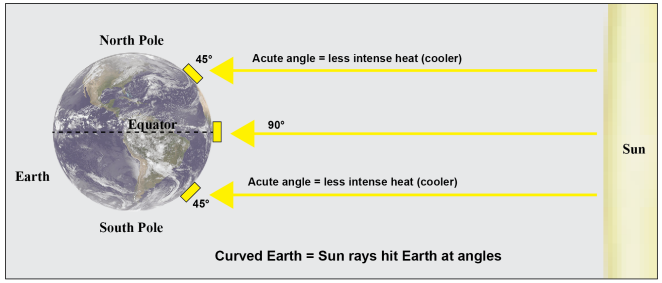
Assessment Schedule – 2023

Earth and Space Science: Demonstrate understanding of physical principles related to the Earth System (91193)

Evidence Statement

Question One

	Expected Coverage	Achievement	Merit	Excellence
(a)	Surface currents are formed by friction between wind and the ocean's surface.	Describes with understanding: • Action of wind on ocean surface.		
(b)	 The energy output received by the Earth is constant, no matter which latitude faces the Sun. However, due to the Earth's curvature, the heating that occurs at the surface changes. At the Equator, the angle of the solar radiation hitting the surface is more direct. In Equatorial regions, solar radiation strikes the surface at a direct angle, the surface exposed to the solar radiation is less, resulting in greater heating effect, i.e. greater wattage / m^2. In polar latitudes, the Sun's angle is less direct; as the curvature increases, the surface exposed to the solar radiation is greater, meaning that there is a decrease in heating of the Earth's surface, i.e. effectively less wattage / m^2.	Describes with understanding: • That the amount of energy from the sun is constant over the Earth. • The angle that solar radiation hits the Equator is direct. • The angle of solar radiation hitting the poles is acute / indirect. • The curvature of the Earth results in a change in the area exposed to the Sun. • A greater surface area is exposed to the sun (solar radiation) at the Polar regions. • A smaller surface area is exposed to the sun's energy (solar radiation) at the Equatorial regions.	Explains in detail: • The relationship between the sun's energy output, the angle that solar radiation is falling on the surface and heating the Earth. • The relationship between the curvature of the Earth and the heating effect on Earth's surface.	Explains comprehensively: • The relationship between the solar radiation, angle of the incident radiation and the curvature of the Earth, with the difference in heating at varying latitudes compared.

(c)	As surface currents move away from the Equator, heat energy gained by the ocean is lost to the cooler atmosphere. Water has a high heat capacity, meaning it takes a large quantity of heat energy to raise the temperature of a fixed mass of water by 1 °C. This means it takes a lot more heat energy to warm an equivalent mass of water than it does the same amount of air. As the ocean water is moved away from the Equator by the surface currents, it carries this heat energy with it. Effectively water acts as a heat sink. The heat energy is distributed into the cooler atmosphere as the surface currents move towards higher latitudes. Immediately above the surface of the ocean, conduction occurs whereby kinetic energy from the more energetic vibrating water molecules passes onto neighbouring air molecules. This increases the kinetic energy of the air molecules, i.e. increasing temperature. Warm ocean currents also radiate heat energy into the atmosphere, which is then absorbed by the air particles, causing the temperature to increase. Since the air above the ocean is warmer, it becomes less dense than the air immediately above and rises to be replaced by more dense colder air, which is in turn heated by the ocean. This is heat transfer through convection. *Evidence maybe taken from any section of the question.* *Evidence may be taken from an annotated diagram.*	Describes with understanding: • The surface currents move heat away from the Equator to higher latitudes. • Heat energy flows from high to low temperatures. • How the colour of the ocean impacts on the absorption of solar radiation • Ocean water's ability to absorb large qualities of heat energy. • How heat transfer takes place between the ocean and air, via conduction / radiation. • The atmosphere is warmed by convection. • How convection currents can he formed.	Explains in detail: • The role conduction / radiation plays in the transfer of heat energy from the ocean surface to the atmosphere. • The role convection plays in heating the atmosphere as less dense warmer air rises to be replaced by colder air. • The influence that water's high heat capacity has in warming the atmosphere.	Explains comprehensively: • Why the movement of water from the Equator effectively warms Earth's cooler regions and how the heat energy is transferred from the warmer ocean to the cooler atmosphere.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or response does not relate to the question.	Describes ONE point at the Achievement level.	Describes ONE point and ONE partial point at the Achievement level.	Describes TWO points at the Achievement level.	Describes THREE points at the Achievement level.	Explains ONE point at Merit level.	Explains TWO points at Merit level.	Explains ONE point at Excellence level.	Explains TWO points at Excellence level.

