

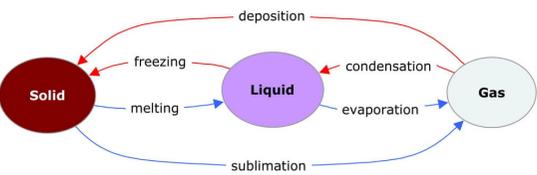
## Assessment Schedule – 2025

### Earth and Space Science: Demonstrate understanding of processes in the atmosphere system (91414)

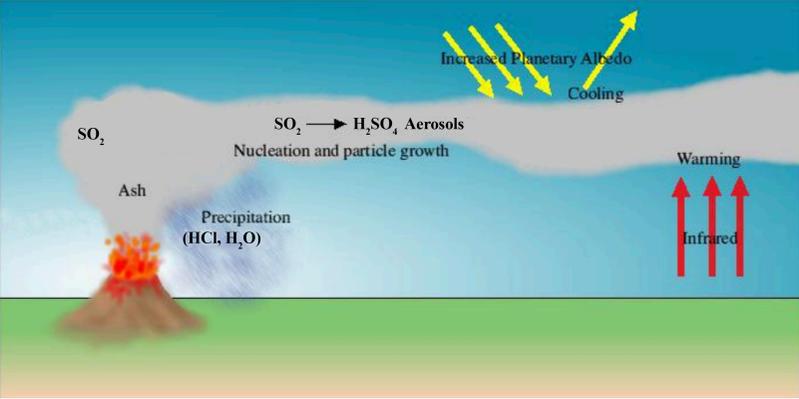
#### Evidence Statement

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
ONE	<p>The <b>ionosphere</b> is created by high-energy solar photons removing electrons from gas particles in the upper layers of the atmosphere, which creates electronically charged ions. The different regions of the ionosphere absorb different types of radiation, including gamma, X-rays, and extreme UV. The thermosphere is the next lower layer, which extends from about 90 to 500 km above the surface. The <b>thermosphere</b> is strongly heated by absorbing much of the X-ray and UV radiation from the Sun. This causes the thermosphere temperature to increase with increasing altitude (ranging from about 500 °C to 2000 °C) and during the day. When the sun is very active, the thin gases heat up and expand, or ionisation of gas particles occur, which increases the volume and altitude of the thermosphere.</p> <p>The <b>mesosphere</b> is from about 50 km to 90 km above the Earth. The mesosphere temperature decreases as altitude increases because very little solar radiation is absorbed here. Most of the heat energy in the mesosphere comes from the layers below. While still very thin, there are enough gases in the mesosphere to cause friction on incoming meteors, which causes them to mostly burn up in this layer.</p> <p>The <b>stratosphere</b> is from about 8–16 km above the surface of the Earth to about 50 km. Much of the Sun’s harmful UV radiation is absorbed in the stratosphere due to the presence of ozone (O<sub>3</sub>) which has its highest concentration at about 20–25 km. High-energy UV is able to split oxygen molecules in this layer, converting it to ozone. Ozone molecules absorb UV and convert it to heat, and as ozone is thinner higher up, temperature decreases with altitude in the stratosphere.</p> <p>The <b>troposphere</b> is mainly heated by (IR / long-wave) energy radiating (and conducting) from the Earth’s surface. The troposphere helps to regulate the Earth’s temperature, keeping it warm enough for life to survive. It contains clouds and aerosols that help to regulate the incoming energy from the Sun. Higher temperatures in the troposphere cause the height of the tropopause (the boundary between the troposphere and stratosphere) to increase, as more energy causes the gas particles to move faster, and the volume of the troposphere to increase.</p>	<p>Describes with understanding:</p> <ul style="list-style-type: none"> <li>• three different EM radiation (UV, X, Gamma, IR, visible, etc) identified</li> <li>• stratosphere contains ozone that protects us from UV</li> <li>• thermosphere / ionosphere protects us from UV / X-rays / charged solar wind particles</li> <li>• meteors burn up in the mesosphere</li> <li>• charged particles form aurora in the thermosphere / ionosphere</li> <li>• mesosphere receives heat energy from the stratosphere below OR mesosphere has no internal heat source</li> <li>• troposphere heated from Earth’s surface</li> <li>• clouds reflect light / shortwave in the troposphere</li> <li>• troposphere traps heat / maintains temperature.</li> </ul>	<p>Explains in detail:</p> <ul style="list-style-type: none"> <li>• the protective effect of the stratosphere OR thermosphere is explained (from UV / X-rays as appropriate)</li> <li>• the protective effect of the mesosphere due to sufficient density causing friction to burn up meteors</li> <li>• the role of clouds in the troposphere in reflecting the Sun’s energy</li> <li>• the increased altitude of the tropopause at the equator</li> <li>• formation of aurora in the thermosphere due to charged particles from the solar wind interacting with magnetic field</li> <li>• temperature gradient linked to heat source for one layer.</li> <li>• troposphere regulates temperature, due to GHG absorbing IR</li> </ul>	<p>Explains comprehensively:</p> <ul style="list-style-type: none"> <li>• how each of the four layers of the atmosphere protect the Earth</li> <li>• how the energy source for three different layers affects the temperature gradient.</li> </ul>

