Answers

Test 1 – Systems, Cycles and the Global Stores of Water

1. A model (generalisation) of a part of the natural world (1 mark) consisting of components (stores) (1 mark) and flows between each component (1 mark).
   Also allow marks for description of systems such as elements, attributes, etc. (1 mark each).

2. To remove excess detail that would make the model too complicated (1 mark), remove spurious data (1 mark), or hide the workings/relationships of the system components (1 mark)

3. - **Open system:** Both inputs and outputs (1 mark) of material and energy (1 mark).
   - **Closed system:** Material can't be transferred (1 mark), but energy can flow into and out of the system (1 mark).
   - **Isolated system:** No inputs or outputs (1 mark) of either material or energy (1 mark).

4. - Dynamic equilibrium as achieved when the inputs and outputs of a system are equal (1 mark).
   - Changes can occur to disrupt the equilibrium (1 mark).
   - Cycles can either return the system towards equilibrium (1 mark), or push the system further from equilibrium (1 mark).

5. Allow any suitable natural example (1 mark), a concise description of the cycle (1 mark), and a reason why the example is positive or negative (1 mark). Do not allow artificial examples, such as a thermostat attached to a heating system or refrigerator, etc.

   Suitable examples include (but are not limited to):
   - Sea ice melting (+ve)
   - Permafrost melting (+ve)
   - Deforestation and decreased rainfall (+ve)
   - Exponential growth of a population (+ve)
   - CO_2 generation and absorption by the oceans (-ve)
   - Carbon fertilisation of increased forest growth as a result of climate change (-ve)

   For example:
   - Sea ice melting is an example of POSITIVE feedback (1 mark).
   - Warming ocean temperature reduces the amount of sea ice; the less sea ice, the more solar radiation is absorbed by ocean water (1 mark).
   - This is positive feedback because the warmer the ocean, the less sea ice can form (1 mark).

   Another example:
   - Increased plant growth due to increased temperature is an example of NEGATIVE feedback (1 mark).
   - Plants often grow faster if the temperature is warmer: the more greenhouse gases in the atmosphere, the higher the air temperature (1 mark).
   - As plants store biomass, they remove carbon dioxide (CO_2) from the atmosphere, reducing the greenhouse effect and returning the system towards equilibrium.

6. - The majority of water is saline (salty) (1 mark) – we can't drink this water without removing the salt (an expensive and energy-intensive process) (1 mark).
   - Only around 3% of water is fresh – therefore, easily usable (1 mark), but the majority of that water (1.74%) is inaccessible because it is locked up as ice (and also some permafrost) (1 mark).
   - Surface water supplies (such as lakes and rivers) can be easily used as a water source (1 mark), but they only make up 0.007% and 0.0002% of the Earth's water respectively – a tiny amount (1 mark).
   - If water is stored in aquifers, then the groundwater can be pumped out (1 mark). The fresh water available under the ground is plentiful compared to surface supplies (1 mark).

7. Allow one mark for each valid statement.
   Wetlands:
   - Very important in areas such as the Arctic, where wetlands cover a significant part of the land surface.
   - Provide habitats for birds and aquatic life (which are often under threat).
   - Peat is a carbon sink, helping to mitigate the effects of climate change.
   - Any other valid point(s).

Groundwater:

- Very important in areas where there is not much surface water (as a water source for drinking and crop irrigation).
- Contributes to the base flow of rivers.
- Keeps aquatic and riparian habitats alive during the drier summer.
- Reduces saline groundwater intrusion in coastal areas.
- Any other valid point(s).

Soil water:

- Important for the maintenance of healthy terrestrial ecosystems (e.g. plants and trees).
- Important in controlling the development of local weather (e.g. moisture availability).
- Helps determine the amount of run-off and affects flood risk.
- Any other valid point(s).

8. Allow one mark for a judgement/viewpoint, and one mark for each valid statement (three statements).
   - Vital for life – both plants and animals.
   - Medium for chemical reactions.
   - Required for photosynthesis, and the uptake of nutrients in plants.
   - Water vapour helps maintain the Earth's temperature (natural greenhouse effect).

9.
   - Humans have increased the concentration of CO_2 in the atmosphere (1 mark) through the use of fossil fuels and land use change (1 mark).
   - This excess CO_2 has partly been absorbed by the oceans (1 mark).
   - Carbon dioxide forms carbonic acid when dissolved in water (1 mark) – the H^+ ions mean that the pH is reduced (1 mark).

10. Allow one mark for each point, or two marks for each explained point.
    Suggested points include (but are not limited to):
    - Frozen water, on the land surface (ice caps, glaciers, etc.), beneath the ground (permafrost), or floating on the sea (e.g. sea ice, reference to the North Pole, or an ice shelf).
    - Distributed near to the poles (high latitude), or at high altitude (e.g. Alpine glaciers).
    - Allow reference to named location(s), and the relative size(s) or proportions of each component.
    - Discussion of expansion or contraction during glacial and interstadial periods.