Question Two

	Expected Coverage	Achievement	Merit	Excellence
(a)	A: Absorption B: Transmission C: Reflection	• States 2 out of 3 correctly.		
(b)	Visible light is a mixture of wavelengths. All of these visible wavelengths, which make up the visible spectrum when added together, make visible light appear white. When these waves meet water droplets and small ice crystals in the clouds, they interact and are scattered. (Mie) scattering occurs when the wavelengths of the visible light interact with particles of similar size, in this case water droplets. All the wavelengths of light are scattered in similar amounts, causing all the colours to be scattered. Since all colours are scattered, they will combine and mix to make light appear white. Hence these clouds appear white. Much of the light that enters and is scattered by a cloud is scattered in a forwards direction. Which is why they appear white.	Describes with understanding: • White light is made up of different colours / wavelengths. • Light can be reflected and scattered by cloud's high albedo • All the light wavelengths are scattered by a similar amount by water droplets. • Scattering in similar amounts produces white light.	Explains in detail: • That light waves interact with water droplets, and since they are similar size. • Clouds appear white, as all the different wavelengths of visible light are scattered by similar amounts and combine.	Explains comprehensively: • How light, although made up differing wavelengths, is scattered by water droplets in clouds, so they appear white.
(c)	Cumulonimbus clouds contain far more water droplets, which means there will be an increase in the scattering of the visible wavelengths as the light penetrates through the cloud. The greater amount of water droplets (mass of cloud) also causes more absorption of light, so less light reaches the bottom of the cloud. When looking up into a raincloud, it will appear dark grey / black due to the visible light having been absorbed. If looking at the cloud from above, it would not appear dark due to the reflected scattered light. *Evidence maybe taken from any section of the question.* *Evidence may be taken from an annotated diagram.*	Describes with understanding: • Increase in reflected light from cloud tops due to cloud thickness. • Increase in number of water droplets increases the amount of scattering. • Increase in water droplets increases the absorption of light. • The dark colouration of clouds is due to light being absorbed.	Explains in detail: • How the light is travelling through more water droplets towards the cloud base results in increased scattering. • How an increase in water droplet density absorbs more of the scattered light creating the dark grey colour at the base.	Explains comprehensively: • Why cumulonimbus clouds appear dark grey when viewed from below due to the absorption of scattered light.

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Question Three

	Expected Coverage	Achievement	Merit	Excellence
(a)	A greenhouse gas can be described as a gas that traps heat within the atmosphere by absorbing and re-emitting heat / infra-red radiation.	Describes with understanding: • The link between greenhouse gases to trapping heat in the Earth's atmosphere.		
(b)	The incoming short wavelength (UV) radiation passes through Earth's atmosphere and is absorbed by Earth's surface. The absorbed short-wave radiation is re-radiated back into the atmosphere as long wavelength (infra-red) radiation. This long wavelength (infra-red) radiation is absorbed by greenhouse gas molecules as it travels back through the atmosphere towards space. This increases the greenhouse gas molecules' kinetic energy, hence raising the atmospheric temperature. The absorbed infra-red will eventually be re-emitted back into the atmosphere randomly, where it may be absorbed by other greenhouse gas molecules and hence further increase the atmospheric temperature, or back to the Earth's surface to be reabsorbed, or out into space.	Describes with understanding: • Solar radiation is a mix of short and long wave radiation. • Solar radiation is absorbed by Earth's surface and re-radiated back into the atmosphere. • Heat/Infra-red radiation can be absorbed by greenhouse gases and increases atmospheric temperature.	Explains in detail: • How incoming solar radiation interacts with Earth's surface. • How greenhouse gases influence the Earth's atmospheric temperature by absorbing and re-emitting IR radiation.	Explains comprehensively: • The link between greenhouse gases, Earth's surface and solar radiation interaction that warms atmospheric temperatures.
(c)	Water vapour is a greenhouse gas. This means that water vapour has the ability to absorb infra-red radiation emitted from the Earth's surface and thereby increase the Earth's atmospheric temperature, along with other greenhouse gas molecules. Most water vapour does not last for long in the Earth's atmosphere as it is rarely reaching above 5–10 km in height, but its behaviour as a greenhouse gas is significant when in the vapour stage. The effect of the increasing water vapour will be to increase atmospheric temperatures, due to its greenhouse effect over the short term. Carbon dioxide is also a greenhouse gas. Unlike water vapour that returns to Earth as precipitation within one week of entering the atmosphere, carbon dioxide stays in the atmosphere between 50–200 years. During this time, it continues to act as a greenhouse gas, absorbing infra-red radiation, and remitting it into the atmosphere, increasing the atmospheric temperatures. This means that increased amounts of carbon dioxide have a long-term effect on atmospheric temperatures. *Evidence maybe taken from any section of the question.* *Evidence may be taken from an annotated diagram*	Describes with understanding: • The increase in water vapour / carbon dioxide will increase atmospheric temperatures. • Water vapour stays in the atmosphere for a short time. • Carbon dioxide stays in the atmosphere for a very long time. • Water vapour returns to Earth as precipitation after a short time. • Carbon dioxide causes long-term changes to atmospheric temperatures, or vice versa for water.	Explains in detail: • How the increase in water vapour can influence atmospheric temperature over the short term. • How the increase in carbon dioxide can increase atmospheric temperature over the long term.	Explains comprehensively: • The differences between water vapour and carbon dioxide as greenhouse gases, explaining why water vapour has a short-term effect and carbon dioxide has a long-term effect.

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Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 12	13 –18	19– 24