<b>NØ</b>	<b>N1</b>	<b>N2</b>	<b>A3</b>	<b>A4</b>	<b>M5</b>	<b>M6</b>	<b>E7</b>	<b>E8</b>
No response or response does not relate to the question.	Describes ONE idea at Achievement level.	Describes TWO ideas at the Achievement level.	Describes THREE ideas at Achievement level.	Describes FOUR ideas at Achievement level.	TWO Merit answers.	THREE Merit answers.	ONE Excellence answer.	TWO Excellence answers.

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
TWO	<p>The Earth’s land surface absorbs short-wave radiation and re-radiates heat / long-wave / infrared radiation, heating the troposphere.</p> <p>Conduction transfers heat from the land surface to the lower atmosphere. This causes an increase in temperature of the atmosphere, known as sensible heat transfer. Convection circulates the heat higher in the atmosphere, increasing the temperature of the upper atmosphere via sensible heat transfer.</p> <p>The ocean absorbs short-wave radiation and stores it as heat. Some heat may be transferred to the atmosphere via conduction from the ocean surface, if the atmosphere is much cooler.</p>  <p>As more heat is absorbed by liquid water molecules at the surface, the temperature increases and molecules gain kinetic energy. The increase in temperature is due to sensible heat transfer. Eventually, the water molecules gain sufficient energy to break the bonds between them and the liquid turns into a gas (water vapour) during the process of evaporation. Latent heat transfer happens as heat is absorbed by the water molecules during the process.</p> <p>Heat is transported by water vapour into the upper atmosphere. As the water vapour rises, its temperature decreases as water molecules release heat to the atmosphere via sensible heat transfer. When dew point temperature is reached, the water vapour condenses into liquid droplets and forms clouds. The stored heat is released into the surrounding atmosphere during this change in state from gas to liquid, via latent heat transfer. This warms the upper atmosphere.</p> <p>Sublimation is the process where solid water (ice) turns into water vapour, without melting to liquid first. This requires a larger amount of latent energy to be absorbed by the ice, compared to evaporation of water.</p>	<p>Describes with understanding:</p> <ul style="list-style-type: none"> <li>• labels THREE processes</li> </ul> <p>OR</p> <p>states changes during evaporation and condensation correct</p> <ul style="list-style-type: none"> <li>• short-wave radiation from Sun heats surface (land / ocean)</li> <li>• land radiates heat / IR / long-wave radiation</li> <li>• convection transports heat, increasing temperature of upper atmosphere</li> <li>• heat energy absorbed during evaporation</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>• heat released during condensation</li> <li>• increasing temperature = increasing KE of particles</li> <li>• water vapour transports heat to atmosphere / troposphere.</li> <li>• latent as change in state OR sensible as change in temperature</li> <li>• heat conducted from surface to atmosphere.</li> </ul>	<p>Explains in detail:</p> <ul style="list-style-type: none"> <li>• surface absorbs short-wave EM and re-radiates it as IR, heating atmosphere</li> <li>• convection linked to sensible heat AND increase in temperature</li> <li>• short-wave EM radiation absorbed and stored as heat by ocean</li> <li>• evaporation linked to absorbing <u>latent</u> energy</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>• condensation linked to releasing <u>latent</u> energy</li> <li>• increase in upper tropospheric temperature linked to release of heat transported in water vapour</li> <li>• dew point temperature linked to condensation</li> <li>• increase in KE breaks bonds between water molecules to cause change of state (or opposite).</li> <li>• Conduction between particles of surface and atmosphere.</li> </ul>	<p>Explains comprehensively:</p> <ul style="list-style-type: none"> <li>• how heat is transferred from land via three processes (radiation / convection / conduction) AND linked to sensible heat transfer</li> <li>• how the state of water changes, linking latent heat transfer and change in atmospheric temperature during evaporation and condensation.</li> </ul>

