A Resource Booklet for SACE Stage 1 Earth and Environmental Science

The following pages have been prepared by practicing teachers of SACE Earth and Environmental Science. The six Chapters are aligned with the six topics described in the SACE Stage 1 subject outline. They aim to provide an additional source of contexts and ideas to help teachers plan to teach this subject.

For further information, including the general and assessment requirements of the course see: https://www.sace.sa.edu.au/web/earth-and-environmental-science/stage-1/planning-to-teach/subject-outline

A Note for Teachers
The resources in this booklet are not intended for 'publication'. They are 'drafts' that have been developed by teachers for teachers. They can be freely used for educational purposes, including course design, topic and lesson planning. Each Chapter is a living document, intended for continuous improvement in the future. Teachers of Earth and Environmental Science are invited to provide feedback, particularly suggestions of new contexts, field-work and practical investigations that have been found to work well with students. Your suggestions for improvement would be greatly appreciated and should be directed to our project coordinator:: lenaltman9@gmail.com

Preparation of this booklet has been coordinated and funded by the Geoscience Pathways Project, under the sponsorship of the Geological Society of Australia (GSA) and the Teacher Earth Science Education Program (TESEP). In-kind support has been provided by the SA Department of Energy and Mining (DEM) and the Geological Survey of South Australia (GSSA).

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

GEOLOGICAL SOCIETY OF AUSTRALIA

TESEP

Chapter 5

Importance of the Hydrosphere

Chapter 5.1

Water is present on the Earth as a result of volcanic outgassing and the impact of icy extra-terrestrial bodies.

Discuss theories of the origin of the Earth's water.

Approximately 4.6 billion years ago when the solar system was a cloud of gas and dust it began to spin as the result of a disturbance such an exploding nearby star (a supernova). The now spinning cloud of dust and gas then began to collapse into rings as gravity pulled the particles together. The Sun formed at the centre of this spinning disk and Earth and the other planets formed from particles accumulating in the outer rings of the disk.

As Earth solidified the planet existed at very high temperatures and had no atmosphere. As a result any water present that accumulated when Earth was formed is thought to have evaporated and been lost to space. As a result of this, scientists have gathered, and are still gathering and analysing, a range of evidence that suggests the origin of water on Earth.

The most common method used by scientists to trace the origin of water is through comparing the deuterium to hydrogen ratio of different water samples.

Each water molecule is composed of two hydrogen atoms and one oxygen atom (H_2O). However there are different versions of the element hydrogen – called isotopes - that can be a part of a water molecule replacing the regular hydrogen atoms. One of the isotopes of hydrogen is called deuterium and is a hydrogen atom with one extra neutron and this makes it slightly heavier than hydrogen.

The amount of hydrogen compared to deuterium in a sample of water molecules can indicate if they originate from the same source or not. The closer the ratio of deuterium to hydrogen the greater chance the water molecules originate from the same location. This is the method most commonly used to determine the origin of Earth's water.

Volcanic Outgassing

There is evidence to support the hypothesis that a significant amount of the Earth's water was already present, trapped in minerals and magma below the Earth's crust.

As the rocks in the Earth's mantle melt due to the internal heat of its magma, water is dissolved into the magma. As hot magma rises to the surface of the Earth, the pressure it is under decreases, allowing water to degas and, ultimately, be released when the magma breaks the surface. This process allows water to be continually released from significant depths within the Earth and occurs when volcanoes erupt today.

A range of evidence supports this hypothesis:

- Samples of magma and rock from Iceland and Baffin Island in the Canadian Artic suggest that Earth's water may have been trapped below the surface as it formed and then began to be released later as the planet's surface cooled. These locations have rock and magma present that is sourced from deep within the Earth's mantle and that has been the least disturbed since the Earth's formation. This rock and magma therefore has present within it water that has a Deuterium to Hydrogen ratio closest of that to early Earth.

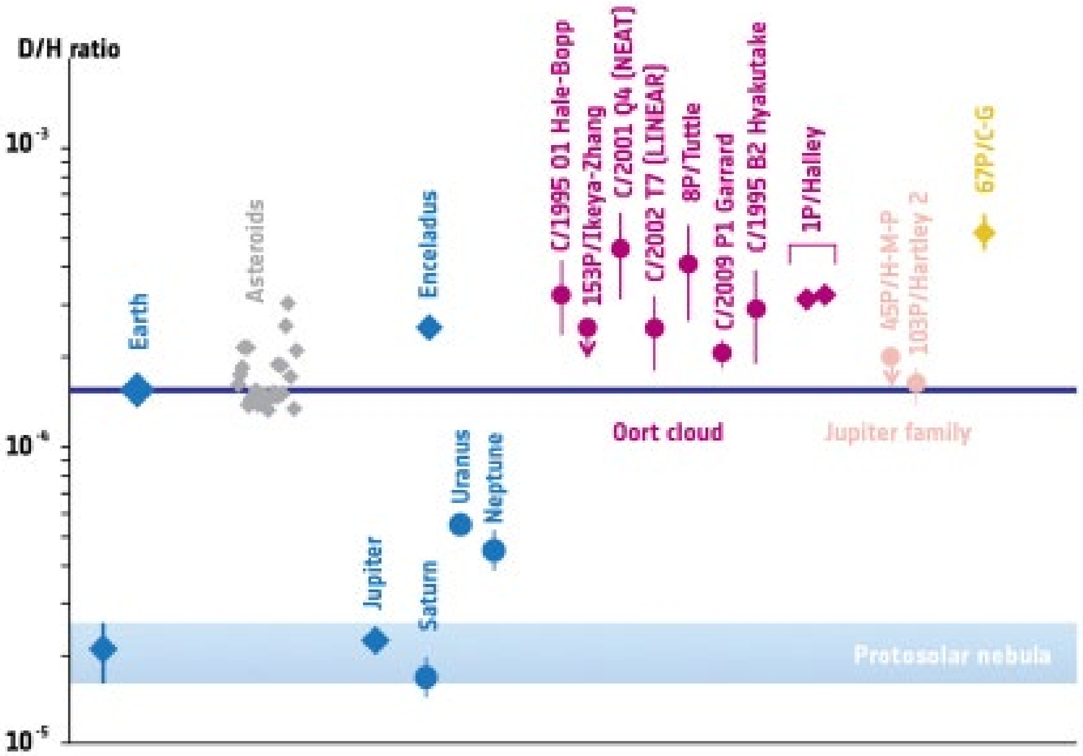
  The Deuterium to Hydrogen (D/H) ratio of the water extracted from the ancient rock and magma is lower than the Earth's ocean's current ratio. This supports the idea that as the spinning Earth and solar system formed most of the water containing Deuterium (which is slightly heavier than water containing hydrogen) was cast away from the forming planets. The remaining water on Earth was trapped in its rock and magma.
- Early studies suggested that water may be contained in minerals and rocks at depths of up to 150km to 200km below the surface.
- Data and modelling from more recent experiments has provided evidence that water can be found as far as 400km to 600km below the surface of the Earth.

Impact of Icy Extraterrestrial Bodies

Given the very high temperatures and lack of atmosphere on early Earth it is hypothesised that Earth's water originated from impacts with icy extraterrestrial bodies. Both asteroids and comets are extraterrestrial bodies that can contain ice. Should these bodies impact Earth's surface, their water load would be added to the Earth. There is debate regarding whether these impacts could provide all of the current water on Earth or if they just provided additional water to what was already present through volcanic outgassing.

Data gathered by space probes allows a comparison of the Deuterium to Hydrogen ratio of Earth's water and the water of other planets and extraterrestrial bodies. These data indicate:

- Multiple samples of different asteroids contain water with a range of Deuterium to Hydrogen (D/H) ratios, many of which are close to that of Earth's water.
- Comets sampled in the Oort cloud have a much higher D/H ratio than that of Earth's water.
- Comets of the Jupiter family have a D/H ratio very similar to that of Earth's water.



This evidence suggests that if Earth received water from extraterrestrial bodies it was most likely from asteroids, although some comets may have been involved.

Overall, given the volume of water on Earth and the evidence gathered it is suggested that a large portion of the water on Earth was produced by volcanic outgassing and that a smaller proportion was provided by icy extraterrestrial body impacts. The asteroids and comets with their higher D/H ratio water explain the overall increase in the D/H ratio of Earth's water when compared to the lower ratio of the water samples from deep within the Earth where the majority of the water outgassed.

Question 1.

Consider the scientific findings regarding the Deuterium to Hydrogen ratio of water - found in Earth's deep rocks and magma, and compare this with the ratio found in comets, asteroids and other planets

a) How does this body of evidence and data suggest that 'collaboration between scientists, governments, and other agencies is often required in scientific research and enterprise'?

____

____

____

____

____

____(4 marks) KA3

b) Consider the technology that must be required to sample water from rock deep inside the Earth and to sample water from planets, comets and asteroids.

How does this demonstrate that 'new technologies improve the efficiency of scientific procedures and data collection and analysis. This can reveal new evidence that may modify or replace models, theories, and processes.'

____

____

____

____

____

____(4 marks) KA3

Chapter 5.3

The global-ocean conveyor belt is a constantly moving system of deep-ocean circulation caused by a combination of thermohaline currents in the deep ocean and wind-driven currents on the surface.

The large-scale movement of water in the Earth's oceans is called the global-ocean conveyor belt. The flow of global ocean water has this name due to the continuous movement in one direction of large masses of water which produces a never-ending circulation. Like a conveyor belt the water moves along continuously and eventually the water will travel the entire water circulation route and end up back where it started.