11. Allow reference to any six valid points, or three explained points, such as:
    - Evaporation / evapotranspiration / soil moisture as a source of water vapour.
    - Rising of warm, moist air, condensation at height and the role of condensation nuclei.
    - Frontal weather systems.
    - Depressions.
    - Also allow discussion of the alteration of rainfall patterns due to climate change or land use changes such as deforestation.

Extension Questions

12. One mark each:
    - Permafrost is a large carbon sink; some estimates are upwards of 1700 Gt in the northern hemisphere.
    - Melting of the permafrost is estimated to cause a positive feedback cycle.
    - As permafrost melts, the carbon can be oxidised by bacteria (releases CO_2 or CH_4).
    - These greenhouse gases can warm the atmosphere, leading to further melting.

13. Earth as a whole is essentially a closed system (1 mark) – energy reaches us from the sun, and can be lost to space once again (1 mark). There are almost no gains or losses of material (except for meteorites, for example) (1 mark).

    There are several different subsystems within the Earth (1 mark) – the lithosphere, hydrosphere, cryosphere and atmosphere (allow a half mark for each).

    These four systems are open systems because they input and output both energy and material (1 mark), but these four systems are linked together (1 mark), which can be classed as 'cascading systems' (1 mark).

Test 2 – The Water Cycle – Drainage Basins and Run-off

1. The area of land drained by a river and its tributary streams, bordered by a watershed.

2. Allow one mark per two correct answers.

Stores	Flows	
• Rivers, or lakes, or other surface stores such as ponds or reservoirs • Soil water • Groundwater • Oceans • Interception • Surface flow	• Precipitation (including onto land or ocean) • (evapo)transpiration (also accept evaporation, and also sources such as soil, ocean, lakes, etc.) • Infiltration • Percolation	• Throughflow • Overland flow • Groundwater flow • Throughflow • Stemflow • River/channel flow • Any form of run-off (river, snowmelt) • Plant uptake

3. Allow any two correct factors:
   - Increasing the porosity of soil by ploughing.
   - Improving drainage to reduce soil saturation from antecedent conditions.
   - Increasing the organic content of the soil.
   - Voids can be created by burrowing animals, allowing rapid movement of water, or from rotted out tree roots.
   - Any other valid point(s).

4. Allow any two correct factors:
   - Soil saturation (e.g. antecedent conditions).
   - Intense rainfall (exceeds infiltration rate).
   - Prolonged rainfall.
   - Compacted soil.
   - Impermeable soil or underlying bedrock.
   - Urbanisation of the catchment.
   - Deforestation.
   - Few channels.
   - Any other valid point(s).

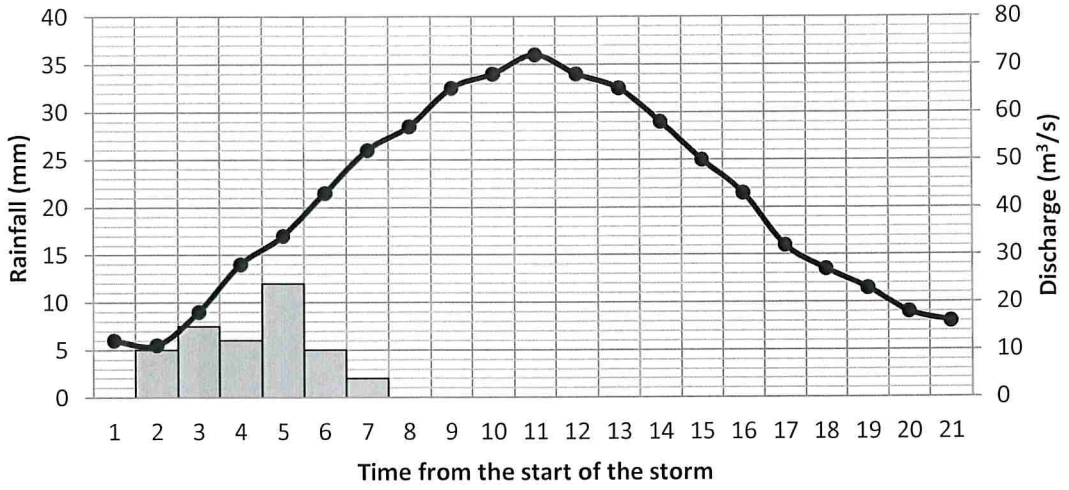
5. Potential evaporation is partly controlled by the amount of water that the air can hold (1 mark). Cold air cannot hold much water vapour (1 mark); for this reason, air can feel very dry, yet be close to saturation (1 mark).

   Warm air can hold a lot of moisture in comparison (1 mark), but if the air is near to saturation point, as can often occur in summer (1 mark), then little more water can evaporate (1 mark). (This is why the outside air temperature can feel considerably warmer than it actually is during the summer, and washing out on lines can take a long time to dry, despite high temperature!)

