Geography AS / A Level | AQA | 7036/7037

A Level AQA Revision Booklet

3.1.1 Water and Carbon Cycles

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POD
9582

Contents

Teacher's Introduction

Remember!

Always check the exam board website for new information, including changes to the specification and sample assessment material.

The revision booklets in this series are designed to support your students as they study the AQA Advanced Subsidiary GCE in Geography (7036) and the AQA Advanced GCE in Geography (7037). These revision summaries match the AQA specification perfectly. **This particular set supports AS Unit 3.1.1 Water and carbon cycles, examined in Paper 1. It also supports A Level Unit 3.1.1 Water and carbon cycles, examined in Paper 1.**

The concept is that *all* students need a clearly explained, concise yet comprehensive body of notes to revise from, both as they progress through the course and when preparing for the end-of-course examination. For this reason, the booklets are broken into manageable chunks and are provided in both A4 and A5 formats for easy photocopying. A5 booklets allow easy carrying and reference for students, right up to the moment they walk into the exam hall, and allow for effective revision time.

Since revision should be ongoing throughout one's study, it is recommended that after teaching each topic you issue students with the relevant revision booklet as they progress through the course. The booklets can also be issued as a complete revision pack in the run-up to the examinations.

By use of bullet points, text boxes and grids, these revision booklets provide succinct yet comprehensive and relatively detailed coverage of the specification content – probably far more than what one would expect from a revision summary.

Each topic follows a clear structure of:

- **Keywords:** lots of keywords are clearly defined, and by covering up the definitions with a sheet of paper, students can easily self-test their memory of these all-important terms.
- **Key points:** these form the main body of the summaries for each topic. Concise, detailed and easy to follow, they provide a solid bank of notes to support students' knowledge, understanding and evaluation.
- **Core content:** the main content of the specification in bullet points, boxes and diagrams. Boxes with suggested examples allow students to name-drop examples in their exam, or give ideas for further research.
- **If you only remember these three things…:** the three most important takeaways from the topic.
- **Consolidation questions:** several quick questions on the core content – designed to ensure that the key points have been retained.
- **Take it further:** offers suggestions to support the option of extending learning further.
- **Student checks:** useful checklist to help students monitor their own learning.

Each pack also contains a **students' introduction** which introduces the topic and sets out some of the exam structure; introduces command words, AOs and level marking, along with exam tips and a checklist; and explains how to use the booklet. At the end are included tips on time management, and planning and writing answers, along with an introduction to synopticity.

By using this resource, teachers will know that all students have the key points for all the topics of the course in a clear, written format. It saves time in class for teachers and decreases the amount of preparatory work needed outside class.

This resource also helps achieve greater equality among students of differing abilities, as often the weakest students make the least helpful notes from which to study and revise outside class. These easy-to-understand revision summary notes help to overcome this problem and promote greater equality of opportunity.

And remember, these revision booklets are also perfect to refer back to as end-of-year summaries before the examination – especially useful nowadays with linear examinations.

I trust that you and your students will enjoy using these revision summaries as much as I have enjoyed writing them for you.

June 2019

Students' Introduc

What's the topic?

'Water and carbon cycles' is a compulsory module. As you may know, this topic tea
important cycles on Earth. These cycles keep us alive – giving you the glass of w
controlling the climate. In a way, we take these cycles for granted – but they are
By burning fossil fuels and changing the land's surface, we're changing the clima
implications for our way of life.

You will be examined on this topic in Paper 1, Section A.

Here's a quick overview of the things you might find in the exam. However, expe
sometimes exam boards can throw in a curveball – a different type of question c
but don't be too alarmed. Just read the questions carefully and be ready to adap

You'll be presented with a range of questions – remember that they ramp up in

- Firstly, you might be presented with a short factual recall question.
- Then, you might be given a couple of figures – maps, charts and data. You p before. They're designed to see how you cope with unfamiliar sources – how analyse them. You might have heard the term 'AO2'. AO2 marks require you that you understand what it means.
    - You may be asked to use the figure(s) and your knowledge to answer t
    - These might be medium-length questions, worth around 6 marks.
- Finally, you'll get a longer, essay-based question – they're worth 20 marks. Y your viewpoints or to weigh up two sides of an argument. You may also be asked to use a case study to support your answer. Justify your opinion(s), and support it with facts and balanced arguments if you are reaching for the highest marks. You'll need to draw on your knowledge and offer up a reasoned opinion. PEE, or even better, PEEL here! And no, we don't recommend you get out a satsuma in the exam – link together evidence.
- And *finally*, don't forget that you'll be asked questions from the whole of th any of the topics. You'll also need to have a few named examples at the tips need to have learnt a couple of case studies in depth to really ace the exam

If you're studying this at **AS**, the exam questions are also part of Section A in
multiple-choice questions at the start.

How to use this guide

You may be given this at the start or at the end of teaching on the topic. Don't w
being stuffed in your pocket (although don't take it into the exam itself!). Remen
you want to. Scribble all over it, or highlight bits you need to look at again.

Here are some brief suggestions:

- Work through it as you go through the course.
- Give it a glance after the lessons.
- Give it [illegible] before an upcoming test.
- Use it when you revise, of course - perhaps even outside the exam hall if yo

Now write down the date of the exam. You can use this to plan your revision tim

Date of my exam:	

Checklist

It can be a useful idea to make a note of when you've read through something. I
confident that you know a topic, or you last looked at this six months ago, then i
another *look*!

Topic	**When did I read this?** ***Write the date here – preferably today's***	**I k**
What are cycles?		
The Water Cycle 1: Stores and processes		
The Water Cycle 2: The drainage basin, run-off and human influence		
The Carbon Cycle 1: Stores and flows		
The Carbon Cycle 2: Changes and human activity		
The importance of water and carbon, and mitigating climate change		
Case Studies: Tropical rainforest and a local catchment		

Exam tips

Now that you've thoroughly revised and hopefully answered a few sample exar
good idea of what to expect in your exam.

