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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 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 (▨). 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: HOW DOES THE ATMOSPHERE PROTECT THE EARTH?

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

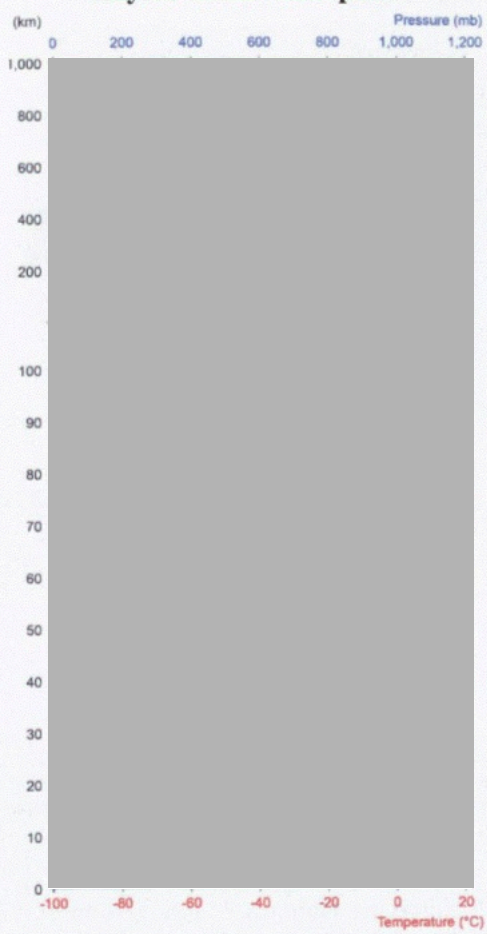
Explain the role that each layer of the atmosphere plays in protecting the Earth's surface from harmful matter and radiation.

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.

Layers of the atmosphere



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

The atmosphere is a layer of gases surrounding the earth and held down by gravity.

The lowest atmospheric layer is the troposphere, which extends to an altitude of about 20km above sea level. As atmospheric air pressure in the atmosphere is greatest closer to the earth's surface, air density is greatest also in the troposphere, which contains 75% of the atmosphere's mass. The earth surface absorbs Incoming solar radiation is absorbed by green house gases and then by the earths surface. The UV radiation is re-emited by the surface in the form of longwave infrared radiation (IR). (IR). This warms the air molecules above through conduction and mainly convection. Closer to the ground as the heat source, temperatures will be greater and moving away from heat source with altitude explains the decreasing temperature in the troposphere.

The layer above is the stratosphere reaching up to 50km high.

Planning:

✓ Troposphere - heat source

✓ stratosphere - UV radiation, Ozone

✓ Mesosphere - heated below, burns meteors

✓ Thermosphere - high energy radiation (gamma + x-ray) + ionisation

✓ + concluding para abt each functions

as air pressure and thus density continues to decrease. The stratosphere contains the Ozone layer, where sunlight energy splits Oxygen atoms to produce free radical Oxygens, which combine with O_2 atoms to create ~~Ozone~~ Ozone molecules. Ozone absorbs incoming shortwave UV radiation from the sun, thereby forming ~~building~~ the heat source for this atmospheric layer. With the heat source ultimately provided by the sun, temperature increase with altitude.

Above 50km ~~exte~~ the Mesosphere can be found. There is very little air pressure and so the air is extremely thin, meaning not much ~~in~~ solar radiation can be absorbed. The heat source for this layer is actually given by the stratosphere, and with heat energy coming from below, the mesosphere ~~does~~ has ~~a~~ shows a decrease of temperature with altitude as one moves away from the heat source. Despite the air being very thin, material from space such as meteors, meet air molecules in the mesosphere. The collision with

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

high speed space matter causes meteors to burn up in the mesosphere, which can leave behind a glowing tail to be seen from earth (unless the object is massive enough, not completely burn up, but penetrate to the earths surface).