6. A river's regime is the change in discharge throughout the year (1 mark), the discharge changes in response to weather and climate (e.g. wetter periods throughout the year, large rainfall of snowfall events, etc.) (1 mark). Flow also responds to temperature and evapotranspiration(1 mark); for example, lower summer rainfall and high transpiration rates will reduce flow (1 mark), and the availability of base flow from ground and soil water (1 mark).

7. During the autumn and winter, when there is more rainfall, precipitation exceeds the potential evaporation (which is low) (1 mark), and soil water recharges (1 mark). Once this recharge is complete, the soil water store is full, and flooding / overland flow can occur (1 mark). As air temperature rises in the spring and early summer, plants begin to 'utilise' the soil moisture because there is more potential evapotranspiration than precipitation (1 mark). At the height of summer, plants use up the store, meaning that there is very little overland flow, and river flow is at the lowest of the year (1 mark). In late summer, plants may not have enough water (1 mark).

8. Award 1 mark for each correctly plotted point/bar (5 marks) and one mark for joining the dots to make a curve.



9. Flashier (1 mark), with higher peak flow (1 mark) and a shorter lag time (1 mark).
This is due to the prevalence of impermeable urban surfaces (1 mark), rapid flows into rivers through storm drains (1 mark), and the possibility of flood engineering or channel modification to reduce flood risk (1 mark).

10. One mark for stating the correct answer, two marks for the explanation.

A (1 mark)

There is a much higher drainage density (1 mark), slowing water to quickly reach the main channel (1 mark).

Or
The drainage basin is more rounded (1 mark), allowing for water to quickly reach the channel at the same time, from most parts of the catchment (1 mark).

11.
- The channel can be widened (1 mark) or straightened (1 mark), increasing flow (1 mark) and capacity (1 mark).
- The channel can be dredged (1 mark), which removes friction (1 mark), which would speed up flow (1 mark) and also increase the capacity of the channel (1 mark).
- Structures such as flood walls (1 mark) can stop the river from spreading out onto its natural floodplain during periods of high flow (1 mark).
- Structures placed within the channel such as bridge pedestals (1 mark) can restrict the flow (1 mark).
- Naturalisation can also take place (1 mark), such as the restoration of meanders (1 mark) or flood storage schemes (1 mark).
- Allow any other valid reason(s).

12. Allow one mark for identifying the field drainage, and allow marks for each positive statement and each negative statement.

The photograph shows a field drainage system. The drainage ditch is likely to be fed by 'tiles' (pipes/tubing with small holes), which remove water from underneath the field.

Advantages	Disadvantages
✓ Allows more land to be used for crop growth.	× Decrease in the area of natural habitat.
✓ Improves the conditions for crop growth, including warmer soil conditions.	× Reduction of the water table to the tile depth.
✓ Can also be used to increase the carrying capacity of grazed land.	× Drier soil may be eroded easily by the wind.
	× Altered flow regime for rivers and increased discharge after rain (flashier).
	× Flood risk may also increase.
	× Increased risk of eutrophication.

Extension Questions

13. Positive feedback cycles can develop (1 mark) because:
    - Evapotranspiration reduced, meaning that there is less moisture available for convectional rainfall.
    - Overland flow is increased because the interception is reduced.
    - Water runs into rivers and is removed from the catchment.

    Allow one mark each, or two marks for well-explained statements.

14. Groundwater abstraction is very important in areas where surface water supplies are limited, both for drinking water or for irrigation, to feed a growing population.
    - Lowers water table, meaning that there is less water available for plant growth.
    - Reduced river flow – aquatic environments become compromised, e.g. low flows, less dispersion of pollutants.
    - Some streams may dry up entirely.
    - Cone of depression can occur around the borehole.
    - In coastal areas saline groundwater intrusion can occur.

Test 3 – The Carbon Cycle

1. Stores (also called sinks) are where carbon is retained for a long period of time in one form or another(e.g. in rock, dissolved in ocean water, etc.) (1 mark).
   Fluxes are the movement of carbon between stores (1 mark); for example, the dissolution of rock, or combustion of fossil fuels).

2. Organic carbon is found in living or once living material (1 mark).
   Inorganic carbon was not produced by living things, e.g. from within the Earth (1 mark).

3. Allow one mark each:
   - Fossil fuels / hydrocarbons / kerogens
   - Carbonate rocks
   - Metamorphism of carbonate rocks (e.g. destructive plate margins)

4. Fossil fuels (e.g. oil, coal, methane, kerogen) are formed from the remains of plants and living creatures that lived millions of years ago (1 mark). The overburden of overlying rock exerted heat and pressure that formed these trapped fuels (1 mark).

   Carbonate rocks can be formed by the build-up and compression (1 mark) of the remains of sea creatures with carbonate shells (1 mark).

   Carbonate rocks can also release gaseous CO_2 when heated (1 mark); for example, when surface deposits of carbonate rock are subducted at plate margins (1 mark).

