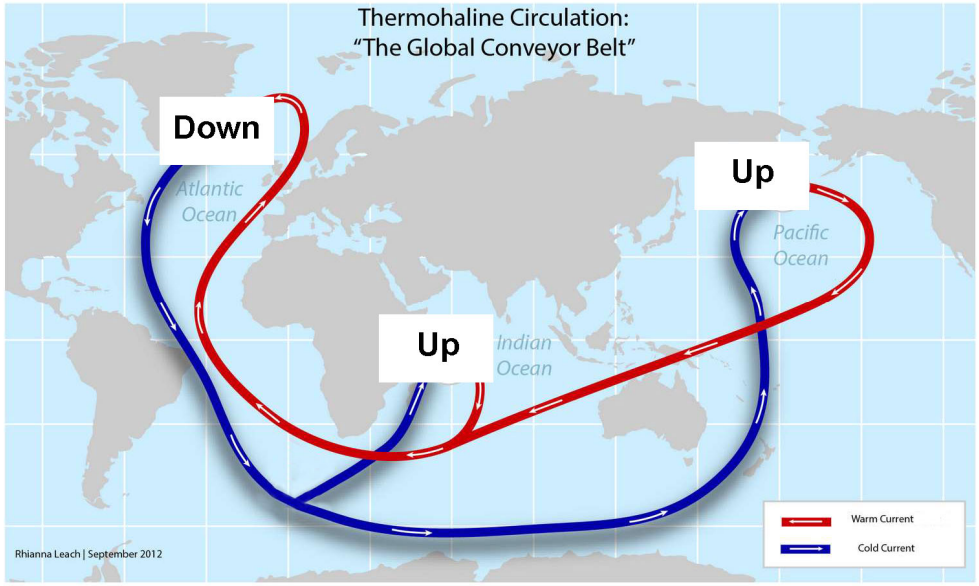
Assessment Schedule – 2022

Earth and Space Science: Demonstrate understanding of processes in the ocean system (91413)