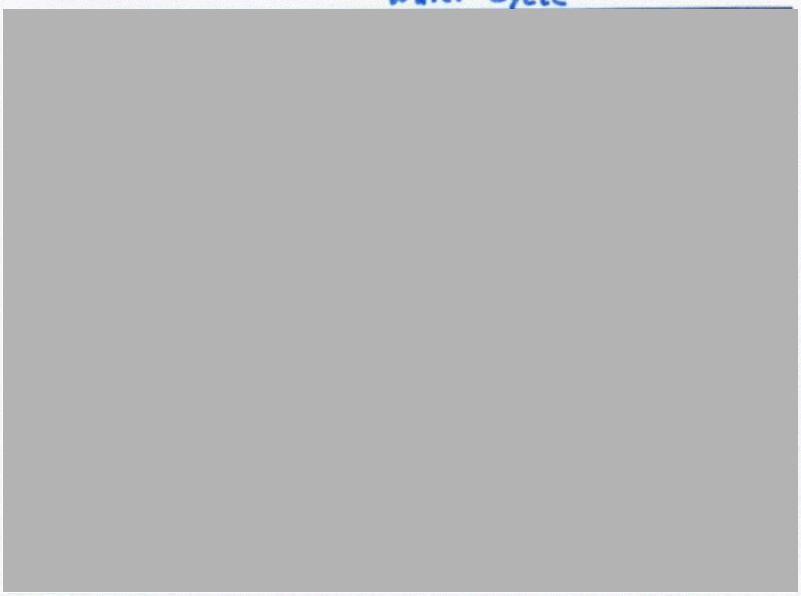
The thermosphere is considered the highest atmospheric layer (excluding the exosphere). Air here is the thinnest, as particles are very spread out. These particles mainly absorb high energy radiation from the sun (in the form of gramma radiation or X-rays), making molecules highly energetic. As atoms are ionised, the electrons become excited and emit visible light in colours we perceive as auroras - this occurs mainly in the ionosphere. As the source of this radiation again is the sun, again the source is coming from above, so thermospheric temperature rise with altitude to thousands of degrees. The thermosphere absorbs charged particles of especially penetrating (and thus harmful to humans) nature, thereby protecting organisms on earth from eg gramma rays.

Similarly, Ozone in the stratosphere absorbs UV radiation, protecting our skin, and mesosphere protects from physical matter / meteors reaching the surface. Thus each layer contributes to protecting organisms from harm from space.

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.

heat water cycle



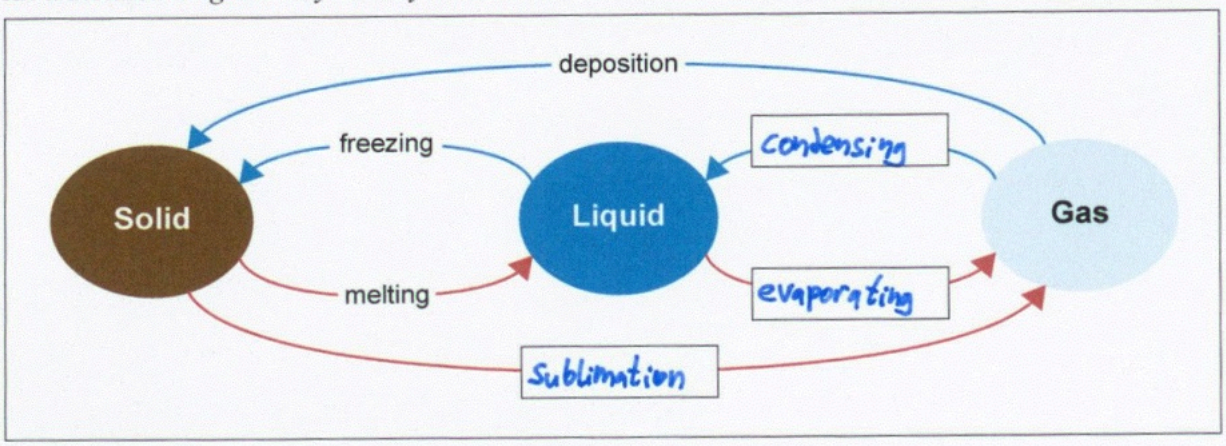
Adapted from: https://earthobservatory.nasa.gov/features/EnergyBalance

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 conduction convection radiation
- ✓explain how heat is transported through the water cycle into the atmosphere latent heat → focus more on this
- ✓explain how latent and sensible heat transfers are linked to the processes.