5a. The pH of the ocean slowly decreased from 1750 to approximately 2000 (1 mark) due to an increase in atmospheric carbon (1 mark), caused by industrialisation – e.g. fossil fuel combustion and land use change (1 mark). The decrease in pH means that the oceans are becoming more acidic – as CO_2 dissolves in water to form carbonic acid (H_2CO_3) (1 mark).

5b. A store (1 mark), shown by the increase in dissolved carbon (1 mark). However, there will be a flux of carbon between the ocean and atmosphere; however, the gain to the ocean is greater than the loss (1 mark).

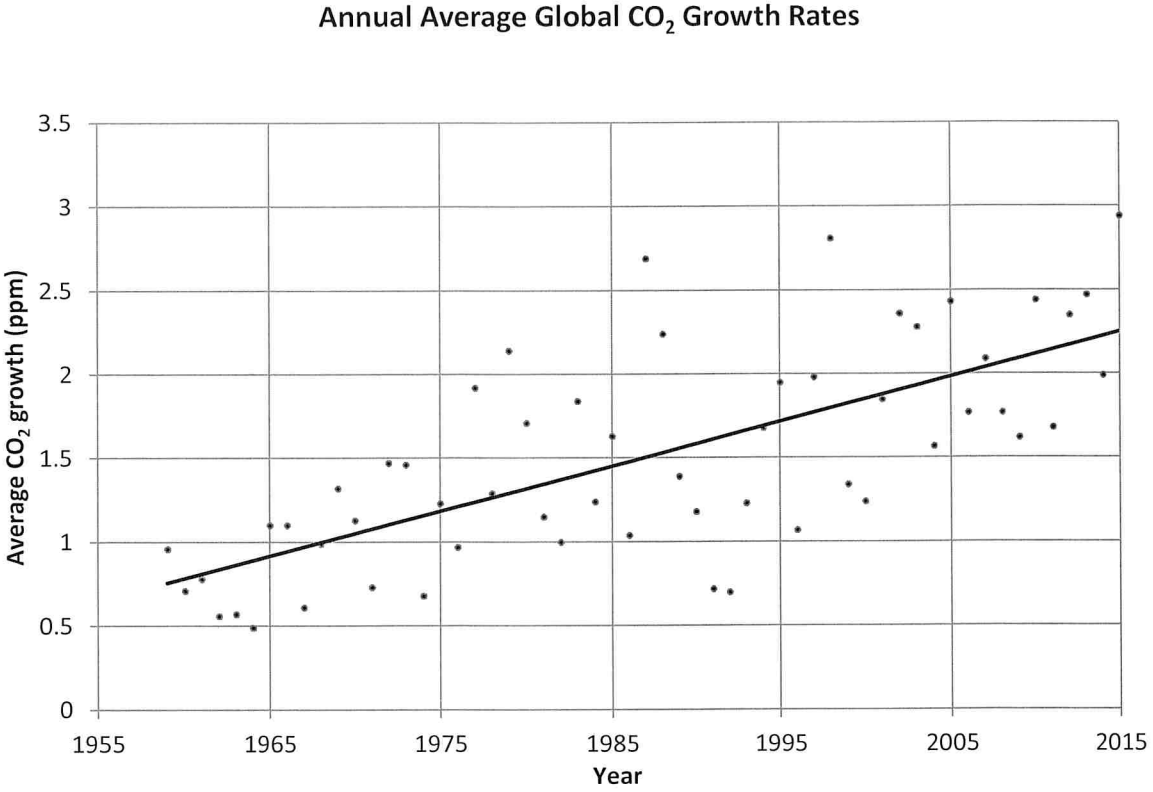
6. Peat, frozen into permafrost.

7a. The diagram shows that up to 800 billion metric tons of carbon is stored within the living (vegetation) component (1 mark). The most carbon is stored in the deceased plant material (1 mark), within the soil and stored as peat (1 mark).

7b. Enters via photosynthesis (1 mark), as plants fix atmospheric CO_2 into their biomass (1 mark). The plants release some of this through respiration (1 mark). Animals consume plants, and the carbon that animals absorb is lost through respiration (1 mark). The plants also add carbon to the soil (1 mark) as a top layer of leaf litter (1 mark), or as peat if the soil is waterlogged (1 mark). Some of this carbon is stored, but the rest is broken down by decomposers (1 mark), and released as CO_2 through respiration.

8. Animals are a very small store of carbon (1 mark), but are very important within the carbon cycle because of their role in transferring carbon around the cycle (1 mark).

9a.



9b. The annual addition of CO_2 into the atmosphere has generally increased during the 56-year period represented by the graph (1 mark). During the 1960s and 1970s, the increase rarely exceeded 1.5 ppm per year (1 mark). Since the early 2000s, there hasn't been a year where less than 1.5 ppm was added to the atmosphere (1 mark). This trend coincides with increased industrialisation and population growth (1 mark each), fossil fuel / transport use (1 mark each), and land use change (1 mark), releasing stores of carbon in the lithosphere and biosphere into the atmosphere (1 mark).