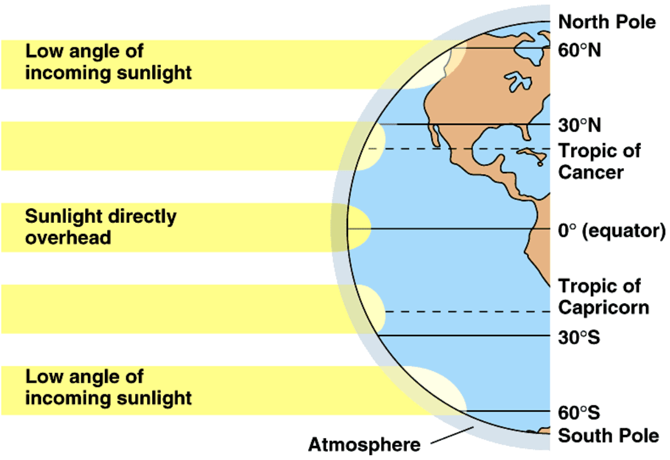
Two different types of ocean currents contribute to this global ocean conveyor belt.

<u>Surface Ocean Circulation</u>

The movement of water at the surface of the ocean in certain patterns is the result of wind. The friction between the particles of the air moving in a certain direction and the particles of water create an effect in which the water is dragged in the same direction as the wind movement. Approximately the top 100 metres of the surface of the ocean is affected by wind driven currents.

The winds that occur in the Earth's atmosphere are the result of unequal heating of the atmosphere by the Sun. The following sequence of events indicates this:

- More direct rays from the Sun reach the equator than the North or South Poles.
- The air at the equator heats to a higher temperature. This hot air rises (as it is less dense) and the equator develops a low pressure zone.
- The air at the North and South poles has a cooler temperature. This colder air sinks (as it is more dense) and the poles develop high pressure zones.
- Air naturally moves from zones of high pressure to zones of low pressure and this produces wind.

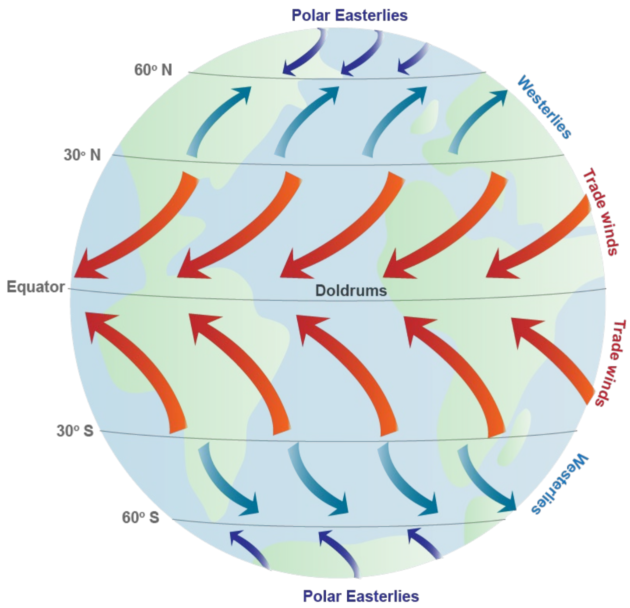


If the earth were not spinning, as a result of this heat and air pressure imbalance there would consistently be wind moving in a straight line from the poles to the equator. However, the Earth is spinning and so other factors come into play.

The Coriolis Effect is the name given to the curved motion in which wind moves across the surface of the Earth as the result of the Earth's spin.

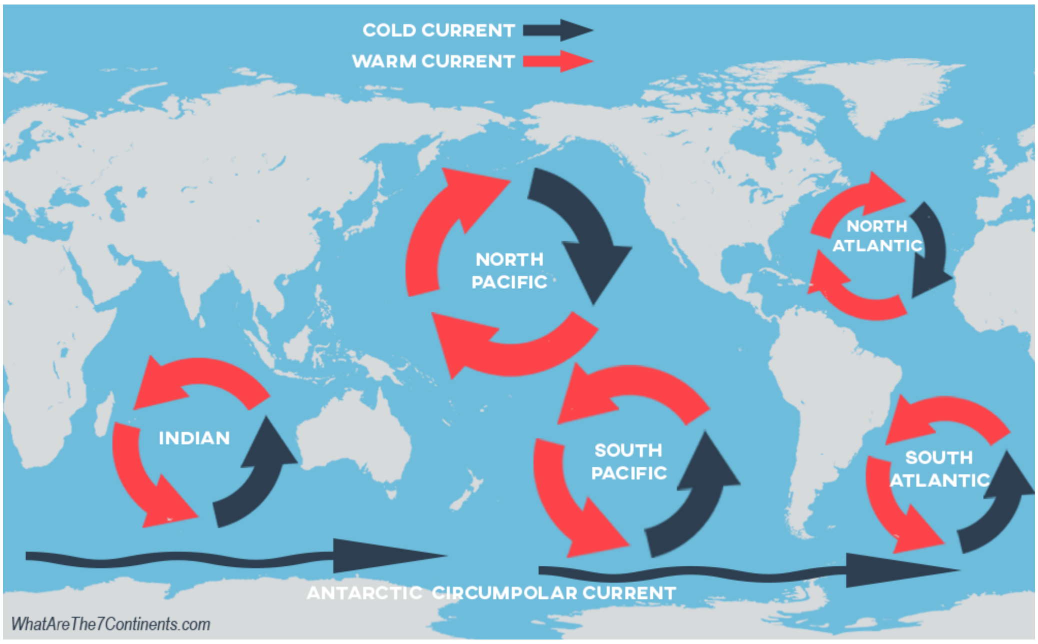
This results in:

- Northern Hemisphere – the wind and corresponding surface ocean currents curve to the **right** producing a clockwise spiral pattern.
- Southern hemisphere - the wind and corresponding surface ocean currents curve to the **left** producing an anti- clockwise spiral pattern.



The Coriolis Effect and the redirection of surface currents when they are interrupted by a continental landmass produces circular surface ocean currents that are called 'gyres'.

- There are five major gyres across the Earth's largest oceans:
  - South Pacific Gyre
  - North Pacific Gyre
  - South Atlantic Gyre
  - North Atlantic Gyre
  - Indian Gyre



The wind driven surface currents can be classified as warm or cold currents depending on where the current is bringing water from. As the earth is heated unevenly, gyres:

- Move warm water from the equator towards the poles and;
- Move cold water from the poles towards the equator.

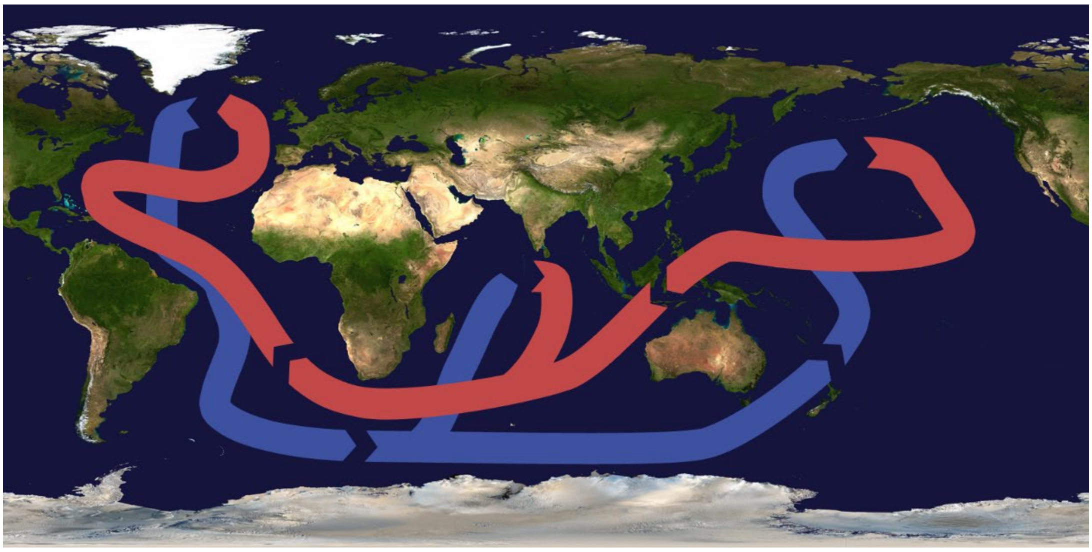
<u>Deep Ocean Circulation</u>

Approximately 90% of the ocean's water mass in affected by deep ocean currents rather than surface currents. This is the water mass that exists more than 100 metres below the surface and extends to the ocean floor – which on average is 3600 metres deep.

The deep ocean circulation follows a regular pattern around the Earth and is produced as a result of thermohaline circulation.

- Cold water on the bottom of the ocean near Greenland flows south through the Atlantic Ocean between Africa and South America.
- Once near Antarctica more cold water is added to the bottom current.
- The current splits into two main flows. One part of the current moves north into the Indian Ocean and the other continues along Antarctica before moving north into the Pacific Ocean.
- The cold bottom currents in both the Pacific and Indian Oceans then warm as they approach the equator and rise to the surface.
- Continental deflection then drives both of these now warm currents back south where they move along the equator and join up again in the Indian Ocean.
- The warm surface current then moves west around the bottom of Africa and north into the Atlantic Ocean where passes the east coast of North America and the west coast of Europe before reaching Greenland.
- Once near Greenland this water cools and sinks to the bottom of the ocean, starting the circulation again.

Deep ocean currents flow much slower than surface currents.



