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91414



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



Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Earth and Space Science 2025

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 (X/X/X). 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: HOW DOES THE ATMOSPHERE PROTECT THE EARTH?

The atmosphere plays an important role in protecting the Earth and making it suitable for life.

Explain the role that each layer of the atmosphere plays in protecting the Earth's surface from harmful matter and radiation.

In your answer, you should consider:

- the different forms of radiation that enter the Earth's atmosphere
- physical space objects, such as meteors and charged particles
- the reason for the changing temperature for each of the atmosphere's layers.

An annotated diagram may assist your answer.

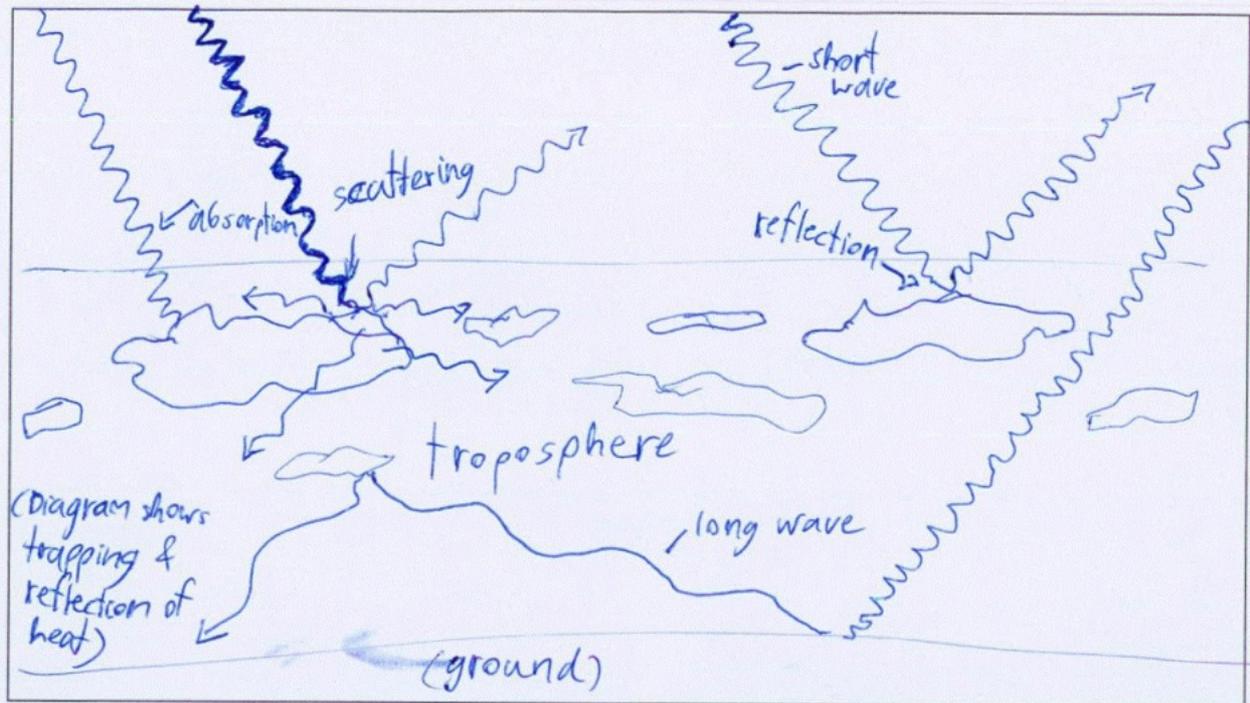
The atmosphere consists of multiple layers. Firstly, the troposphere.

This layer holds around 80% of the mass of the entire atmosphere, which is the reason it has the most weather & clouds by far, there's more matter. The clouds protect earth as they act as reflectors for of radiation from the sun, keeping the atmosphere cool. While also ~~scatte~~ absorbing, reflecting and scattering some forms of incoming radiation, and long wave radiation re-radiated from the earth's surface, keeping us warm. The troposphere's ability to trap heat is what makes it warm, and it becomes colder as you move upwards, further away from the trapped heat. The layer above the troposphere holds around 19% of the matter/mass of the atmosphere and is very stable due to the lack of weather. It ~~is~~ known as the stratosphere.