9c. The average increase was 1.5 ppm per year, over a 56-year timespan. Therefore, the atmospheric CO_2 concentration rose by 1.5 x 56 (1 mark for methodology), which means the rise was approximately 84 ppm (1 mark for answer).

10. The equations for photosynthesis and respiration are in reverse (1 mark) – plants trap CO_2 through photosynthesis as sugars and make up other products from the sugar (1 mark) and plants and animals release the stored carbon through respiration (oxidation) (1 mark). There is a gain of carbon storage because not all of the stored carbon is oxidised (1 mark), such as where it is stored as peat (1 mark) – hence the imbalance (1 mark).

11. One mark each:
    - Decomposers break down plant litter so that the carbon can be stored in the soil as humus.
    - Decomposers recycle nutrients so that they are able to be taken up by plants.
    - Decomposers help reduce the limiting factors of plant growth by providing such nutrients.

12. One mark each:
    - The surface of the ocean absorbs CO_2 from the atmosphere.
    - Due to temperature difference between the equator and the poles, ocean currents occur.
    - Water flows at the surface from the equator to the poles.
    - At the poles, the now carbon-rich water sinks, and flows back to the equator at depth.
    - Upwelling at low latitude causes the water to rise to the surface and warm.
    - Warm water can't support as much dissolved gas as cold water, so the dissolved CO_2 is released back into the atmosphere.

13. Weathering (allow other suggestions such as oxidation) (1 mark).
Calcium carbonate is a mineral found in rocks such as limestone or chalk (1 mark). The process releases carbon stored for millennia in the lithosphere (1 mark), back into the atmosphere (1 mark).

Extension Questions

14. There is a far greater store of carbon from dead plant material than currently living plants (1 mark). But, living plants sequester large amounts of carbon (1 mark), making them a vital part of the carbon cycle (1 mark). The carbon from plants can be stored for millions of years, such as in the case of coal.

15. Extremely important!

    Suggested content can include:
    - The Earth would be too cold for life without the natural greenhouse effect.
    - The carbon allows for photosynthesis – allowing for the generation of oxygen.
    - Plants are also the basis of complex food webs, providing a source of food for primary consumers and omnivores.

Test 4 – Changes to the Carbon Cycle and Carbon Budgets

1. Allow one mark each:
   - Grasslands (e.g. savannah)
   - Some forests – e.g. conifer forests where some trees are adapted to regular fires; for example, some pines don't open their cones until exposed to fire.
   - South African Fynbos
   - Some wetlands

2. Sources – where fire and decay (1 mark) release more carbon than is sequestered by the trees (1 mark).
Sinks – forests can store carbon if more is sequestered than lost (1 mark), such as the gain of biomass and soil carbon (1 mark).

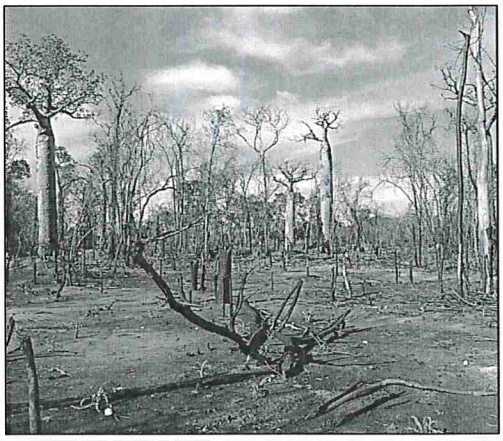
3. A lot of leaf litter can build up and decompose slowly under the dark canopy (1 mark). Also, the trees themselves can reach very large sizes, storing much carbon – some may be stored for hundreds of years (1 mark).

4a. Volcanic activity is not very important (1 mark) – they don't actually release much CO_2 (1 mark) – far less than humans produce (1 mark).

4b. Volcanoes produce some CO_2 (greenhouse gas) which causes warming (1 mark), but explosive volcanoes eject large volumes of ash and dust into the stratosphere (1 mark). Such aerosols reflect incoming radiation back into space, which cools the atmosphere.

5. Ploughing reduces the amount of soil carbon (1 mark), by allowing soil exposure to the air where bacteria can oxidise the carbon (1 mark), releasing the carbon into the atmosphere as CO_2 (1 mark). Soils that are poor in carbon are more likely to have poorer health (1 mark), and may be prone to leaching and erosion by water or wind (1 mark per point). Yields from crops planted on carbon and nutrient deficient soil will be reduced (1 mark), leading to hunger, or in extreme cases, famine (1 mark).

6a.



The image shows:	Slash-and-burn agriculture	Logging
This method releases carbon because:	Existing vegetation is burned, releasing stored carbon. Soil erosion likely and soil carbon reduced.	Even selective logging damages the surrounding vegetation. Bare soil likely to be eroded and release carbon to the atmosphere.
Some carbon can be restored because:	As soil fertility declines, the land is abandoned after a few years, and forest cover quickly begins to restore itself.	

