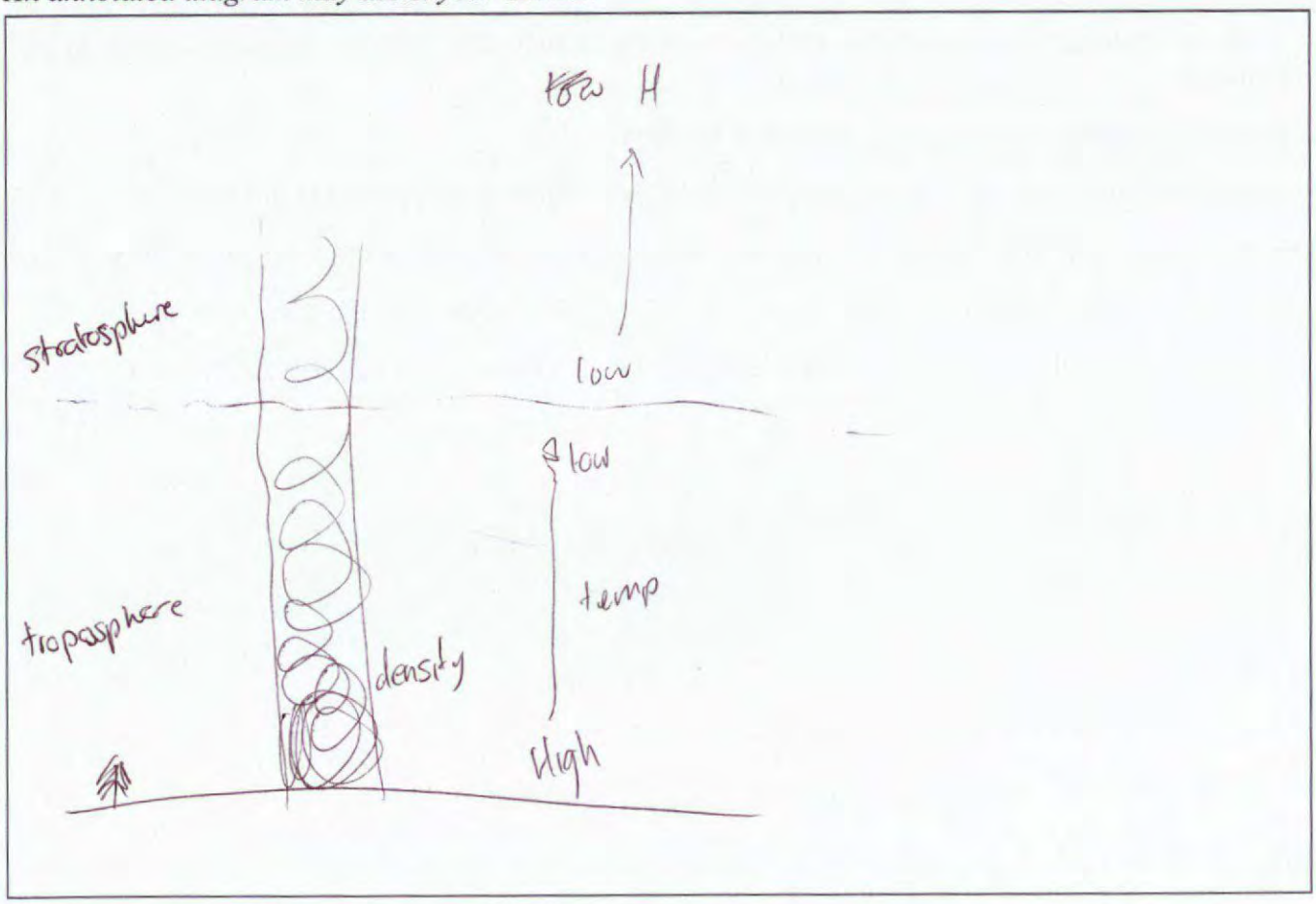
Source: https://geoengineering.global/stratospheric-aerosol-injection/

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.