Question 2.

a) Identify two of the factors control the path of a surface current.

____

____

____ (2 marks) KA1

b) Compare surface currents and the deep ocean circulation currents. How are they the same and how are they different?

____

____

____

____

____

____ (4 marks) KA1

Explain how differences in temperature and salinity produce movement of water deep in the ocean.

Movement of the deep ocean water is driven by a natural process called the thermohaline circulation. In the word thermohaline:

- ‘Thermo’ refers to heat.
- ‘Haline’ refers to salinity (the amount of salt dissolved in a volume of water).

Thermohaline circulation causes the movement of water because of changes made to the temperature and salinity of water.

A mass of water will rise or sink through the surrounding water when its density is altered. Changing the temperature or salinity of a mass of water alters its density.

- Increasing the density of a water mass will cause it to sink through the surrounding water.
- Decreasing the density of a water mass will cause it to rise through the surrounding water.

Water will decrease in density and rise through the surrounding water when:

- The temperature is increased, and/or;
- The salinity is decreased

Water will increase in density and sink through the surrounding water when:

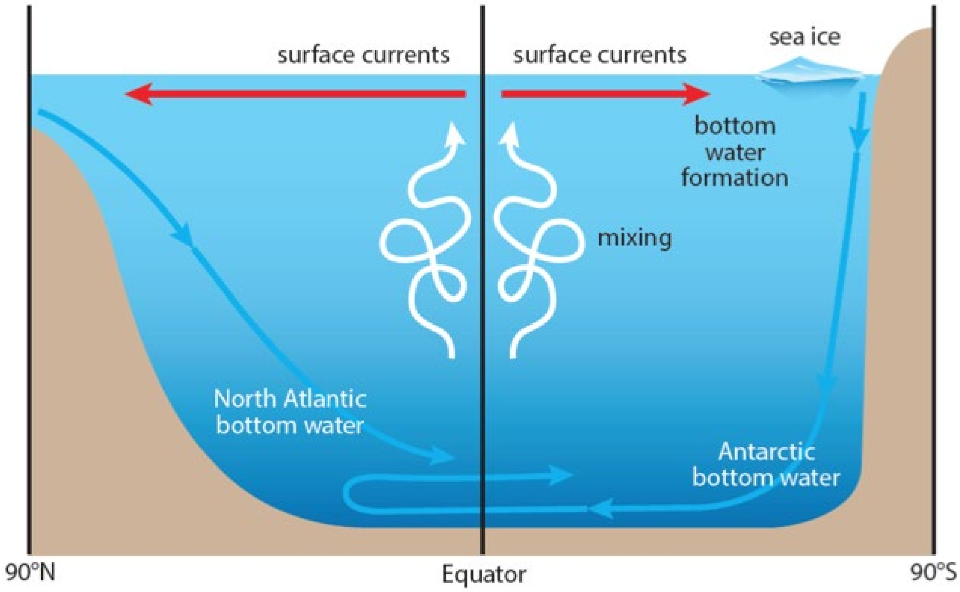
- The temperature is decreased, and/or;
- The salinity is increased

These changes in the temperature and salinity of water occur naturally as a result of the unequal heating of the Earth.

At the equator deep ocean water is warmed and it rises as a result of the increased heating by the sun. This deep ocean water now circulates closer to the surface and due to its decreased density will not sink again until either its temperature drops or its salinity is increased.

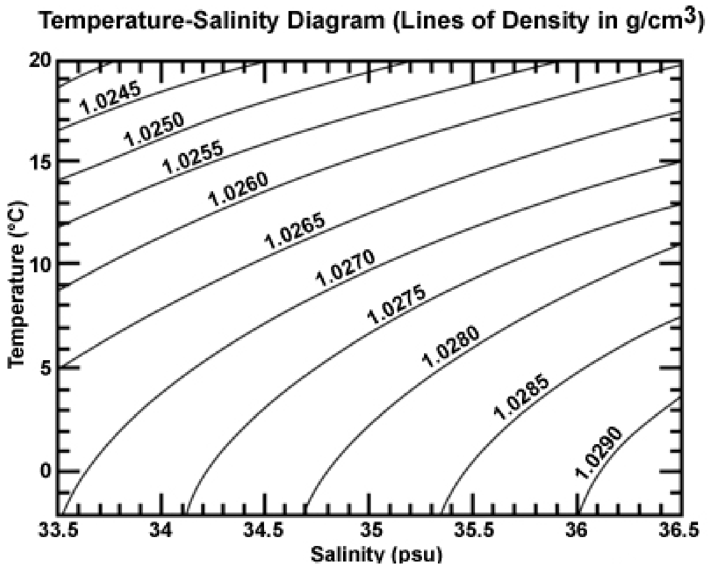
At the poles the air is colder due to decreased heating by the sun. This means the water is colder – increasing its density. The cold temperature also means that ice forms at the poles removing fresh water from the ocean and leaving behind large amounts of salt - increasing the salinity of the water. Together the cooling of the water and the increase in its salinity causes it to sink rapidly to the bottom of the ocean.

This regular alteration of the salinity and temperature of the ocean water at different locations and the resulting continuous rising and falling of ocean water drives the deep ocean circulation around the Earth.


surface currents
surface currents
sea ice
bottom
water
formation
mixing
North Atlantic
bottom water
Antarctic
bottom water
90°N
Equator
90°S

Question 3.

Consider the Temperature-Salinity graph below.



a) A sample of ocean water is taken and is determined to have a salinity of 34.5 psu and at the time of sampling had a temperature of 3°C. What density will the resulting sample have and how would this be determined using the graph above?

____

____

____ (2 marks) IAE3

b) If the water sample in a) was taken near Greenland what density would you expect water near the equator to be and why?

____

____

____ (2 marks) IAE3

c) How can a sample of water that has a density of 1.0265 g/cm^3 have a temperature anywhere from 5 °C to 17 °C but the water not change density?

____

____

____ (2 marks) IAE3

Question 4.

The world's largest waterfall is actually underwater and can be found beneath the Denmark Strait, which separates Iceland and Greenland. This waterfall plunges from close to the ocean surface to the bottom of the ocean making the waterfall approximately 2.4 kilometres tall.

What causes this 'waterfall' to exist?

____ (6 marks) KA2

Question 5.

An Earth and Environmental Science student wishes to test the following hypothesis:
'If a sample of high salinity cold water is placed in a mass of low salinity hot water then the high salinity cold water will sink.'

a) Consider the independent variable being tested in this hypothesis. What is the problem with this hypothesis?

____

____

______________________________ (2 marks) IAE1

b) Re-write the original hypothesis so that is contains one independent variable stated clearly.

____

____

______________________________ (2 marks) IAE1

c) Design an experiment to test **either** the effect of salinity on water density **OR** the effect of temperature on water density. Ensure you:

- State the independent variable and how you will alter it.
- State the dependent variable and how you will alter it.
- State the controlled variables and how they will be kept constant.
- The limitations of this experiment.

____

____

____

____

____

____

____

____

____

____

____

______________________________ (8 marks) IAE1

Explain the role of the global-ocean conveyor belt in regulating temperatures in Europe.

As a result of the deep ocean circulation and surface currents, large masses of warm water and cold water are moved continuously around the Earth's oceans. This movement of water redistributes heat around the Earth beyond where the Sun's initial heating of the water took place.

- Warm water moves from warm locations near the equator to colder locations near the poles.
- Cold water moves from cold locations near the poles to warmer locations near the equator.

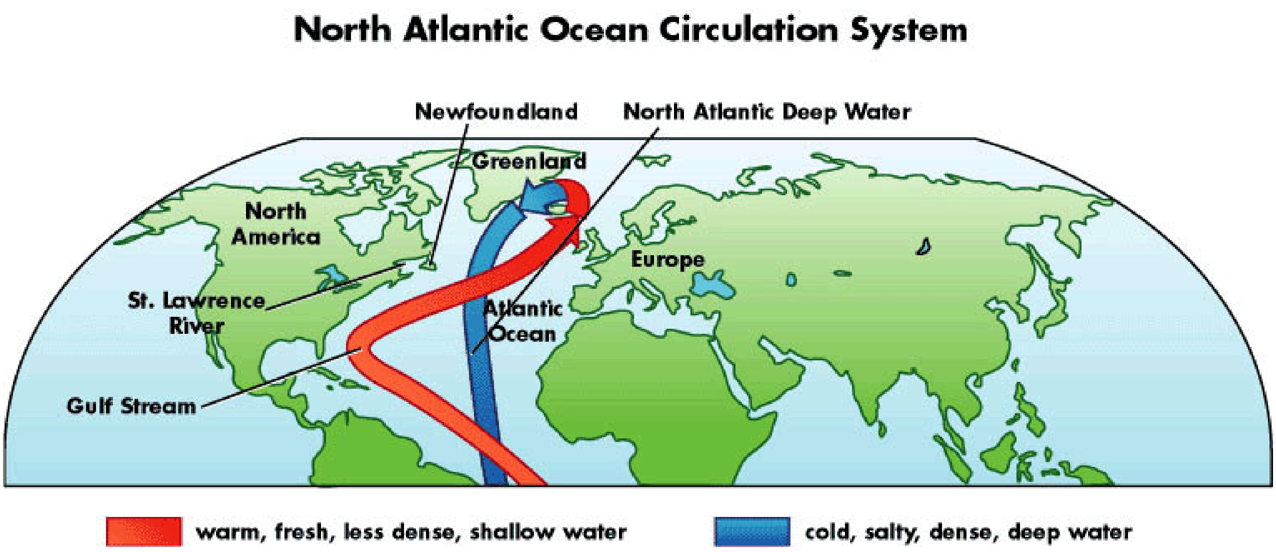
The temperature of the ocean also effects the temperature of nearby landmasses as warm water transfers heat to the air in contact with it. Therefore, the temperature of the land is altered as well as that of the ocean as a result of the ocean circulation of warm and cool water masses.