6b. The timber can be made into buildings and furniture, which may persist for hundreds of years, storing the carbon away from the atmosphere (1 mark). In addition, forest may later recover (1 mark).

7. Allow one mark each:
   - Removal of trees reduces stored biomass.
   - Increase in soil erosion.
   - Removal of litter layer.
   - Reduction in soil carbon.
   - If some of the land is used for cattle grazing, methane production increases.
   - The roads open up the forest for further habitation, logging, etc.
   - Any other valid point(s).

8. - Warming of the oceans due to increased air temperature (1 mark) leads to less phytoplankton (1 mark) which alters food webs (1 mark). Warming also leads to coral bleaching as algae is expelled (1 mark).
   - Acidification from the extra dissolved CO_2 (1 mark) damages coral and other marine (1 mark). Carbonate shells are also dissolved and become thinner, resulting in higher mortality of some organisms (1 mark).

9. Melting of land-based ice (NOT sea ice) adds volume to the oceans (1 mark).
   As the water warms, it will expand slightly, increasing the capacity (1 mark).

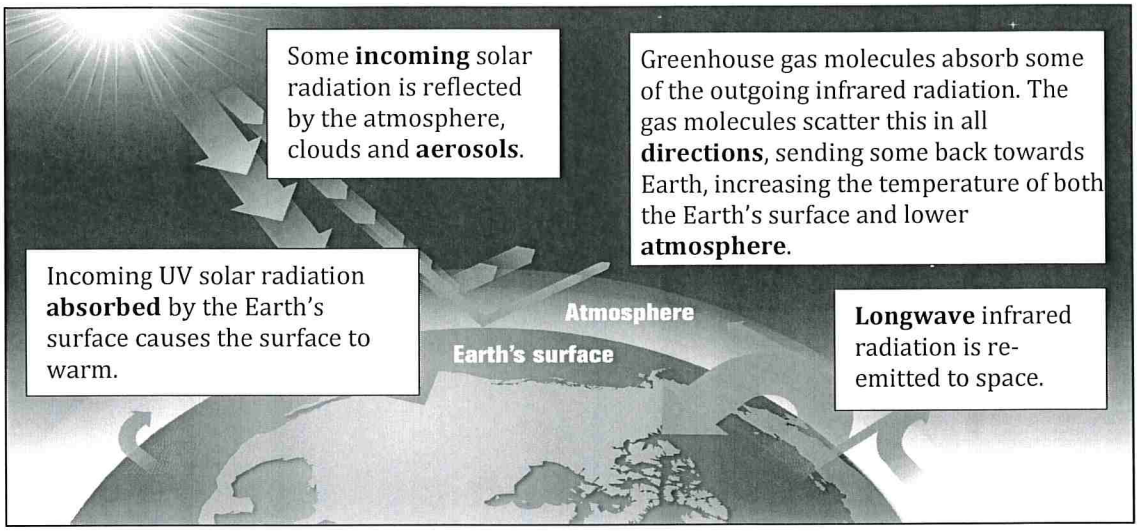
Extension Questions

10. - CO_2 is a greenhouse gas, meaning that addition to the atmosphere causes air temperature to increase (1 mark).
    - There are many parts of the carbon cycle where an increase in temperature causes more carbon to be released (1 mark).
    - Examples of these include melting of permafrost, forest fire frequency, and ocean warming – all deplete stores and add carbon to the atmosphere (allow one mark for an example, and one mark for an explanation).

11. Allow a discussion of human modification of the land and ocean, positive feedback cycles, emissions of gases, urbanisation, deforestation and population growth. Also allow examples of how humans have increased the storage of carbon, such as afforestation, carbon capture and storage, and discussed concepts of geoengineering.

Test 5 – Climate Change

1. Allow one mark for each two correct words.



2. Radiative forcing is the balance between incoming and outgoing radiation (1 mark), caused by the addition of greenhouses gases, which absorb and re-emit outgoing radiation (1 mark). Warming occurs when the outgoing radiation is reduced (1 mark) – there is more incoming energy than outgoing energy (1 mark).

3. Albedo is the reflectivity of a surface (1 mark) – light colours are more reflective (1 mark). The conversion of forest to farmland in northern latitudes has increased the albedo and, therefore, reflectivity (1 mark), because snow on land is more reflective than snowy trees (1 mark).
Also allow a discussion of tropical rainforest deforestation and corresponding increase in Albedo.

4a. The removal of CO_2 from flue gases (1 mark), and the storage of the gas by injecting liquid CO_2 into geological formations such as oil fields, rock strata or the ocean, etc. (1 mark).

4b. Allow two marks for both advantages and disadvantages.