An annotated diagram may assist your answer.



conduction – transfer thru contact, air poor conductor

radiation – am UV → IR

✓ convection – adiabatic cooling mäßig, brief description

surface water evaporated, /sublimed thru sensible then latent heat rising air condenses...

Conduction, radiation and convection are processes of heat transfer; where the land releases heat energy to the atmosphere. The solar energy absorbed at the surface (UV radiation) is re-emitted by the land in the form of infrared radiation. This longwave radiation transfers heat energy to the air above. Neighbouring air molecules in contact can exchange heat through conduction, however air is a poor conductor, so not much energy will be transferred. The main heat transport into the atmosphere occurs through convection, where warmed air molecules transfer heat to particles above and begin to rise adiabatically.

Convection encompasses the transport of heat through water cycle. Surface waters in oceans, lakes and rivers or on land mass also absorb solar energy, and in the form of sensible heat, gain kinetic water molecules gain kinetic energy. As they move around faster, water temperature first increases, and but weak intermolecular forces

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

between the H_2O molecules are weakened. As ice, until melting point is reached, as liquid until the boiling point, where energy invdues latent heat. The temperature of the ~~water vapour~~ solid or liquid water remains constant, as latent heat is being absorbed to ~~it~~ overcome the bonds of the H_2O molecules, which undergoes a phase change ~~from~~ solid to liquid or gas or liquid to gas.

When ice or water has sublimed/evaporated into gaseous form, the water vapour is contained within the air. When the air is heated, it expands to lower density and rises. This takes the energy contained in ~~gaseous~~ water molecules ~~from~~ the ~~surface~~ land into the atmosphere as water vapour. The sublimation and evaporation of water ~~into gas~~ absorbs latent heat, which is then transported to the atmosphere through water vapour. ~~In the air, heat~~ When air is heated from the earth surface, ~~and~~ expands rises with water vapour, the ~~kinetic energy of~~ air begins to cool adiabatically. This releases sensible heat back to the ~~surrounding~~ atmosphere, ~~as the total energy as the air~~ causing the temperature to decrease and ~~particle~~ become more dense. At the dew point, air is saturated and loses its ability to hold water vapour. ~~and~~ In the presence of small particles such as aerosols, the gaseous H_2O condenses back to liquid state. When the air is cold enough essentially, the gaseous water condenses, releasing latent heat in the process. This shows how water absorbs energy ~~from the~~ at the land surface, is transported through the atmosphere and the water ~~it~~ vapour releases this energy into the atmosphere through condensation.

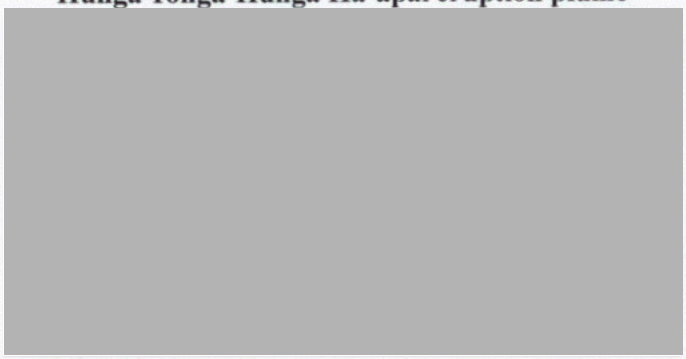
QUESTION THREE: THE HUNGA ERUPTION

also release salts as cause of salinity...

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.

GHG SO_2 ! $SO_2 \rightarrow H_2SO_4$

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. ? → is like local vs global spread? winds? convection currents...

An annotated diagram may assist your answer.