As a result of the global ocean conveyor belt a current called the Gulf Stream exists.

The Gulf Stream travels along the following path:
- Warm water from the equator is moved into the North Atlantic Ocean.
- This warm water moves up the East coast of North America before moving across to the West coast of Europe.
- Western Europe would normally be very cold due to its location closer to the poles (and decreased solar heating) however it is warmed throughout the year due to these warm masses of water that the Gulf Stream bring to the European coast.

If there were no global ocean circulation:
- The air and water at the poles would be colder.
- The air and water at the equator would be hotter.

Current research suggests that the Gulf Stream alone is not responsible for the moderation of Europe's climate but that there are more complex interactions with large scale atmospheric air flows that also produces this warming effect.



Question 6.

a) The climate in Northwestern Europe is much more mild than it is directly across the Atlantic in Canada and Northeastern USA. The Atlantic Ocean near Canada (Newfoundland) is locked in ice in winter but the Atlantic Ocean near England is not.

Explain how the Gulf Stream causes this difference in winter conditions despite the countries being similar distances from the Northern pole.

____

____

____

____

____

____ (4 marks) KA1

b) If global climate change results in a significant increase in ocean temperature across the world, what impact will this have on the polar regions where dense, cold and saline water usually forms? Consider both the immediate local effects and the long term global effects on the global ocean conveyor belt.

____

____

____

____

____

____

____

____

____

____

____

____ (8 marks) KA2

Explain the role of the global-ocean conveyor belt in global-ocean nutrient and carbon dioxide cycles.

- Ocean water that is warm surface water tends to have low amounts of carbon dioxide dissolved in it and is nutrient deficient.

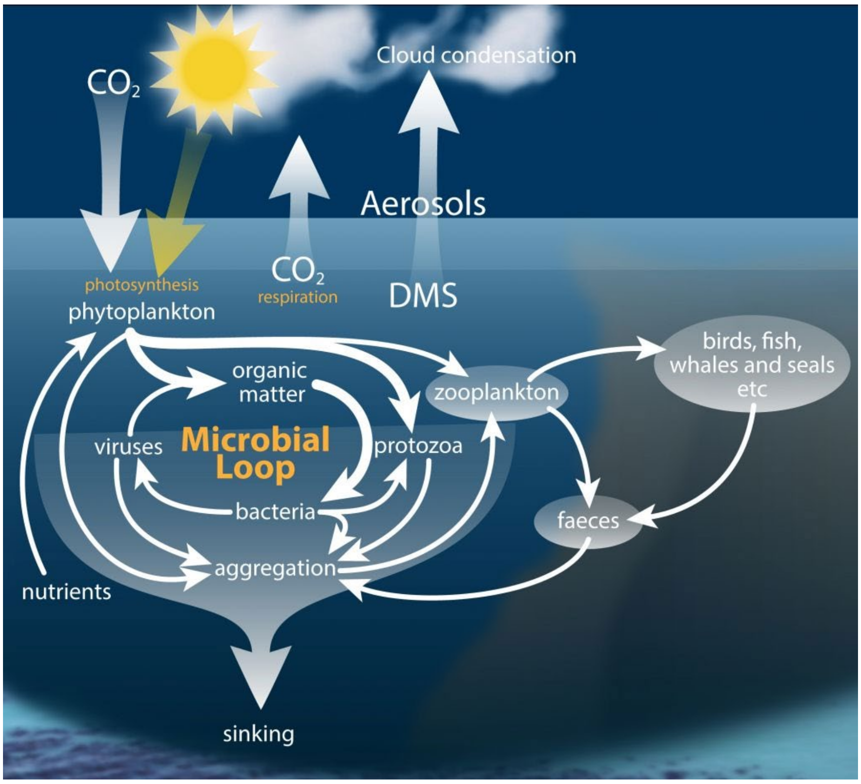
Many of the ocean's organisms including photosynthesising organisms operate in the surface waters of the ocean when sunlight is abundant. In the process of photosynthesis many of these organisms use up the carbon dioxide that is naturally dissolved in the water. Warm water is also less capable of dissolving and holding carbon dioxide within it.
As a result of the photosynthesising organisms and the warm water temperatures there is often low levels of carbon dioxide in warm surface waters.

As the organisms that are abundant in the warm upper ocean live, produce waste and die, their nutrients sink through the ocean decomposing until they reach the ocean floor. This means that nutrients are removed from the upper portion of the ocean just through organism life cycles. This leaves the upper portion of the ocean often nutrient deficient.

- Ocean water that is cold and deep or bottom water tends to have high amounts of carbon dioxide dissolved in it and is nutrient rich.

The Earth's oceans have a very large capacity to absorb carbon dioxide from the atmosphere. Larger amounts of carbon dioxide can be dissolved and held in colder waters. As a result, carbon dioxide from the atmosphere that dissolves in the cold ocean water at the pole sinks and therefore the carbon is stored in the deep or bottom ocean water.

As the deep ocean circulation moves water slowly through the bottom waters of the ocean and then brings them to the surface as a part of the global ocean conveyor belt, the carbon dioxide and nutrient rich water are brought with them. This provides nutrients and carbon dioxide to the organisms in the surface waters such as algae and phytoplankton that supports the whole aquatic food chain.



Question 7.

(a) Upwelling is the process in which deep, cool nutrient-rich ocean water rises towards the ocean surface. Explain how this circulation supports processes in the biosphere.

____

____

____

____

____

____ (2 marks) KA1

(b) If global ocean temperatures rise as a result of climate change, what may be the resulting impact on the role of the ocean as a reservoir of carbon?

____

____

____

____

____

____ (4 marks) KA2

Review Test 5

Question 1 (Multiple Choice)

(a) Which of the following is **not** responsible for the resulting circulation patterns of the surface wind circulation?

J Unequal heating from the sun.
K The Coriolis Effect.
L Continental deflection.
M. Thermohaline circulation

Your answer _________ (1 mark) KA1

(b) *Water that is near at the poles is ____________ and ____________, as a result it will ____________.*

Select from the options below the correct sequence of missing words to complete the sentence above.

J cold, not salty, sink
K cold, salty, rise
L cold, salty, sink
M cold, warm, sink

Your answer _________ (1 mark) KA1

(c) Ocean surface waters tend to be:

J warm and have low nutrient levels and low dissolved carbon dioxide levels.
K warm and have high dissolved carbon dioxide levels.
L warm and have low nutrient levels and high dissolved carbon dioxide levels.
M warm and have high nutrient levels.

Your answer _________ (1 mark) KA1

(d) If the global ocean conveyor belt slowed or stopped its circulation of water around the Earth, which of the following would be a possible impact?

J The cool water of the Gulfstream would slow its progress north through the Atlantic Ocean.
K The air and land temperatures in Europe would decrease.
L The distribution of heat from the sun around the Earth would increase.
M The overturning of the ocean waters and movement of nutrients would increase.

Your answer _________ (1 mark) KA1

Question 2: Short Answer

(a) What name is given to the wind driven surface ocean currents?

____ (2 marks) KA1

(b) What key property of water is used to identify the origin of water and provides evidence for the origin of water on Earth?

____

____

____ (3 marks) KA1

(c) It is hypothesised that the origin of Earth's water is from both volcanic outgassing and impacts from icy extra-terrestrial bodies.
What limitations are there to scientists' ability to collect data to either support or refute these hypotheses? (Identify at least two limitations)

____

____

____

____

____ (4 marks) KA1

(d) Use the following information to test the following hypothesis:

The warming and cooling rates of land are greater than those of the ocean at similar latitudes in Australia.

The following data table has been constructed to display the temperatures for Adelaide and Murray Bridge for this week.

	Adelaide			Murray Bridge		
	max (°C)	min (°C)	range (°C)	max (°C)	min (°C)	range (°C)
Wed	31	18	13	35	15	20
Thu	31	19	12	35	16	19
Fri	30	18	12	32	15	17
Sat	26	17	9	26	15	11
Sun	24	16	8	23	15	8
Mon	26	16	10	25	13	12
Tue	28	17	11	30	14	16
AVERAGE	28.0	17.3	10.7	29.4	14.7	14.7

(1) Use the grid below to draw a well-labelled and titled graph to show the range of temperatures in Adelaide and Murray Bridge over the seven days.

(6 marks) KAE2

(2) Use your graph to explain whether the hypothesis is confirmed, refuted or uncertain.

____

____

____

____

____ (4 marks) KAE3

Question 3: Extended-response question

Credit is given for clear, well-expressed answers that are well organised and relevant to the question.

The global ocean conveyor belt plays in important role in the

- Describe and explain the components and processes that produce the global ocean conveyor belt and how this circulation plays a role in climate moderation, carbon storage and the movement of nutrients.