N0	N1	N2	A3	A4	M5	M6	E7	E8
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Q	Evidence	Achievement	Merit	Excellence
<p>THREE</p>	<p>The huge volume of water vapour released into the troposphere would be very short lived. Due to the troposphere cooling with altitude, vertical circulation of the troposphere, the water vapour would rise, cool, and form clouds, leading to precipitation back to the surface of the Earth. However, as this eruption was very large, a lot of water vapour reached the stratosphere.</p> <p>Due to the stratosphere warming with altitude, little vertical circulation takes place, and therefore little mixing. Strong winds lead to rapid horizontal mixing and circulation around the globe. This means that the water vapour is likely to stay in the stratosphere for a longer period of time, and to have a measurable effect on temperatures around the globe.</p> <p>This stratospheric water vapour is likely to form thin stratospheric clouds, which allow much of the short wave solar radiation through, as they are virtually transparent. However, they are able to trap some of the outgoing longer-wave radiation from the surface of the Earth, which leads to a warming effect.</p>  <p>Sulfur dioxide is likely to have the opposite effect. When sulfur dioxide reaches the stratosphere, it will react with water vapour and form sulfuric acid, which has a very high albedo. This will reflect significant amounts of solar radiation, resulting in a cooling effect on the Earth. Due to the stable nature of the stratosphere, this is likely to last 1–3 years, whereas in the troposphere it would be washed out by weather much more quickly.</p>	<p>Describes with understanding:</p> <ul style="list-style-type: none"> <li>• much of the water vapour released would lead to increased (local) precipitation in the troposphere</li> <li>• remaining water vapour that enters the stratosphere would form thin clouds</li> <li>• SO<sub>2</sub> forms sulfuric acid</li> <li>• sulfuric acid (or SO<sub>2</sub> products) has a high albedo / reflects sunlight</li> <li>• strong stratosphere winds spread aerosols</li> <li>• Tongan eruption linked to short-term warming, because high clouds increase temperature</li> <li>• Tongan eruption linked to longer-term cooling, as aerosols stay in stratosphere for longer.</li> </ul>	<p>Explains in detail:</p> <ul style="list-style-type: none"> <li>• effect of stratospheric clouds on radiation linked to temperatures</li> <li>• SO<sub>2</sub> forms sulfuric acid linked to reflected sunlight / reduced temperatures</li> <li>• stratosphere temperature increases with altitude, preventing vertical mixing/aerosols rising</li> <li>• stratospheric eruption products likely to be quickly circulated around the globe, due to strong horizontal winds</li> <li>• vertical circulation in the troposphere leads to formation of precipitation, so water / aerosols are quickly removed.</li> </ul>	<p>Explains comprehensively:</p> <ul style="list-style-type: none"> <li>• the water vapour in the stratosphere will form thin stratospheric clouds, which allow most solar radiation in, but reduce longer-wave radiation going out, having a warming effect</li> <li>• how the SO<sub>2</sub> in the stratosphere quickly becomes sulfuric acid, which increases the albedo of the stratosphere and reduces incoming solar radiation having a cooling effect</li> <li>• how the stratosphere is heated from above, so there is little vertical circulation and therefore mixing, but strong winds take the eruption products around the globe.</li> </ul>

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**Cut Scores**

<b>Not Achieved</b>	<b>Achievement</b>	<b>Achievement with Merit</b>	<b>Achievement with Excellence</b>
0 – 7	8 – 13	14 – 18	19 – 24