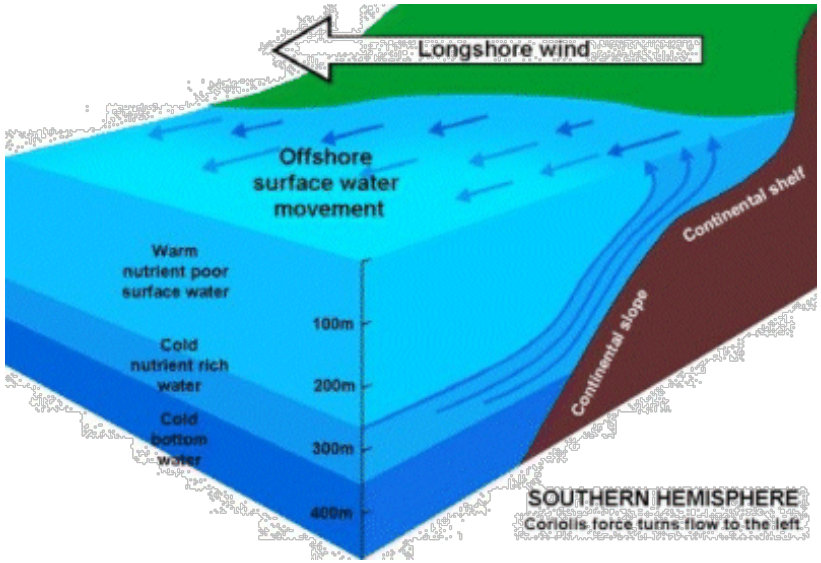
Evidence Statement

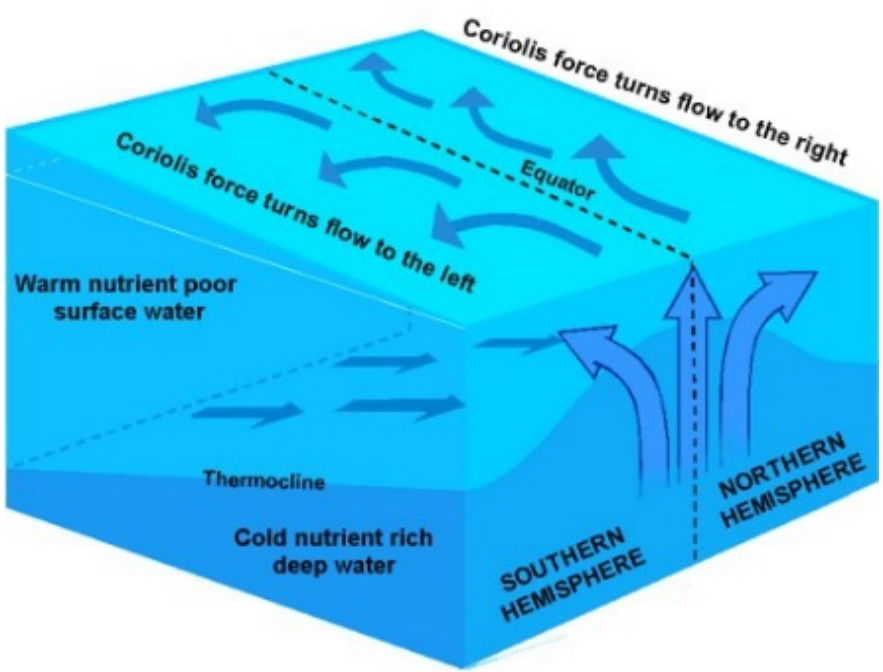
Q	Evidence	Achievement	Merit	Excellence
ONE	 https://hchscollier.weebly.com/uploads/6/5/1/8/65182593/day_6_-_el_nino_la_nina_notes.pdf Upwelling may occur due to wind-driven coastal currents, or deep-water currents meeting a coastal shelf and being forced towards the surface. Coastal upwelling is the wind-driven motion of dense, cooler, and usually nutrient-rich water from deep water towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water. As winds blow along western coasts towards the Equator, the Coriolis effect deflects the surface currents to the left in the Southern Hemisphere, and to the right in the Northern Hemisphere. This initiates Ekman transport which pulls the surface water away from the coasts, and this gets replaced by cold, nutrient rich waters from the deep ocean.	• Identifies one area of upwelling, e.g., north Pacific or eastern boundary currents AND area of deep-water formation (downwelling), e.g., north Atlantic. (Annotation of diagram may assist the description.) Describes with understanding: • upwelling as area where cold deep water rises to surface • how downwelling is driven by temperature / salinity/density .how heat energy is transported by THC (diagram OK)how nutrients are transported by THC (diagram OK).	Explains: • how temperature OR salinity impact the vertical movement of water in the THC • how factors (e.g winds, Coriolis effect, Ekman transport, sunlight) influence the horizontal movement of water how heat energy OR nutrients are transported through THC • (Diagram may be used to explain.)	Explains comprehensively: • the relationship between temperature and salinity, and how this impacts vertical AND horizontal movement of water in the thermohaline circulation • how heat energy is transported from the Equator towards the poles by THC linked to upwelling / downwelling • how nutrients from the deep ocean (marine snow etc.) are taken to the surface by upwelling. (Diagram may assist this explanation.)

Downwelling is the process of accumulation and sinking of higher density cold, saline water. Water near the poles loses energy to the atmosphere and becomes colder. Also, formation of sea ice increases the salt content of the surrounding water. This decreasing temperature and increasing salinity results in an increase in the density of the surface water near the poles, so it sinks to the deeper ocean below the less dense surface layer. Heat is transferred from the Equator towards the poles. High intensity sunlight is absorbed by the surface water, which is able to carry a large amount of heat due to water's high specific heat capacity. This heat is absorbed by the tropical waters, and is then transferred to the high latitudes, where it is finally given up to the atmosphere, which helps to moderate extremes of temperature around the globe.

Winds blowing across the ocean surface pull water away from coasts. Water then rises up from beneath the surface to replace the coastal surface water. This process is known as "upwelling." Cold water from the bottom of the ocean has collected many nutrients from decaying organisms, which rise to the surface with the upwelling.