(15 marks) KA1

Chapter 5

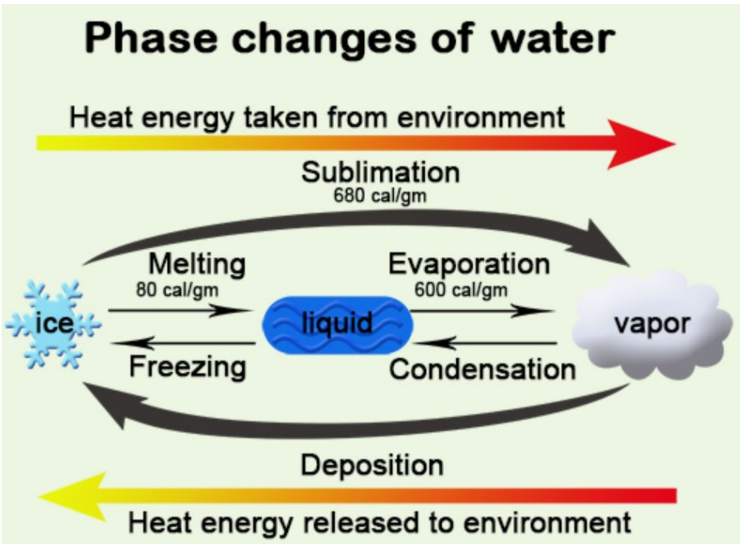
Importance of the Hydrosphere

Chapter 5.2

Water occurs in three phases on the Earth, solid, liquid, and gas.
Describe examples of the occurrence of the three phases of water in each of the Earth's spheres.

Water, a substance composed of the chemical elements hydrogen and oxygen, exists in gaseous, liquid, and solid states. It is one of the most plentiful and essential of compounds. A tasteless and odourless liquid at room temperature, it has the important ability to dissolve many other substances.

The versatility of water as a solvent is essential to living organisms. Life is believed to have originated in the aqueous solutions of the world's oceans Living organisms depend on aqueous solutions, such as blood and digestive juices, for biological processes.
Although the molecules of water are simple in structure (H_2O), the physical and chemical properties of the compound are extraordinarily complicated, and they are not typical of most substances found on Earth.



http://www.geochembio.com/ecology/climate-components/water-in-atmosphere.html

Water goes through three different states in the water cycle. It can be a liquid (water), a gas (water vapour) or a solid (ice).

These three states of matter are interchangeable, as water can freeze into ice or evaporate into water vapour, water vapour can condense as water, and ice can melt into water. The water cycle consists of a number of steps which sees water go through each of these states.

- **Gas to liquid, and vice versa**. As the temperature drops, the molecules in the gas phase come together and form a liquid in the **process of condensation**; the opposite process, changing from a liquid to a gas, is **vaporisation**.

- **Liquid to solid, and vice versa**. As the temperature drops further, below 0°C, the particles move slower and become fixed in position in the **process of freezing**; the opposite change is called **melting, or fusion**.

- **Gas to solid, and vice versa**. All three states of water are familiar because they are stable under ordinary conditions. Carbon dioxide, on the other hand, is familiar as a gas and a solid (dry ice), but liquid CO_2 occurs only at pressures of 5.1 atm or greater. At ordinary conditions, solid CO_2 changes directly to a gas, a **process called sublimation**. Freeze-dried foods are prepared by sublimation. The opposite process, changing from a gas directly into a solid, is called **deposition**—ice crystals form on a cold window from the deposition of water vapour.

Occurrences of the three phases of water in each of the Earth's spheres.

The Earth consists of different spheres:

- Biosphere
- Atmosphere
- Hydrosphere
- Lithosphere
- Cryosphere

https://www.eduweb.com/portfolio/earthsystems/parent_page.html

The water cycle consists of a number of steps which see water go through each of the phase states.

1. Evaporation: Water is found in lakes, oceans, swamps, and soil, as well as in all living creatures and plants. When heat is applied from the sun, through exertion, or by artificial means, the water molecules become excited and spread out. The loss of density is called 'evaporation', and it sees the water rise into the air forming clouds of water vapour. Normally, the evaporation of water occurs when the water hits boiling point, around one hundred degrees centigrade.

However, in places in which the air pressure and humidity are lower, far less heat energy is needed to evaporate the water because there is less pressure holding the water molecules together. The water that evaporates from the oceans is not salty, as the salt is too dense and heavy to rise with the water vapour, which is why water from rivers and lakes is not salty.

Snow and ice can actually turn into water vapour without first turning into water. This process is called 'sublimation', and it results from low humidity and dry winds. This usually occurs at the peaks of mountains or other high-up places, as the lower air pressure means that less energy is needed to sublimate the ice into water vapour.

Some of the highest peaks on earth, such as Mount Everest, have all of the necessary components for sublimation, namely: strong sunlight, low temperatures, low air pressure, strong wind, and low humidity. If you've ever seen dry ice, which has a fog pouting off of it, this is an example of sublimation in action.

When water evaporates off of a plant's leaves, the process is known as 'evapotranspiration'. A small percentage of the water in the atmosphere is produced by this process due to the large areas covered by plants and trees across the planet. While about ninety per cent of the water vapour in the world comes from lakes, oceans, and streams, the remaining ten per cent is comprised of the various plant life around the world.

2. Condensation and precipitation: The water vapour that has risen into the sky cools significantly when it comes into contact with the cooler air found up high. The vapour becomes a cloud, which is pushed around the world by moving air currents and winds.

If the water vapour cools to anything above zero degrees centigrade, it will condense as water. Essentially, the water vapour will start to condense on the surface of tiny particles of dust and dirt that rose with the vapour during the process of evaporation. These tiny droplets will start to fall into one another and merge, producing a larger droplet. When a droplet is large enough, gravity will pull it down at a rate that exceeds the updraft in the cloud, leading to the droplet falling out of the cloud and onto the ground below. This process is called 'precipitation', or – more commonly – rainfall.

If precipitation occurs in conditions which are particularly cold or have very low air pressure, then these water droplets can quite often crystallize and freeze. This causes the water to fall as solid ice, known as hail, or as snow. If the conditions are in between those associated with snow and rain, the droplets will fall as icy cold, half frozen water commonly referred to as sleet.

3. Infiltration: The water that has fallen as rain is absorbed into the ground through a process known as 'infiltration'. Soil and other porous materials can absorb great deals of water this way, while rocks and other harder substances will only retain a small amount of water.

When the water infiltrates soil, it will move in all directions until it either seeps into nearby streams or else sink deeper into what is known as 'groundwater storage'. This is where the water that does not seep out or evaporate joins up under the ground, saturating the smallest nooks and crannies of rock and soil under the ground. These formations are also known as 'aquifers' and explain why sometimes the ground underneath the top soil is damp or sodden.

When an aquifer becomes too full, it starts to leak out onto the surface forming what is known commonly as a 'spring'. These can often be found in formations of porous or brittle rock, which can crack following slightly acidic rainfall. Should the water be located near a volcano or any source of natural thermal energy, it will form a hot spring.

4. Runoff: After the water has fallen and the soil has become saturated, or the snow has melted, the water follows gravity and falls down any hills, mountains, or other inclines to form or join rivers. This process is known as 'runoff', and it is how water comes to rest in lakes and returns to the ocean. The water falls according to the incline of the place from which it is falling, and when several threads of water meet they form a stream.

The direction in which the water moves is known as 'streamflow', and it is central to the concept of the currents within rivers and streams. These streams and rivers will run off eventually to either form lakes or rejoin the ocean, depending on their proximity to the ocean. Due to the amount of water stored in snow or ice, sudden increases in the heat can lead to flooding due to the water suddenly melting and running off at an alarming rate. This is why flooding can occur so easily during a warm spring following a particularly cold and biting winter.

When more snow falls than evaporates or sublimates, the ice will compact densely to form what are known as ‘ice caps’. The ice caps and glaciers located in the coldest regions of the world are the biggest collections of ice in the world, and are slowly starting to shrink as the water in which they sit is becoming warmer.

This happens in a cyclical manner, with no beginning or end. As precipitation happens in one part of the world evapotranspiration is happening somewhere else. The cycle of water never ends, which is why the oceans stay level, there are always clouds somewhere in the sky, and drinkable water doesn’t suddenly just run out. At some point, any water that has infiltrated will be released, any that has joined the ocean will evaporate, and even a large portion of the ice caps may melt, releasing water that has been stored for millions of years back into the water cycle with potentially cataclysmic effects.

<u>Question 1</u>
Clearly state the three phases that water is found in on Earth.

____
____
____(3 marks) KA1

<u>Question 2</u>
The three states of matter are interchangeable, as water can freeze into ice or evapourate into water vapour, water vapour can condense as water, and ice can melt into water.
Draw a diagram to illustrate the interchangeable properties of water.

(6 marks) KA4

<u>Activity 1</u>
The Earth consists of five(5) spheres.
List the five spheres. Give examples for the occurrence of where water exists in each of the phases for each the spheres.