In the troposphere, density and air pressure decreases as hieght increases. ~~As~~ Air pressure is highest close to the surface as it is pulled in by ~~the~~ gravity and has air ontop pushing down (due to gravity). Density (~~pa~~ measure of particles of a set ~~vol~~ area) decreases as air pressure decreases. Temprature decreases with hieght in the troposphere as it is heated from the ground. Solar radiation from the sun is absorbed by the ground which emits infrared radiation which heats up the atmosphere. The troposphere has ~~both~~ verticle and horizontal winds driven by ~~circulation~~ convection cells.
In the stratosphere, the density and air pressure continues to decrease as they are less affected by gravity and there are less particles above that do not compress the air as much. The stratosphere is heated from above due to the ozone layer. The ozone layer/gases absorb UV radiation from the sun and emit the heat generated to the surrounding area, thereby heating the ~~atmosphere~~ Stratosphere. The stratosphere has little to no verticle movement of air ~~is~~ and has mostly horizontal wind movement/air circulation.
The troposhere is also where evaporation, condensation and precipitation takes place (water cycle), which transports ~~water around~~ water to and out of the atmosphere, causing rain. The troposhere has areas of high and low pressure due to rising and sinking ~~air~~ air, which the stratosphere does not have.

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

The atmospheric conditions in the troposhere make flying aircrafts more difficult. The verticle movement of air creates turbulance which can create a bumpy flight. The increased air pressure and density (compared to the stratosphere) costs the aircraft more fuel to travel due to friction of air particles and due to the air above pushing down due to gravity. The tropashere has more oxygen than the stratophure which supplyes the jet engines with more oxygen to work. The stratosphere has little verticle air movement and therefore no/little turbulance, making the flight more comfortable. The reduced air pressure and density means that the aircraft uses fuel more effecienty as the air is thinner (there is less friction and overhead pressure). The planes fly lower in the stratosphere as they require sufficient oxygen for the jet engines to work.

The jet streams can help flights when aircrafts are traveling along them as they can allow themselves to be pushed along by the strong winds and thereby consume less fuel. The jet streams can hinder flights when the aircraft is flying againt it which requires more energy/fuel to travel through, and slows down the aircraft. Pilots prefer

to fly in the stratosphere due to less verticle ~~s~~ air movement/turbulance and because it is more energy efficient (requires less fuel), due to the lower air density and pressure which makes the air thinner. Jet streams can also be used to consere fuel and perhaps speed up the flight.