✓ - Mostly into tropos, short term local effects as not global spread & incr albedo (decrs sunlight✓, incrs clouds✓) albedo?✓

✓ - 55km plume into strato, stay for much longer, global spread
$SO_2 \rightarrow H_2SO_4$ aerosol incrs cloud, albedo +effects

+ water vapour as greenh GHG!

Aerosols are miniscule particles of solid or liquid state and are suspended into the atmosphere through volcanic erruptions.

Most of the eruption would have reached into the troposphere, ejecting ash and smoke plume. Aerosols released into the troposphere would deflect incoming sunlight and thus decrease the amount of insolation reaching the earths surface. The volcano would likely emit dark coloured (eg carbon) aerosols, which whose dark colour would have the effect of decreasing the albedo of the atmosphere and in turn absorbing more heat energy from the sun. Aerosols in the troposphere would especially serve as cloud condensation nuclei, increasing the cloud formation in local weather patterns. The high albedo (reflectivity of sunlight) of clouds would have a cooling effect on the earth below, but also have an insulating effect on outgoing IR radiation from earth. However, the relatively large size of aerosols in the troposphere means they would be washed out by rain and weather within a few days / weeks and would therefore have a short term, locally contained effect.

The strength of this Hunga eruption however emitted particles all the way into the stratosphere. The stable conditions in the stratosphere, with little vertical air movement and minimal clouds / precipitation due to dry stagnant air, would leave aerosols in the stratosphere for very long times. The effect in the stratosphere is hence much more long term than in the troposphere. In the stratosphere, the release of sulfur dioxide into the stratosphere reacts with water molecules (such as the water vapour also emitted in this eruption), driven by sunlight energy, to produce sulfuric acid, H_2SO_4, which is an aerosol. The excess of emissions of sulfuric sulfur dioxide result in a large concentration of H_2SO_4 aerosols. In the stratosphere, these aerosols

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

provide an area for water vapour to condense around at the dew point and form clouds. Sulfur dioxide emissions creating H_2SO_4 therefore increase cloud formation in the stratosphere. The clouds increase the albedo of the atmosphere to reflect incoming solar radiation and thereby reduce the amount of heat energy reaching the earths surface, leading to decreased temperatures.

As mentioned, aerosols in the troposphere would be removed within a short period of time and would not travel very far to have as far reaching effects. As they remain for much longer in the stratosphere, strong horizontal winds in the stratosphere transport aerosols all around the globe. The H_2SO_4 molecules could therefore lead to greater cloud formation globally and have a net cooling effect (although clouds also trap outgoing re-emitted IR from earth). The aerosols would therefore circulate more in the stratosphere.

Water vapour acts as a greenhouse gas and its emission would contribute to cloud formation, as the gaseous H_2O is what condenses around aerosols for liquid water droplets to produce clouds. In both troposphere and stratosphere, the gas is smaller than liquid/solid aerosols, so will remain for much longer. In the atmosphere, water vapour could increase the greenhouse effect, by trapping outgoing radiation from earth and re-emitting it back to the surface. The greenhouse effect is a global phenomena that leads to increasing temperatures (ie global warming) and water vapour would likely circulate globally, with longer long term effects. Water vapour also circulate through condensation & precipitation

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

QUESTION NUMBER

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QUESTION NUMBER

Excellence

Subject: L3 Earth & Space Science

Standard: 91414

Total score: 23

Q	Grade score	Marker commentary
One	8	Comprehensive discussion of the protective factor of each layer and reasons for temperature gradient in each layer, clearly explained with thorough understanding of physical processes causing these.
Two	7	The answer shows a comprehensive explanation and discussion of latent heat exchange during water cycle processes with a good understanding of heat transfer via radiation, conduction, and convection.
Three	8	The answer provides a comprehensive discussion of the effects of sulfur dioxide forming sulfuric acid in the stratosphere and the effect of water vapour in the troposphere. This is linked to the reasons why aerosols remain in the stratosphere for longer time. The analysis also links to the varying effects on temperature.