Example of suitable diagrams:

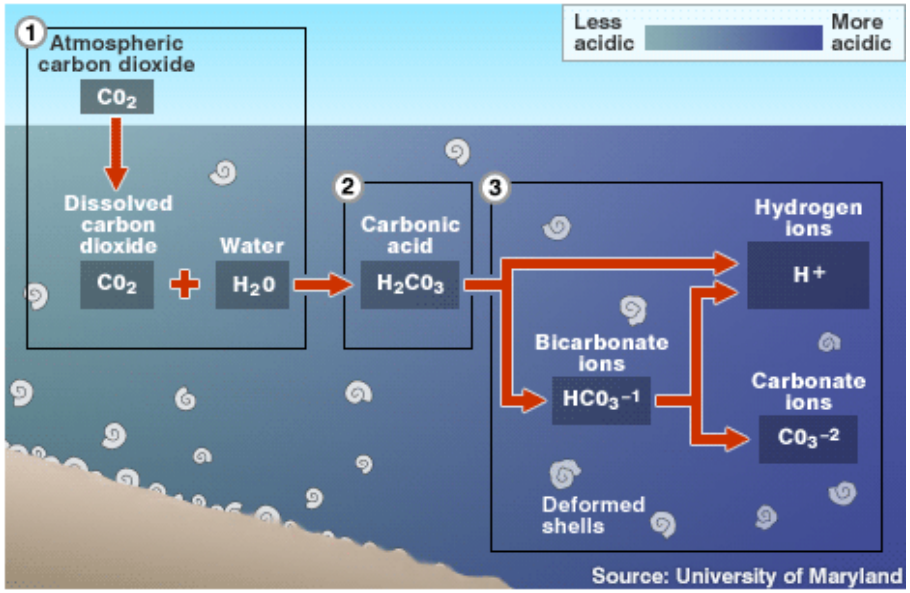




https://seos-project.eu / oceancurrents / oceancurrents-c04-s01-p01.html

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	ONE point from Achievement.	TWO points from Achievement.	THREE points from Achievement.	FOUR points from Achievement.	ONE point from Merit.	TWO points from Merit.	ONE point from Excellence.	TWO points from Excellence linked together.

Q	Evidence	Achievement	Merit	Excellence
TWO	When carbon dioxide (CO_2) levels in the atmosphere increase due to e.g., industrialisation, more is absorbed by seawater. Chemical reactions occur that reduce seawater pH, carbonate ion concentration, and saturation states of biologically important calcium carbonate minerals. These chemical reactions are termed "ocean acidification". Carbon dioxide may enter the ocean by dissolving in the surface layer. Wave action and lower temperatures can increase the rate at which the CO_2 dissolves. This CO_2 may be drawn down to deeper layers of the ocean by downwelling, which has the following effects on ocean carbon chemistry: CO_2 from the atmosphere is absorbed by the ocean, where it reacts with seawater to form carbonic acid. $CO_2 + H_2O \rightarrow H_2CO_3$ Then, carbonic acid dissociates (breaks-up) to form bicarbonate ions and hydrogen ions (H^+, hydronium, H_3O^+, protons, or acid particles). $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$ Some of the bicarbonate ions then further dissociate into carbonate and more acid (H^+) particles. $HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$ The increasing carbon dioxide entering the ocean will cause a shift in the equilibrium of these reactions, resulting in an increase in acid particles and reduced ocean pH. The biological pump involves marine organisms such as phytoplankton that perform photosynthesis to convert CO_2 into glucose. They may either be eaten, transferring the carbon into other organisms via the ocean food web or die and fall to the bottom of the ocean as "marine snow". This carbon may then build up in layers and store carbon in the deep ocean; alternatively, the carbon may then be released back into the (deep) ocean by respiration or decay. Increasing levels of CO_2 in the atmosphere are also resulting in increased levels of CO_2 entering the oceans. In turn this is resulting in lower pH (full explanation required) and less carbonate being available for microfauna to build shells in the ocean, which may result in an interruption of the marine food web. Alternatively, increasing atmospheric CO_2 is also resulting in an increase in global ocean temperatures, which could reduce the dissolving of carbon into the ocean as more of the gas can dissolve in colder water.	Describes with understanding: • role of atmospheric carbon dioxide in ocean surface temperature or decreasing pH • physical pump or factors affecting CO_2 entering the ocean • biological pump • increased atmospheric carbon dioxide leads to more dissolved CO_2 • dissolved CO_2 leads to carbonic acid being formed • carbonic acid reacts with water to form bicarbonate ions • any one relevant chemical equation (balancing not required).	Explains: • role of atmospheric carbon dioxide in raising ocean surface temperature OR decreasing ocean pH • how the physical pump takes carbon dioxide into the ocean • how the biological pump takes CO_2 into the deep ocean • increased atmospheric carbon dioxide leads to more carbonic acid and bicarbonate ions • two relevant chemical equations with charges (balancing not required) with supporting explanations.	Explains comprehensively: • the role of the physical and biological pump in CO_2 transport – including a range of balanced chemical equations • increased atmospheric carbon dioxide impacts ocean chemistry by increasing formation of both carbonic acid and bicarbonate ions.



NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	ONE point from Achievement.	TWO points from Achievement.	THREE points from Achievement.	FOUR points from Achievement.	ONE point from Merit.	TWO points from Merit.	ONE point from Excellence	TWO points from excellence with minor omission.

Q	Evidence	Achievement	Merit	Excellence
THREE	Salinity of the ocean is caused by the gradual weathering and erosion of rocks, which leads to mineral salts being washed into the ocean by rivers. However, as this process is very gradual, the salinity of rivers is very low compared to the ocean. Other sources of salt include volcanic vents that release solid and gaseous mineral salts from the Earth's crust. Salt can be lost to the atmosphere through salt aerosols being lost from the surface on windy days. Generally, the main factors that change the salinity of the ocean are evaporation and precipitation. At the poles, salinity is low as there is very little evaporation taking place due to very low temperatures. Sea ice formation removes water from the ocean leaving the salt behind and increasing salinity and descending. However, there is much more melting ice, runoff, and precipitation, which all add fresh water to the ocean and reduces the overall surface salinity of the ocean near the poles. In the mid latitudes, especially around the tropics, the sun is at a high angle, which provides a large amount of heat / energy to drive a large amount of evaporation from the surface of the ocean. However, there is little precipitation in these latitudes. As water particles evaporate from the ocean surface, salt particles remain in the ocean and increase the surface salinity. As this surface layer is warm, it will be less dense than the deeper ocean and it will remain at the surface, losing water through evaporation and increasing salinity of the surface layer. Around the Equator, as solar insolation is at the highest angle, there is still a large amount of evaporation, but this is offset by a large amount of precipitation (and runoff). Evaporation removes water but leaves salt behind, increasing concentration of salt; however, precipitation dilutes the surface water as fresh water is added to the surface layer. This less dense fresh water tends to float above the more dense water. Salinity is often lower near the land as there is a large amount of runoff which adds fresh water and lowers salinity. However, the Mediterranean has a very high salinity as there is a lot more evaporation than precipitation and runoff. As it is almost isolated, it doesn't mix with the ocean. Also, the Atlantic Ocean is relatively narrow and isolated compared to the Pacific, so high evaporation as it is close to land results in a higher salinity in the Atlantic.	Describes with understanding: • defines salinity as dissolved salts per unit volume • links high solar insolation (Equator / mid latitudes) with high evaporation rates • links high precipitation rates at the Equator with lowered salinity • a source of increasing salinity (evaporation, ice making, gradual weathering and runoff, volcanic vents) • a method by which salinity is reduced (precipitation, melting ice, runoff, surface loss of aerosols) • salinity at lowest at the poles, highest in the subtropics (30^{o} latitude) and lowered at the Equator.	Explains in detail: • lowered salinity near the Equator as high evaporation (due to solar angle) is offset by high precipitation • high salinity in the mid latitudes is due to solar angle / high evaporation with little precipitation removing water / leaving salt • low <u>surface</u> salinity at the poles is due to very low evaporation due to low solar angle and/or ice formation • one other process that increases salinity of the surface ocean (gradual weathering and runoff, volcanic vents) • one other method surface layer salinity is reduced (melting ice, runoff, surface loss of aerosols)	Explains comprehensively: • the link between solar insolation angle, precipitation, evaporation, and salinity at ALL 3 locations • processes that increase and decrease surface salinity in the ocean (e.g., weathering, volcanoes, isolation, runoff, aerosols, ice formation)

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	ONE point from Achievement.	TWO points from Achievement.	THREE points from Achievement.	FOUR points from Achievement.	ONE point from Merit.	TWO points from Merit.	ONE point from Excellence	TWO points from Excellence with minor omissions.

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 13	14 – 18	19 – 24