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

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

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

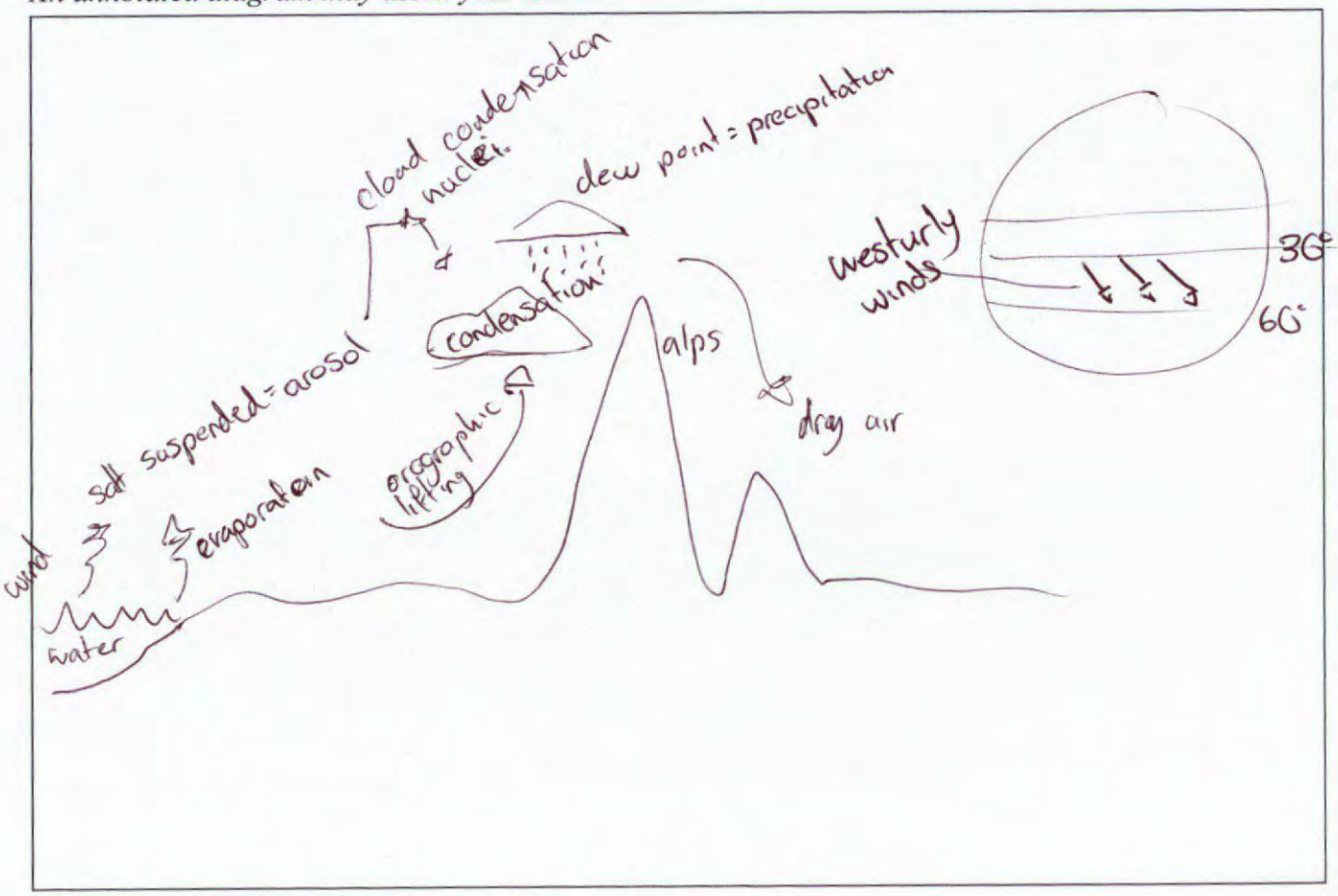
Source: https://pdfs.semanticscholar.org/8eb9/33a0e3594e9c6f13ad6b17d020acea94b138.pdf?_ga=2.189352232.2063430432.1658545364-1415782361.1658545364

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.



The Ferrel cell is a covection cell sitting between latitudes of 30° and 60° and is an open cell driven by the Hadley and polar cells. The Hadley cell is caused by directed heating from the sun at the equator which causes warm, wet air to rise, (and precipitate) which creates an area of low pressure. This warm air will move away from the equator and cool before sinking at 30° due to an increase in density, creating a area of high pressure. The polar cell is driven by the poles where cold, dense, dry air sinks, creating an area of high pressure where it flows toward the equator and warms before rising again at 60°, creating an area of low pressure. The high and low pressure areas created by the Hadley and polar cells at 30° and 60° form the Ferrel cell. The pressure gradient of high pressure at 30° causes air to flow along the surface towards and area of low pressure, 60°. This creates the westerly surface winds which are deflected left (in Southern Hemisphere) by the coriolis effect (the deflection of objects moving across the surface of the earth due to the earth's spin).
The strong westerly winds cause surface mixing in the ocean and cause spray (high winds = high waves = more friction =