Advantages	Disadvantages
• Removes CO_2 that would otherwise be vented to the atmosphere. • The high costs can be recovered by injecting the CO_2 into oil and fields to improve the recovery rate. • The technology can be retrofitted to existing factories and energy installations. • Any other valid point(s).	• Expensive • Little real-world experience as yet, unproven; experimental stage. • Some of the gas may later be released back into the atmosphere. • Energy-intensive to transport, compress and pump into the ground. • Doesn't help the transition to find alternative fuel sources, and allows more fossil fuel to be burned. • If injected into the ocean, could increase the acidity of the water. • Any other valid point(s).

5.

Cropland	**Reduction of ploughing**	Less soil carbon is oxidised due to enhanced microbial action as oxygen level is increased.
	Increased use of manure	Addition of carbon to the soil, improved soil structure and enhanced crop growth.
Grassland	**Irrigation**	Increased grassland productivity increases the carbon stored in the biomass.
	Ensuring no overgrazing	The grasses are healthy and maintain soil cover, increasing the amount of litter added to the soil and decreasing the erosion.
Forest cover	**Planting orchards**	Increases the above ground store of carbon as biomass.
	Reforestation	Store of carbon as biomass both above and below ground. Increase in soil carbon due to the increased litter layer.

6.

Urban design or waste	• Pedestrianisation / safe cycle routes / good public transport to decrease the reliance on the private car. • Improve recycling facilities, reducing the energy requirements to produce new goods and environmental destruction, or the generation of methane from landfills. • Use landfill gas, or generate methane from digestion of waste food.
Building design	• Increased insulation to reduce heating in winter and cooling in summer. • Increase solar gain (e.g. south-facing windows) to reduce the need for heating. • Increase natural light to decrease the need for artificial lighting.
Energy generation	• Use renewable energy sources, such as wind, solar PV / hot water, tidal, hydroelectric, etc. • Use combined heat and power generation. • Introduce CCS technology. • Switch to cleaner fuels, e.g. biomass.

7. The answer will vary based on the examples used. For example:

- **Tropical rainforest**
  - Deforestation and changes to carbon store, increase in atmospheric CO_2 and alteration to rainfall patterns due to reduced transpiration.
  - Changes in farming types; slash and burn, commercial cash cropping, e.g. coffee, palm oil, biofuels such as sugar cane, etc.
  - Increase in overland flow due to reduced interception.
  - Extreme precipitation events.
  - Changes to the soil structure.
  - Alteration in the vegetation type and structure, and species of animals.
  - Discussion on the size of the deforested area – i.e. the magnitude of changes.
  - Also allow a discussion of conservation schemes, such as reforestation, conservation reserves, etc.

- **River catchment**
  - Human modification of the catchment, changing land uses and effects on overland flow, interception rate, flooding, etc.
  - Hard or soft engineering schemes, both to reduce the flood risk, or naturalisation of the catchment.
  - Dams and reservoirs, the flooding of terrestrial ecosystems and changes to river flow regime throughout the year.
  - Alteration of river regimes due to water abstraction, lowering of water table, reduction of flow during the summer months, and the corresponding changes to the aquatic habitat.

Extension Questions

Question 8: AS Level –9 marks

Many of the human modifications of the natural cycles have negative effects, increasing the severity of positive feedback cycles.

Discussion may then follow, referring to specific examples. For example (**AO1**):

- Increased fossil fuel combustion.
- Agricultural intensification.
- Deforestation.
- Land-use change.

Impacts relating to these changes include (**AO2**):

- Climate change.
- Altered weather and rainfall patterns.
- Increased food risk in some regions, droughts may be more severe in others.
- Increase in ocean acidification, reduction in sea ice.
- Changes to soil carbon loss and carbon stored as permafrost.
- Increases in greenhouse gas emissions, and aerosol production.
- Decrease in the stores of carbon.
- Alteration in the amount of CO_2 that can be absorbed by the oceans.
- Increased melting of land ice and sea level rise.

Level 3 (7–9 marks)	**AO1**	Thorough knowledge and comprehension of all points raised.
	AO2	Concepts are developed and linked.
Level 2 (4–6 marks)	**AO1**	Good knowledge and comprehension, largely accurate and pertinent to the answer.
	AO2	Good level of linkage and supported evaluation.
Level 1 (1–3 marks)	**AO1**	Some knowledge and understanding shown, although inaccuracy may creep in at times.
	AO2	Connections are still made, but could lack detail and/or support.

Question 8: A Level – 20 marks

Allow a wide-reaching discussion based on modification and their subsequent effects on natural systems – the water and carbon cycles.

The student should provide an equal split of AO1 marks to demonstrate knowledge and understanding of how humans modify the natural cycles, and AO2 marks to show application of the knowledge – how the changes could affect us.

The student may link a factor to both the carbon and water cycle, and explain how the two cycles are linked – such as deforestation – which releases stored carbon which leads to climate change, and also reduces rainfall through reduced transpiration and increased run-off, if the deforested area is sufficient in size. This will affect us by changing temperature on a global scale, and affecting local people by altering the frequency of droughts and floods.