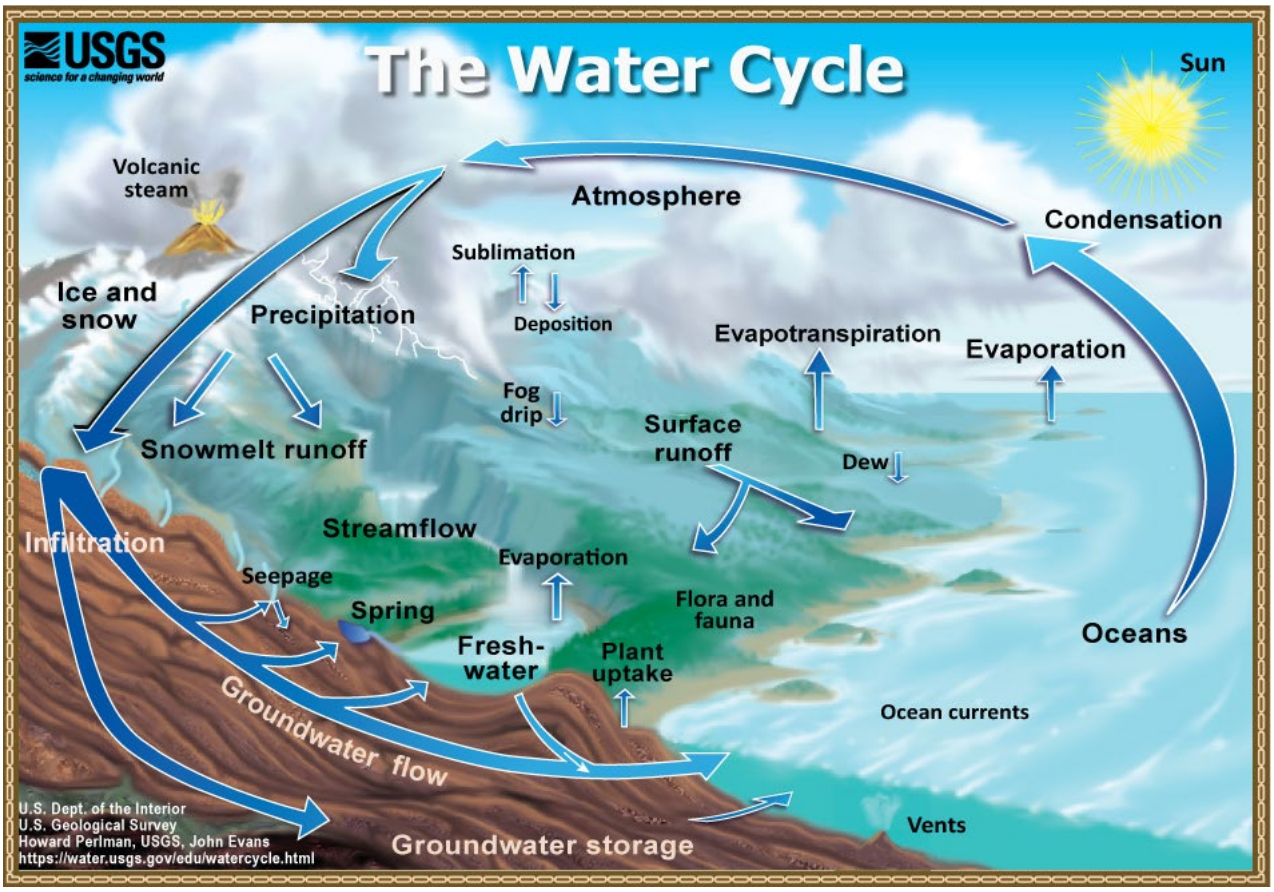
- This could be completed in table format
- As a concept map or
- Presented as an Infographic

(10 marks) KA4

The Hydrological cycle.

Describe the hydrological cycle.

Earth's water is always in movement, and the natural water cycle, also known as the **hydrological cycle**, describes the continuous movement of water on, above, and below the surface of the Earth.



https://water.usgs.gov/edu/watercycle.html

The hydrological cycle (as seen in the diagram) has no starting point as it is a continuous movement.

- Starting in the oceans. The sun, which drives the water cycle, heats water in the oceans. Some of it evaporates as vapour into the air; a relatively smaller amount of moisture is added as ice and snow sublimate directly from the solid state into vapour.
- Rising air currents take the vapour up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. The vapour rises into the air where cooler temperatures cause it to condense into clouds.
- Air currents move clouds around the globe, and cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years.
- Snowpack's in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt.
- Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff.

- A portion of runoff enters rivers in valleys in the landscape, with streamflow moving water towards the oceans. Runoff, and groundwater seepage, accumulate and are stored as freshwater in lakes.
- Not all runoff flows into rivers, though. Much of it soaks into the ground as infiltration. Some of the water infiltrates into the ground and replenishes aquifers (saturated subsurface rock), which store huge amounts of freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as groundwater discharge, and some groundwater finds openings in the land surface and emerges as freshwater springs.
- Some groundwater is absorbed by plant roots to end up as evapotranspiration from the leaves.

<u>Explain why evaporation from large bodies of water, e.g. the ocean and rivers, is important for atmospheric moisture.</u>

Evaporation and why it occurs

Evaporation is the process by which water changes from a liquid to a gas or vapour. **Evaporation is the primary pathway that water moves from the liquid state back into the hydrological cycle as atmospheric water vapour.**

Evaporation is important for atmospheric moisture as studies have shown that the oceans, seas, lakes, and rivers provide:

- nearly 90 percent of the moisture in our atmosphere via evaporation
- with the remaining 10 percent being contributed by plant transpiration.

Evaporation from the oceans is the primary mechanism supporting the surface-to-atmosphere portion of the water cycle. The large surface area of the oceans (over 70 percent of the Earth's surface is covered by the oceans) provides the opportunity for such large-scale evaporation to occur. On a global scale, the amount of water evaporating is about the same as the amount of water delivered to the Earth as precipitation.

This does vary geographically, though. Evaporation is more prevalent over the oceans than precipitation, while over the land, precipitation routinely exceeds evaporation. Most of the water that evaporates from the oceans falls back into the oceans as precipitation. Only about 10 percent of the water evaporated from the oceans is transported over land and falls as precipitation. Once evaporated, a water molecule spends about 10 days in the air.

The hydrological cycle is all about storing water and moving water on, in, and above the Earth. **Although the atmosphere may not be a great storehouse of water, it is the superhighway used to move water around the globe.**
There is always water in the atmosphere. Clouds are, of course, the most visible manifestation of atmospheric water, but even clear air contains water—water in particles that are too small to be seen.

One estimate of the volume of water in the atmosphere at any one time is about 12,900 cubic kilometres (km^3). That may sound like a lot, but it is only about 0.001 percent of the total Earth's water volume. If all of the water in the atmosphere rained down at once, it would only cover the ground to a depth of 2.5 centimetres.

Question 3

Explain the importance for atmospheric moisture and the mechanism within the hydrological cycle which allows for this to occur.

____
____
____
____
____
____
____
____
____
____(4 marks) KA2

Question 4

Label the following Hydrological diagram correctly by placing "letters in the diagram" from the "water movement titles" in the list.

- A - Storage in ice and snow
- B - Precipitation
- C - Snowmelt runoff to streams
- D - Infiltration
- E - Groundwater discharge
- F - Groundwater storage
- G - Water storage in oceans
- H - Evaporation
- I - Condensation
- J - Water storage in the atmosphere
- K - Evapotranspiration
- L - Surface runoff
- M - Streamflow
- N - Springs
- O - Freshwater storage
- P - Sublimation

https://water.usgs.gov/edu/watercycleprintnotext.html

(4 marks) KA4

How changes to the hydrological cycle impact on ecosystems and people's use of water resources.

Impacts on the hydrological cycle by human activity

We are becoming increasingly aware of our impacts on nature.
A number of human activities can impact on the hydrological cycle: damming rivers for hydroelectricity, using water for farming, deforestation and the burning of fossil fuels. Different countries use different amounts of water, but we all tend to use them in the same ways, and some of these actions can impact on the hydrological cycle – generating hydroelectricity, irrigation, deforestation and the greenhouse effect, as well as motor vehicle use and animal farming.

- **Hydroelectricity**

Australia and New Zealand have electricity which is generated using hydro dams. This involves changing the stored gravitational energy of water held behind the dam into electrical energy that can be used. While this is a non-polluting renewable way to generate electricity, it does have environmental impacts – especially when mismanaged.

Rivers must be dammed, which can affect the function of the river both upstream and downstream – lakes are usually formed from the water accumulating above the dam and a build-up of silt can occur, while the amount of water is reduced further downstream. This can be problematic for any plants and animals that may find themselves with too much or too little water, and migrating fish cannot get through the dams.

Seriously mismanaged dams can result in droughts downstream, with smaller streams completely drying up, leaving areas of unwatered land. People then have to look at ways of getting more water into these dry areas.

https://www.sciencelearn.org.nz/resources/726-humans-and-the-water-cycle

- **Irrigation**

As the human population has increased, so have our demands on the land. We need more food, and to make food, we need water. Irrigation is the artificial watering of land that does not get enough water through rainfall. Irrigation is used substantially by most countries, some more than others. Arid (dry) lands require far more water, as do countries that have large intensive farming communities.

The problem with irrigation is that it removes water from its natural source and often causes leaching and run-off where it is used. This removal of nutrients results in farmers using more fertilisers to keep their pastures productive while the waterways become polluted. Another problem is that salt is brought up from lower levels (salination).

https://www.sciencelearn.org.nz/resources/726-humans-and-the-water-cycle

- **Deforestation**

The removal of trees (deforestation) is having a major impact on the water cycle, as local and global climates change.
Normally, trees release water vapour when they transpire, producing a localised humidity. This water vapour then evapourates into the atmosphere where it accumulates before precipitating back to the Earth as rain, sleet or snow. Deforestation in one area can therefore affect the weather in another area because if trees are cut down, there is less water to be evapourated into the atmosphere and subsequently less rain.

At a local level, the land becomes drier and less stable. When it rains, instead of the water being soaked up, there is increased run-off and leaching. Areas can become more prone to both droughts and flooding, impacting on plants and animals, and also humans living near deforested areas.

http://4.bp.blogspot.com/_On9T9zYx3uQ/TQEGtPlM2uI/AAAAAAAAADg/L6spe9U-TIw/s1600/deforestation1.jpg

How changes to the hydrological cycle affects people’s use of water resources

Water is essential for human survival and well-being and important to many sectors of the economy. However, resources are irregularly distributed in space and time, and they are under pressure due to human activity.