It protects us from harmful ~~UV radiation~~ ^{UV radiation} ~~ionising~~ ~~charged particles~~ from the sun due to the ozone layer, which ozone is made when ionising UV light strikes



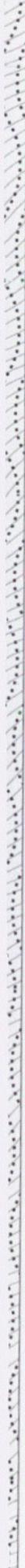
Adapted from: www.severe-weather.eu/wp-content/gallery/weather-maps/winter-storm-bomb-cyclone-gaetan-uk-atmospheric-layers.jpg



Oxygen molecules in the atmosphere, The Ozone layer protecting us from UV light causes the stratosphere to heat up the higher you go, as rising air is less dense & lifts above cooler air. This warm air is due to the action of UV light being stopped via reflection, scattering etc. The mesosphere is above the stratosphere and contains less than 1% of the total mass of the atmosphere. It protects us from debris in space, as it is where the air becomes dense enough to cause ~~asteroids~~ meteors to begin to burn up in the air, stopping them from reaching earth. The average temperature of the air begins to cool down in the mesosphere due to ~~no~~ little to no heat being trapped there, resulting in the colder temperatures. Above the mesosphere is the thermosphere which contains even less mass than the mesosphere. The thermosphere contains the ionosphere which is a layer that protects us from harmful ionising radiation ~~by~~ by reflecting and ~~defracting~~ ^{charged particles} it. The thermosphere gives us the Auroras, due to this radiation being caught

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

in the electromagnetic field of earth. The atmosphere is most dense at the troposphere, and becomes less dense the further up you go due to ~~densi~~ gravity holding most of the atmosphere closest and the pressure from upper layers pushing down on lower ones. Each layer of the atmosphere protects us from different particles, radiation & objects, and makes life possible on earth.



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QUESTION TWO: HEAT TRANSFER

Heat is transferred from the ocean and land into the atmosphere by different processes. These include radiation, conduction, convection, evaporation, condensation, and sublimation.



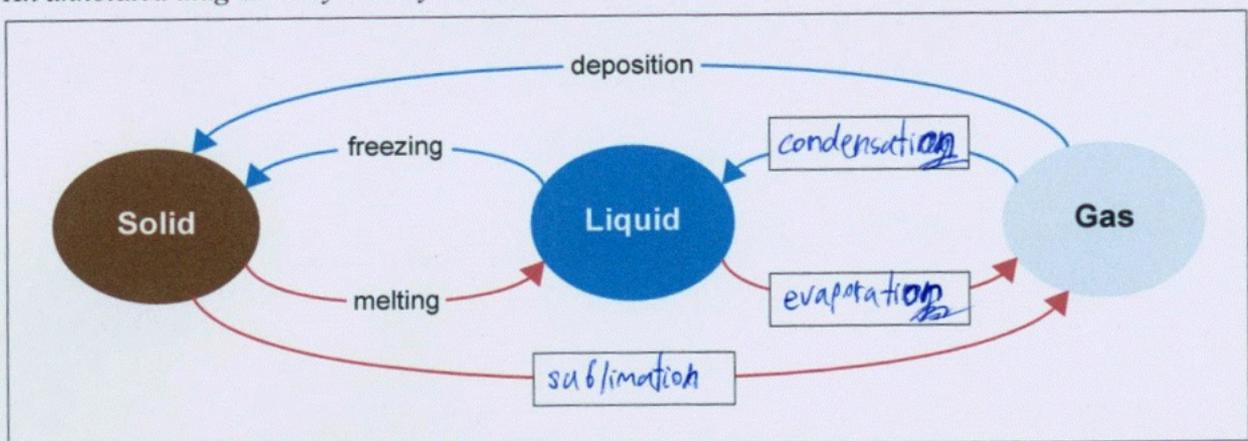
Adapted from: <https://earthobservatory.nasa.gov/features/EnergyBalance>

Explain, in detail, how heat is transferred from the Earth's surface to warm the atmosphere.

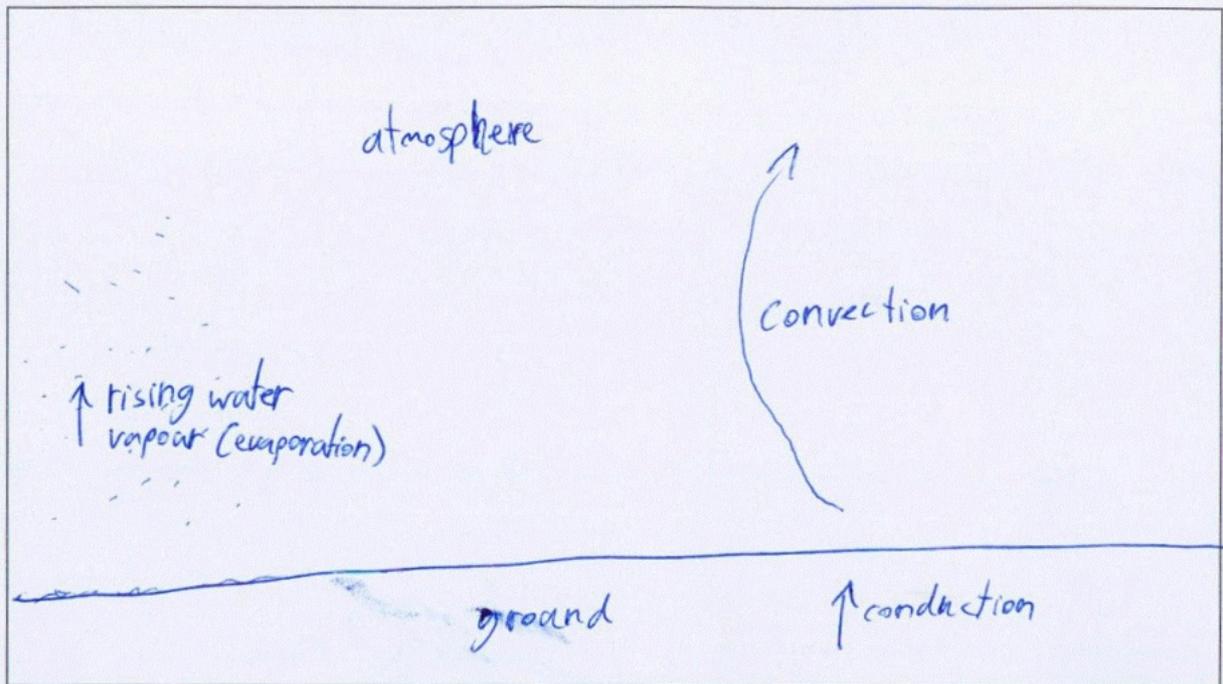
In your answer, you should:

- label processes in the text boxes on the diagram below.
- explain three processes that transport heat from land to the atmosphere.
- explain how heat is transported through the water cycle into the atmosphere.
- explain how latent and sensible heat transfers are linked to the processes.

An annotated diagram may assist your answer.



Heat is ~~transf~~ transferred all around the earth, making it habitable. Heat is transferred from land to atmosphere in multiple ways. An example of this is conduction, when the



ground is heated, (usually by the air) it becomes warm, that some heat energy can then move through the ground and come out and enter the air, this can be especially prevalent on non windy nights, when the ground is storing a lot of heat. After the conduction of heat through the ground, convection currents cause the heated air to rise higher into the atmosphere as it is less dense than warm air. Another way heat enters the air is through evaporation, when the ~~ground~~ ^{land} is heated by the sun, the ~~water~~ ^{water} ^{present on or in the} can be evaporated and rise into the atmosphere as warm humid air is especially not dense, this shows heat entering the atmosphere through evaporation. The water cycle plays a big part in transferring heat into the atmosphere as when the ocean is heated it evaporates which brings warm humid air into the atmosphere. Leaving the salt behind, ~~and~~ eventually this humid air is no longer heated by the sun, it condenses and falls back down as rain, either directly into the ocean or onto

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land which then runs off ^(the water) into the ocean & the cycle repeats. Latent heat & sensible heat are linked to the ~~of~~ aforementioned processes as for example the heating effect of the sun warming the ground & ocean shows ~~the transfer~~ ^{the transfer} of sensible heat, as when you heat something its heat increases. Then, the evaporation & condensation mentioned in the water cycle for example shows latent heat being absorbed in order to evaporate the water and cause the humid air to rise due to that. And latent heat is released when the ~~air~~ ^{water} is cooled & condenses into a liquid, as removing or releasing the heat causes the particles to become less agitated and form intermolecular bonds again, which forms a liquid (releasing latent heat).

Lined writing area with horizontal lines for text entry.

QUESTION THREE: THE HUNGA ERUPTION

On 15 January 2022, the underwater volcano Hunga Tonga-Hunga Ha'apai (Hunga) erupted. This was the largest underwater explosion ever recorded by modern scientific instruments. It launched huge amounts of water vapour and sulphur dioxide into the troposphere and stratosphere, which may impact the climate.