Suggested changes for **AO1** include:

- Deforestation
- Fossil fuel combustion
- Changes to albedo
- Permafrost melting
- Land use change
- Increased temperature
- Shifts in rainfall patterns
- Altered cloud formation
- Ocean carbon storage changes
- Allow any other plausible changes

Suggested affects for **AO2** include:

- Increased likeliness or severity of drought or flooding, leading to higher mortality risk and extreme weather events, and heat-related mortality.
- Decrease in comfort levels for many due to higher temperatures.
- Altered farming patterns, irrigation need, impacts on health, nutrition and famine.
- Increase in extinction rate.
- Increase in the number of wildfires and spread of plant disease, invasive species and spread towards the poles.
- Some changes will be beneficial; new crops can be grown in areas that they couldn't previously be grown in, fewer cold-related deaths.
- Allow any other suitable effects.

Level 4 (16–20 marks)	High level of evaluation and analysis, with a thoughtful conclusion, showing detailed understanding and knowledge, relevant to the question.
Level 3 (11–15 marks)	Good level of evaluation and analysis, with good linkage of topics, showing understanding and knowledge, relevant to the question.
Level 2 (6–10 marks)	Shows facts, knowledge and some understanding of the question asked. Facts and figures are usually accurate.
Level 1 (1–5 marks)	Basic analysis and some information presented, but issues may be confused, or the conclusion unfounded. The answer may not be presented logically or coherently.
Level 0 (0 marks)	Answer lacks anything worthy of marks.

Test 6 – General

1. **Inputs:**
   Dust and rock from space; meteors (completely burned in the atmosphere) and meteorites (rock survives entry and reaches the ground).

   Outputs:
   Gases – hydrogen and helium

2. Isolated system

3. The system is balanced (1 mark) – inputs and outputs are equal (1 mark).

4. - Important because the oceans are a store of carbon, reducing warming.
   - Can be useful to countries with insufficient surface or groundwater supplies as a water source (after desalination – an expensive and energy-intensive process).
   - Allow any other valid arguments.

5. - Differentiation of sources (ground, surface, oceans) and their relative proportions, fresh water vs saline water, as noted in the diagram below.
   - Discussion of accessibility – most of water is saline and, therefore, difficult to use, or locked up as ice.
   - Techniques used to obtain water.

6. Discussion could include the effects to both people and the environment:
   - Rivers dry up or pollution becomes more concentrated, damaging aquatic habitats.
   - Groundwater levels drop, meaning that plants can die, and the ground subsides – leading to structural building damage.
   - Decreased surface water supplies could affect water supply for drinking and irrigation.
   - Saline groundwater intrusion occurs in coastal areas.

7. Allow any four points, or two explained points.
   - Understanding when peak flow will be so that planners and engineers can plan flood relief and engineering schemes appropriately.
   - Understand how the river is affected by human modification, both to the channel and catchment.
   - Know how much water is available for extraction, or how much compensation water needs to be released from a reservoir.
   - To understand the ecology of the river.
   - Any other valid point(s).

8. Discussion of the size of different stores in the carbon cycle – carbonate rocks and kerogens being among the largest stores, but also discussion of stores at the other end of the spectrum – such as the minor stores seen in animals and marine biota.

9. Oceans:
   - Remove excess CO_2 from the atmosphere as carbon dissolves in the water (1 mark) and offset the warming effects of climate change (1 mark).
   - Operate carbonate pumps (1 mark) and ocean currents circulate carbon (1 mark).
   - Embed carbon as rocks, because carbonate shells sink to the ocean floor (1 mark) and form new rock over geological time (1 mark).

10. Allow:
    - Discussion of permafrost.
    - Discussion of climate change, positive feedback cycles, and release of carbon from bacterial oxidation, including methane production.

11. Allow a discussion of the following:
    - Positive feedback cycles.
    - 'Dangerous' climate change (often referred to as 2 °C from pre-industrial levels).
    - Increased incidence and severity of natural hazards.
    - Alteration to ecosystems and habitats, spread of invasive species.
    - Rising sea level.
    - Decreased living standards or comfort levels.
    - Food production could be affected.
    - Any other valid suggestions.

Extension Questions

12. Allow a wide-ranging discussion with issues such as:
    - Land use change (modification of the water and carbon cycles).
    - Ocean acidification.
    - Changes to the stores of water and carbon.
    - Increases in the fluxes of material through the water and carbon cycles.
    - Specific examples, e.g. farming, deforestation, water abstraction and reservoir building.
    - Any other valid point(s)

13. Allow a well-supported viewpoint, with a discussion on some of the following points:
    - Climate regulation (carbon cycle)
    - Source of fuel/energy (fossil fuels and hydro power)
    - Source of fresh water
    - Provide soil for food production
    - Naturally occurring greenhouse gases provide warmth so that life can exist on Earth