How can water resources be managed sustainably while meeting an ever-increasing demand.

Some countries have programs to reduce demand and losses from urban water distribution systems, but more efforts are necessary. However, this will involve changes in behaviour requiring education and political commitment. Such efforts to conserve water and reduce demand are not only useful in regions where water is in short supply, they can also bring economic benefits in wetter regions.

Most water companies focus on developing infrastructure rather than on managing demand. **A shift towards reducing demand will require changes in patterns of behaviour by individuals and organizations, as well as political commitment to enforce rational water management.** Countries have responded to the present situation with new laws, new techniques, and local knowledge. Regular assessments of basins and aquifers will bring economic, social, and environmental benefits.

Programmes that focus on managing demand emphasise steps to encourage lower consumer use and fewer leaks in water distribution networks. Such leaks can lead to the loss of from 40% to 70% of the water within the supply system.

Water quality and flow in a body of water influences the way in which communities use the water for activities such as drinking, swimming or commercial purposes. More specifically, the water may be used by the community for:

- supplying drinking water
- recreation (swimming, boating)
- irrigating crops and watering stock
- industrial processes
- navigation and shipping
- production of edible fish, shellfish and crustaceans
- protection of aquatic ecosystems
- wildlife habitats
- tourism activities
- scientific study and education.

How changes to the hydrological cycle affects Indigenous people's use of water resources

Indigenous peoples and water

Water is vital to life, essential to agriculture and a valuable energy source which may be utilised in the mitigation of climate change impacts. Water is extremely valuable globally to both Indigenous and non-Indigenous peoples and is used for many different purposes. Water is also important to both for different reasons.

In a study undertaken in Anmatyerre country, in the Northern Territory, the Anmatyerre (people) identified that: Our cultural values of water are part of our law, our traditional owner responsibilities, our history and our everyday lives. Everyone and everything are related. Our law has always provided for the values we place on water. It is the rules for men, women and country. Anmatyerre Law is strong today, but it is invisible to other people. Australian law should respect Anmatyerre Law so we can share responsibility for looking after water.

Indigenous barrister Anthony McAvoy argues that to date 'there is no place in modern river management systems for the protection of Indigenous spiritual values.' In most expressions of Aboriginal religion in Australia there are creation stories detailing the creation of waterways, often by a spirit being in the form of a serpent.

In the Gunanurang, Ord River, Western Australia, the traditional owners believe their rights and interests in land and waters were created in the Ngarangani or Dreaming. The dreaming is a continuing force providing for a complex of cultural values. According to Indigenous law, water places have special spiritual significance and accompanying cultural responsibilities.

https://www.humanrights.gov.au/sites/default/files/content/social_justice/nt_report/ntreport08/pdf/chap6.pdf

Question 5

Consider the article "**Indigenous peoples and water",** discuss briefly the connection the Australian Indigenous peoples have to water.

____

____

____

____

____

____

____

____

____

____

____(4 marks)IAE4

Question 6 **Extended-response question**

Credit is given for clear, well-expressed answers that are well organised and relevant to the question.

- Have students watch the video, “Earth’s water distribution”(5 mins)

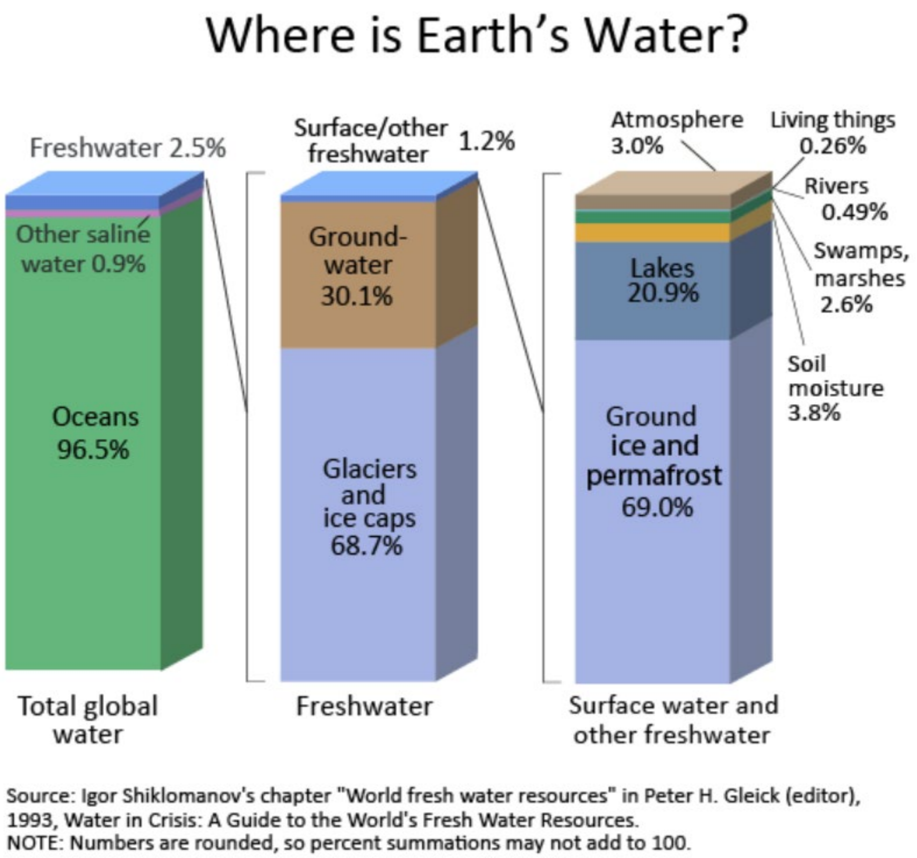
https://www.sciencelearn.org.nz/resources/726-humans-and-the-water-cycle

Describe and explain how humans have changed the hydrological cycle. Evaluate the impact on ecosystems and people’s use of resources due to the changes.

(15 marks) IAE3

Global water distribution.

Water is distributed between all spheres of the Earth. The bar charts below show how almost all of Earth's water is saline and is found in the oceans.
Of the small amount that is actually freshwater, only a relatively small portion is available to sustain human, plant, and animal life.



- In the first bar, notice how only 2.5% of Earth's water is freshwater - the amount needed for life to survive.
- The middle bar shows the breakdown of freshwater. Almost all of it is locked up in ice and in the ground. Only a little more than 1.2% of all freshwater is surface water, which serves most of life's needs.
- The right bar shows the breakdown of surface freshwater. Most of this water is locked up in ice, and another 20.9% is found in lakes. Rivers make up 0.49% of surface freshwater. Although rivers account for only a small amount of freshwater, this is where humans get a large portion of their water from.

Question 7

Water is distributed between all spheres of the Earth. Explain why the percentages of global water distribution:

- Cannot be accurate all the time
- Cannot be the same every year

____

____

____

____(2 marks)KA2

A new NASA study provided estimates for the global water cycle budget for the first decade of the 21st century, setting a baseline for future comparisons.

Scientists combined data from 10 sources that made use of observations from more than 25 satellites to describe different aspects of the water cycle: precipitation and evaporation over land and oceans, atmospheric water vapour and its movement, river runoff, and water storage including groundwater, soil moisture and snowpack.

The goal was then to balance the amount of water that went into each "compartment" of the water cycle, such as the ocean, a continent or a lake, with what came out. Earth is a closed system, which means that any water that evaporates from the surface must be accounted for in the atmospheric water vapour, which must then be accounted for when it condenses into rain or snow, and so on. Each of these stages was described by a different dataset.

The amount of water per year that precipitates, evaporates, runs off into streams and rivers, or soaks into groundwater storage for each of seven main land masses. The amounts listed are in units of thousand cubic kilometers. For reference, all yearly human water use is 9.1 thousand cubic km on this scale. Credit: NASA Goddard/Conceptual Image Lab

https://phys.org/news/2015-07-nasa-liquid-assets.html#jCp

Question 8 **Prepare a Case study**

Australia as a nation could not exist without taking water out of the natural environment and using it for domestic and productive purposes. (soe.environment.gov.au)

Prepare a case study to address the statement above.

- Gather information from secondary sources to summarise total water distribution in Australia.
- Consider scientific research completed in Australia regarding water distribution.

(15 marks) IAE3

<u>The importance of water's unique properties in sustaining life on Earth and in shaping Earth processes.</u>

Life on Earth depends on the unique properties of water. Water has several properties that make it unique amongst compounds and make it possible for all forms of known life to function.

Ice is less dense than water

Ice floats on water and lakes freeze from the top down to the bottom. This is important for animals that live on ice, as their habitats would be greatly reduced or not exist at all if ice sank. Similarly, fish and other pond-life would be affected if lakes and ponds froze from the bottom upwards - the layer of frozen water at the top of the pond provides some insulation and prevents the rest of the water getting cold as quickly.

Water has a very high melting and boiling point compared to other similar molecules

Water is seen as a solid, a liquid and a gas on Earth. If water was not a liquid at most of the temperatures we see on Earth the seas would all be ice, there would be no rain, nothing for plants to collect and animals to drink. Even our cells are filled with liquid water, which would not be possible either.

It is called the 'universal solvent' because it is capable of dissolving so many substances.