Hunga Tonga-Hunga Ha'apai eruption plume



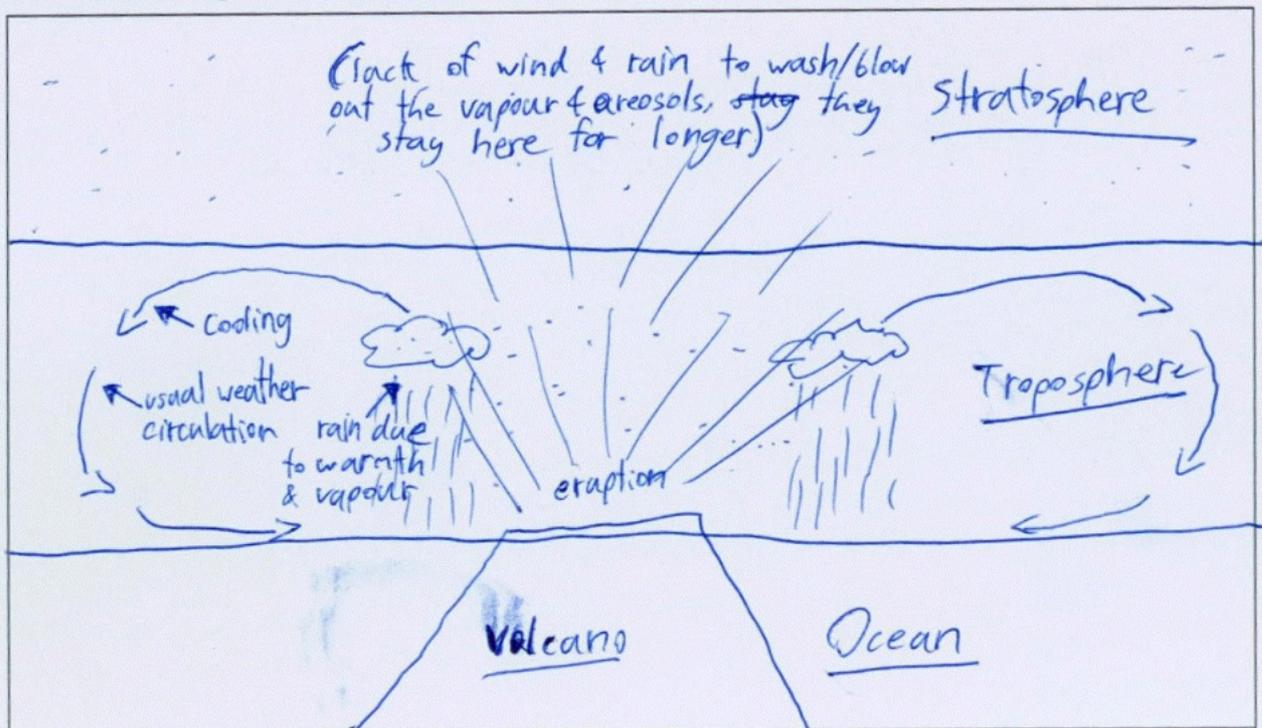
Source: www.qatarday.com/volcano-in-tonga-sends-plume-half-way-into-space

Explain the likely effects of the Hunga eruption on climate.

In your answer, you should:

- consider local effects of the eruption on the troposphere
- consider the effects of the huge increase in stratospheric clouds caused by the volcanic eruption
- consider the effect of large amounts of sulphur dioxide entering the stratosphere
- compare the likely circulation patterns of the water vapour and aerosols in the troposphere and stratosphere.

An annotated diagram may assist your answer.



The eruption of the Hunga volcano had massive impacts of local weather & climate. Firstly, the local effects of the eruption could have caused acid rain as the ^{warm} water vapour heavy air containing sulfur dioxide could have combined and rained down out of the troposphere due to the cycle of weather as acid rain. The fact that water vapour & sulfur dioxide was also ~~also~~ ~~launched~~ ^{launched} into the stratosphere could have long term ~~implications~~ ^{effects} on local climate, or at least longer effects ~~that~~ than the weather from the troposphere caused by the eruption. This is because the lack of density ~~cause~~ in the stratosphere causes it to have barely any weather & wind, which makes it more stable. This causes the ^{added} particles & added clouds of volcanic material in the stratosphere could stay there for a while & limit the amount of sunlight getting through. Badly affecting farms and other sunlight requiring operations nearby. The large volumes of sulfur dioxide in the stratosphere could also further affect other not local regions, this is because the sulfur dioxide staying in the stratosphere for longer gives it time to travel further than if it were in the troposphere. Acting as a greenhouse gas for a decent amount of time, warming the atmosphere ^{as well as water vapour (they both act as GHGs)} locally and potentially further away as well, it could also cause acid rain in non local regions too as it descends from the stratosphere eventually. As mentioned earlier, the water vapour and aerosols would stay in the ~~stratosphere~~ troposphere for a ~~brief~~ brief amount of time, acting as ~~a~~ greenhouse gases, limiting sunlight and causing acid rain before eventually being rained out of the atmosphere or circulating down to the surface after losing their heat due

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to normal weather patterns. In comparison, the water vapour & aerosols would remain in the stratosphere for much longer, due to aforementioned factors. becoming a larger threat.

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

QUESTION
NUMBER

91414

Merit

Subject: L3 Earth & Space Science

Standard: 91414

Total score: 17

Q	Grade score	Marker commentary
One	6	Detailed explanation of the protective effects of the stratosphere and troposphere, as well as friction destroying objects in the mesosphere, but did not discuss protection from all layers.
Two	6	Detailed explanation of conduction, intermolecular bonds being broken during evaporation and latent heat exchange, linked to evaporation and condensation, but not atmospheric temperature.
Three	5	Explained the effect of clouds on surface temperature and how stratospheric products will be circulated, while tropospheric water vapour will remain for a shorter period, but incorrectly identified sulfur dioxide as a greenhouse gas, causing warming.