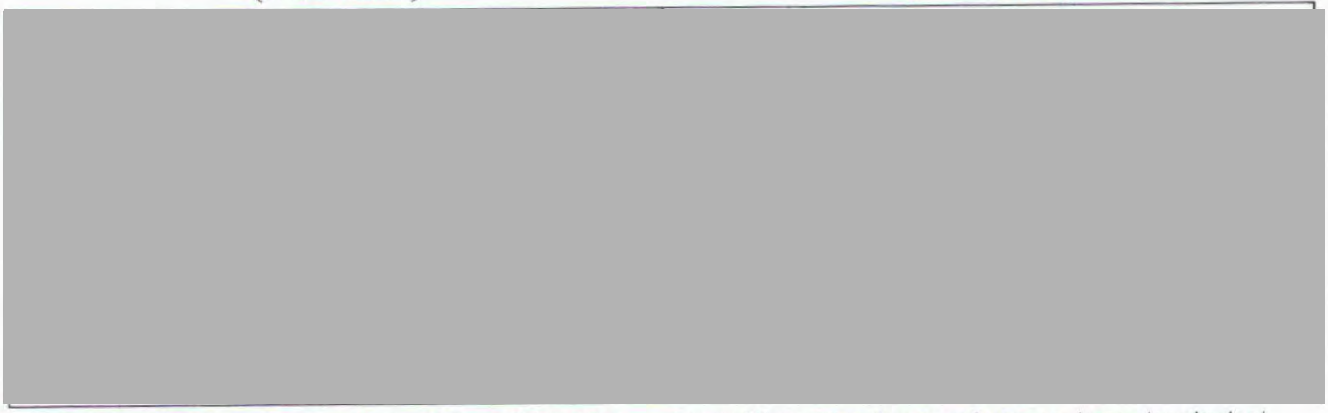
There is more space for your answer to this question on the following pages.

spray), and creates salt spray aerosols. Aerosoles are tiny particles suspended in the atmosphere. The salt that is now suspended in the atmosphere is transported by the wind.
Due to evaporation and latent heat, the water is heated and changes state from a liquid to a gass where it is also transported by the wind towards the west coast of the south island.
Due to the Alps (mountain rigde), the water vapor and salt aerosols are forced up (orogrophic lifting). The salt aerosols act as also cloud condensation nuclei which react with the H_2O_g and form clouds (condensate). As the clouds are forced higher they cool, reducing their water bearing capacity untill they meet their dew point. Having released latent heat, the H_2O_g reverts back to H_2O_L, resulting in rainfall (precipitation). Resulting in high rainfall along the west coast of the south island.

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)



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

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

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

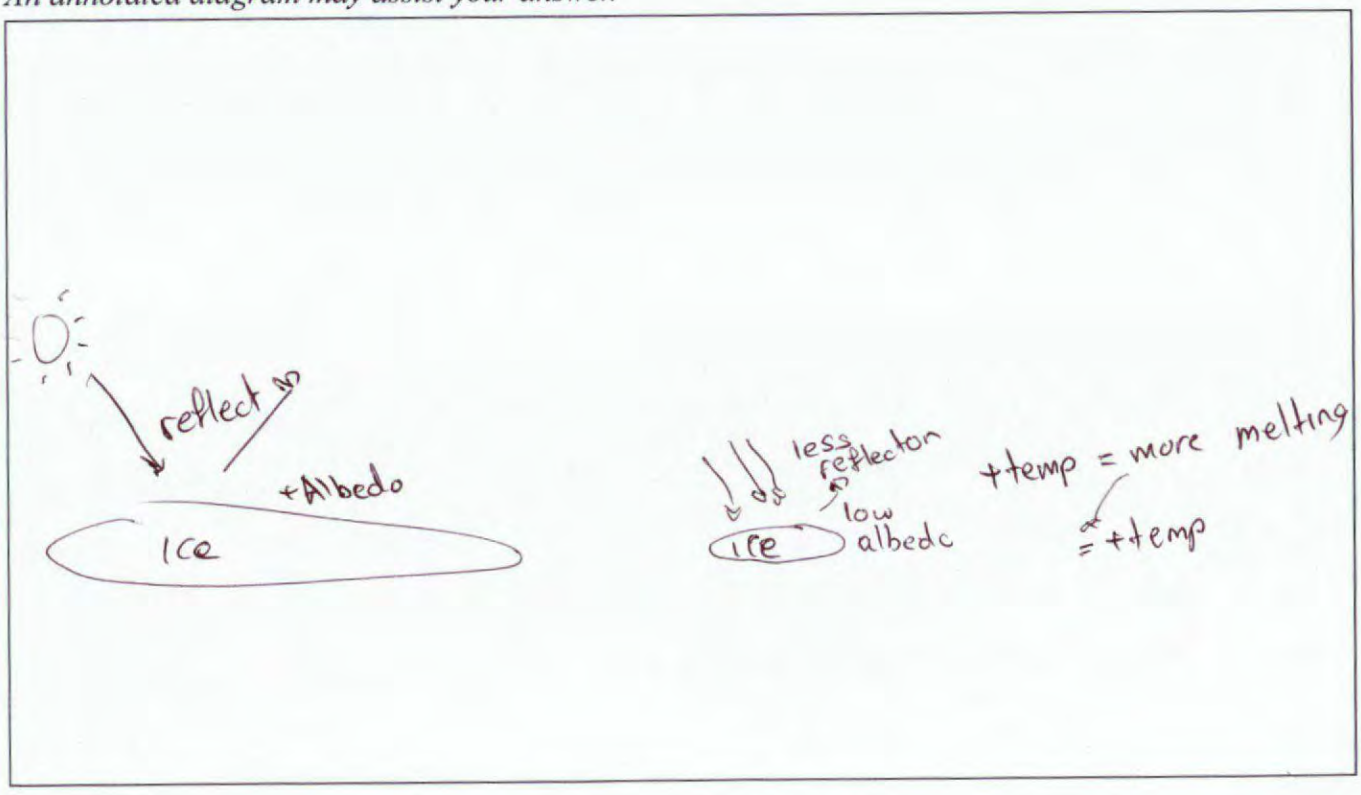
Discuss the causes and effects of a decline in polar ice on the atmosphere and global climate.