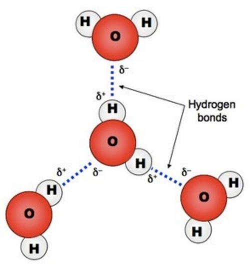
The water in our bodies is mostly contained in our cells, where it gives them a clear shape as well as having many useful molecules dissolved in it. Our cells need to be filled with water to work properly because the enzymes inside them only work in solution. Water is also the means by which transport occurs in our bodies', blood is mostly water and has hormones and gasses dissolved in it as well as toxins such as urea, which are removed from the body with yet more water.

Water has a high specific heat capacity.

Water has a very high heat capacity. It is great in holding onto heat. It takes a great deal of energy to change liquid water to vapour. The human body uses this peculiar property of water to regulate body temperature. When your body gets hot, you sweat. Your body heat excites water molecules on your skin breaking hydrogen bonds in water. This allows water to escape your skin taking with it lots of heat, leaving you cooler.

What does polarization have to do with the properties of water?

Everything! Because water has a slightly negative end and a slightly positive end, it can interact with itself and form a highly organized 'inter-molecular' network. The positive hydrogen end of one molecule can interact favourably with the negative lone pair of another water molecule. This interaction is called "Hydrogen Bonding". It is a type of weak electrostatic attraction (positive to negative). Because each and every one of the water molecules can form four Hydrogen Bonds, an elaborate network of molecules is formed.



https://nrich.maths.org/7273

The importance of water’s unique properties in shaping Earth processes.

Earth is often called the water planet because of the abundance of liquid water on its surface and because water’s unique combination of physical and chemical properties is central to Earth’s dynamics.

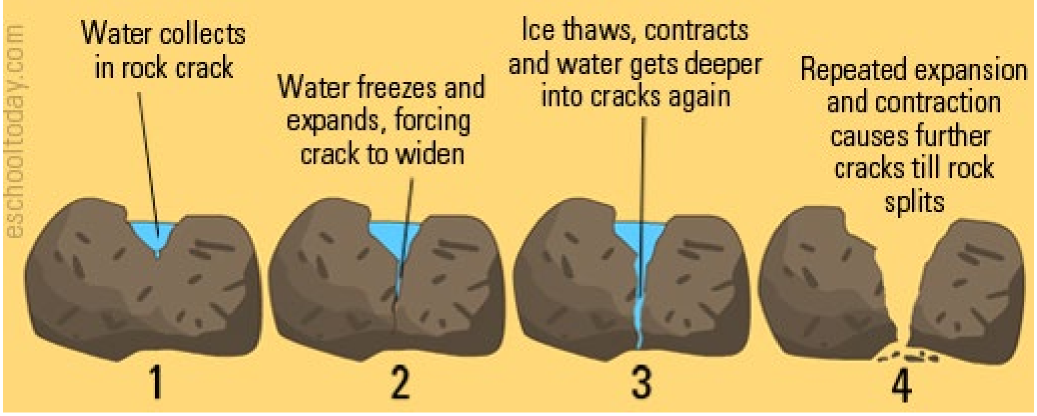
These properties include:

- water’s capacity to absorb
- store, and release large amounts of energy as it changes state
- to transmit sunlight
- to expand upon freezing
- to dissolve and transport many materials
- and to lower the viscosities and freezing points of the material when mixed with fluid rocks in the mantle.

Each of these properties plays a role in how water affects other Earth systems (e.g., ice expansion contributes to rock erosion, ocean thermal capacity contributes to moderating temperature variations).

Water participates both in the dissolution and formation of Earth’s materials. The downward flow of water, both in liquid and solid form, shapes landscapes through:

- erosion
- transport, and deposition of sediment.
- Shoreline waves in the ocean and lakes are powerful agents of erosion.
- Over millions of years, coastlines have moved back and forth over continents by hundreds of kilometres, largely due to the rise and fall of sea level as the climate changed (e.g., ice ages).



Ice expansion contributing to rock erosion

http://weatheringerosionrivers.weebly.com/uploads/3/9/1/2/39120785/8374343_orig.png

Question 9

Explain why water's solvent properties are important to life on Earth.

____
____
____(2 marks)KA1

Question 10

Explain how the properties of water can cause weathering.

____
____
____(2 marks)KA2

Question 11

If water is important as a cause of weathering, explain why high latitude areas, such as Siberia or Antarctica, have little chemical weathering but lots of water present.

____
____
____
____
____
____
____(4 marks)KA2

Design an experiment

Background information:

Ice expansion: Water from rain, or snow, regularly fills the cracks and openings of rocks. When the water freezes the ice produced is capable of splitting the rock into pieces. This happens because waters volume increases. It increases by up to 9% and the pressure of the ice on surrounding rock may be as high as 110kg per square centimetre. Repeated freezing and thawing leads to cracks becoming larger and eventually the rock breaks.

Design an experiment to test the idea that water can cause erosion over time by ice expansion.

- Complete further reading on Ice expansion and weathering processes
- Deconstruct and Design a suitable laboratory experiment to test ice expansion
- Write a hypothesis to test your experiment
- State independent, dependent and controlled variables
- Write method, equipment list, and safety considerations
- Record all results
- Analyse results
- Discuss limitations of the experiment
- Write a conclusion

Experiment presentation format

- Report
- Concept map
- Infographic
- Storyboard

(15marks) IAE1

Review questions

Living organisms need water to survive. All oxygen-dependent organisms need water to aid in the respiration process. Some organisms, such as fish, can only breathe in water. Other organisms require water to break down food molecules or generate energy during the respiration process. Water also helps many organisms regulate metabolism and dissolves compounds going into or out of the body.

1. What is the percentage of water available on Earth for all living organisms?

____(1 mark)KA1

2. Consider the statement above, discuss whether it is an advantage for living things to rely on water reservoirs in which water has a small storage time.

____
____
____
____
____(4 marks)KA2

3. What is the hydrosphere?

a. the gases in the air
b. the solid, rocky part of Earth
c. all of the water on the planet
d. the study of Earth's atmosphere

(1 mark)KA1

4. Increase in human population impacts which of Earth's spheres?

a. biosphere only
b. biosphere and hydrosphere only
c. biosphere, hydrosphere, and atmosphere only
d. biosphere, hydrosphere, atmosphere, and geosphere

(1 mark)KA1

5. Explain how the density of water changes as the temperature decreases from 10°C to 0°C.

____
____
____
____
____
____
____
____(3 marks)KA2

The Earth consists of different spheres:

- Biosphere
- Atmosphere
- Hydrosphere
- Lithosphere

6. The spheres are involved in the water cycle. Describe how water occurs and interacts within the spheres.

____
____
____
____
____
____
____
____(5 marks)KA2

7. Briefly describe the following processes:

Condensation

____
____
____(2 marks)KA1

Transpiration

____
____
____(2 marks)KA1

Review question Answers

Living organisms need water to survive. All oxygen-dependent organisms need water to aid in the respiration process. Some organisms, such as fish, can only breathe in water. Other organisms require water to break down food molecules or generate energy during the respiration process. Water also helps many organisms regulate metabolism and dissolves compounds going into or out of the body.

1. What is the percentage of water available on Earth for all living organisms?

_____31.3% (1.2% surface/freshwater_30.1% groundwater)______________(1 mark)KA1

2. Consider the statement above, discuss whether it is an advantage for living things to rely on water reservoirs in which water has a small storage time.

- Depends on organisms ability to adapt
- Organism may not be able to reproduce due to time changes
- To have access to water for consumption groundwater may be the only source available, could cause financial issues
- Any logical discussion points

(4 marks)KA2

3. What is the hydrosphere?

a. the gases in the air
b. the solid, rocky part of Earth
c. all of the water on the planet
d. the study of Earth's atmosphere

(1 mark)KA1

4. Increase in human population impacts which of Earth's spheres?

a. biosphere only
b. biosphere and hydrosphere only
c. biosphere, hydrosphere, and atmosphere only
d. biosphere, hydrosphere, atmosphere, and lithosphere

(1 mark)KA1

5. Explain how the density of water changes as the temperature decreases from 10°C to 0°C.

Ice expansion: When water freezes the ice produced is capable of splitting rock into pieces. This happens because waters volume increases. It increases by up to 9%.

Between 10° and 4° the density slowly increases as the temperature decreases due to the decreasing kinetic energy of the molecules. This denser water sinks below water that is warmer. From 4° to 0° the density decreases, so that as the water gets colder and eventually freezes it forms a surface on top of the liquid water.

(3 marks)KA2

The Earth consists of different spheres:

- Biosphere
- Atmosphere
- Hydrosphere
- Lithosphere

6. The spheres are involved in the water cycle. Describe how water occurs and interacts within the spheres.

• In the atmosphere: Water is transferred between the hydrosphere and the atmosphere by evapouration. The weather patterns we experience are driven by the movement of this water.

• The biosphere is where the living organisms such as plants and animals are found. These organisms, e.g plants contain between 90-95% of water and through transpiration water is re-introduced into the atmosphere. Plants and animals cannot survive without water which is needed for biochemical reactions.

• The hydrosphere: the water interacts between movement of water continually moving between the oceans, surface water, and groundwater.

• The lithosphere : The landscape of the Earth is shaped by erosion as water flows over the ground and into the sea . This is possible because flowing water causes soil erosion, physical and chemical weathering of rocks.

(5 marks)KA2

7. Briefly describe the following processes:

Condensation

Condensation is the transformation of water vapour to liquid water droplets in the air, creating clouds and fog.

(2 marks)KA1

Transpiration

Transpiration is the release of gaseous water vapour from plants and soil into the air as a result of life sustaining biochemical processes occurring in plants.

(2 marks)KA1