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.



The Earth is heated by the sun where solar radiation is absorbed by the ground which emits infra red, causing the surrounding atmosphere to heat. Greenhouse (GHG) gasses such as methane and CO_2 absorb infra red radiation and get "exited", generating more heat energy, resulting in a increase of tempreture Due to human activity, such as the burning of fossil fuels and deforestation, there is an increased amount of CO_2 in the atmosphere. Burning fossil fuels releases CO_2 and deforesation means there are less photosynthesizers to convert CO_2 to Oxygen. This increases global temps which can also lead to the melting of permafrost, which releases methane gass which is a greenhouse gas and thereby also heats the atmosphere. More GHG in the atmosphere results in increased tempretures as there are more gasses that absorb infrared and emit heat energy into the surronding area.

Surface ice regulates atmospheric tempreture through a high albedo. The light colour of the ice gives it a high albedo. Surfaces with high albedo (ice) reflects solar radiation which cools the atmosphere. As the surface ice decreases, the albedo will be lower which means not as much solar radiation is deflected by the ice (as there is less of it), resulting in a rise in temperatures.

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

The decrease in surface ice, ~~from~~ (having lost 28 ~~35~~ tons between 1994 and 2017) resulted/ ~~in an~~ contributed in an increase of global tempretures by 0.7°C (over the same period). This may lead to faster climate change as an increase of GHG cause ~~and~~ an increase in ~~the~~ global tempreture which causes the ice to melt which lowers the albedo. This causes less solar radiation to be reflected, so tempretures increase, melting more ice, which causes tempretures to increase, causing a positive feedback loop /runaway effect. Thereby resulting in faster climate change.

Excellence

Subject: Earth & Space Science

Standard: 91414

Total score: 23

Q	Grade score	Marker commentary
One	E8	Candidate provides a comprehensive explanation comparing the properties of the troposphere and stratosphere with reasons, as well as reasons for presence or absence of weather.
Two	E8	Candidate provides a comprehensive explanation of formation of Ferrel cell and westerlies, linking all physical properties, pressure gradient and impact of Coriolis. Extensive explanation of the cloud formation process.
Three	E7	Comprehensive explanation of positive feedback loop caused by melting ice, linking to faster rate of change.