Command words
In each question there are 'command words'. These are essentially the instructio
to answer the question, and give you a clue on the type of response the examin

Command words are not a secret, and they're nothing to worry about. You've pr
from throughout your year(s) studying the course.

AQA has created a list for you to refer to:
https://www.aqa.org.uk/resources/geography/as-and-a-level/geography/t
Unfortunately, AQA hasn't given a breakdown of the possible number of marks,
sound, the more marks they will be worth.

- For example, the word 'define' wants a short answer stating facts (AO1). As
  definition, you can quickly gain a couple of marks.
- Assess, for example, requires more thinking, and you might have to conside
- The words with the most marks might be 'to what extent' – you will need ar
  topic and will need to provide examples!
- However, the same command words may have different numbers of marks.
  example, uses 'assess' for both 6- and 9-mark questions and 'to what exter
  mark questions!

Here's our quick run-down of the different command words and what you need
balanced answer.

- ✓ **JUSTIFY:** Identify the pros and cons of EVERY view or opinion. Weigh them
  should have stronger pros according to your weighing of opinion.
- ✓ **DISCUSS:** Set out for and against of an argument, and come to a conclusion
  between sides.
- ✓ **EXPLAIN:** Set out causes of the issue, event and/or factors influencing its f
  understanding of processes.
- ✓ **OUTLINE:** Provide a brief account of relevant information.

- ✓ **TO WHAT EXTENT:** Express opinion on merit or validity of a view after exa different sides of argument.
- ✓ **COMMENT ON:** Make a statement arising from a factual point. Add a view, like a Geographer!
- ✓ **EVALUATE:** Consider several options or arguments and come to a conclus success or worth.

Assessment objectives

You may come across the words 'assessment objectives', or 'AOs' for short. The command words. They are set by the government and vary by subject. As you'd get, and AO3s are the hardest.

Here's a quick summary:

	What you need to do	F
AO1	Show your knowledge and understanding of geographical concepts and issues	✓ Collecting e together
AO2	Manipulate and draw conclusions from geographical information, both familiar and new	✓ Use of maps ✓ Statistics ✓ ICT skills: us ✓ Analysis, pre
AO3	Investigating questions and reaching conclusions through many geographical skills and techniques	✓ Concluding ✓ Use of maps ✓ Statistics ✓ ICT skills: us ✓ Analysis, pre

In your Paper 1 exam, you'll mostly be assessed on AO1 and AO2. There will be most of those in the NEA (fieldwork investigation).

For every question, AQA will have decided which AOs they are targeting. Bare t answer. If it says that an answer is looking for some AO2 or AO3 marks, don't s through.

You might find it useful to have a look at a couple of mark schemes for the topi each AO marks are achievable.

Level marking

Now that you've got a handle on how the command words work and what the you need to be aware of how they will mark your answers.

For anything but the shortest of questions, you will be level marked. Each level L1 = 1–3 marks, L2 = 4–6 marks. The essay-based questions will have four levels for, the more marks you'll get.

An example of level marking criteria can be found below.

Level	Mark	Descriptor
Level 1	(1–5 marks)	AO1: • The answer uses little geographic theory, and inf superficial. • No use of geographical terms. • Little evidence of comprehension. • No or restricted use of example material, where a
		AO2: • Investigation, connections and developments are • Argument is unclear; points may be brief, biased of structure. Answer is likely to be poorly written question.
Level 2	(6–10 marks)	AO1: • Use of more complex theories may be inaccurate, information is correct. • Geographical terms used infrequently. • Comprehension is apparent but may be patchy. • Case study material is present, where appropriate superficial.
		AO2: • Investigation, connections and developments are • Argument is apparent but may be poorly structur relevant to the question.
Level 3	(11–15 marks)	AO1: • Reliable reference to geographical theories; the a and appropriate • Geographical terms used often. • The answer demonstrates a good level of critical c • Case study material is appropriate, specific and w where applicable.
		AO2: • Investigation, connections and developments are • Argument is explicit, with a good balance of evide conclusion. Answer is highly relevant to the ques
Level 4	(16–20 marks)	AO1: • Geographical theories and processes are appropri demonstrating comprehensive and specific know • Frequent use of geographical terms. • Critical comprehension is self-evident from the co geographical theory and information. • Use of case study material is suitable, broad and t • Specific facts and figures are fully integrated and
		AO2: • Investigation, connections and developments are • Argument is well written, supported by the evide • Uses a balance of viewpoints in order to reach a ju • Conclusions are creative, sophisticated and highly

What are Cycles

Keywords

- ✓ **System:** Simplified model of the real world, where a process occurs. There a and stores within the system.
- ✓ **Open system:** A cycle or process where inputs and outputs can add or remov
- ✓ **Closed system:** Linked processes which there are no inputs or outputs of ma out of the network.
- ✓ **Input:** Addition to a system.
- ✓ **Output:** [illegible] system.
- ✓ **Store:** [illegible] where water, for example, is retained for a period of time, e.
- ✓ **Dynamic equilibrium:** The steady, balanced state of a system.
- ✓ **Positive feedback:** A 'runaway' system loop where the system moves further
- ✓ **Negative feedback:** A cycle that returns a system back towards a normal (e

Key Points

- We simplify the world into systems. Energy and matter can flow in and out
- Systems contain stores and have inputs and outputs.
- Systems can be open or closed.
- The water and carbon cycles are systems.
- When inputs and outputs are balanced, the system is in a state of dynamic e
- Positive and negative feedback changes the equilibrium.

What are systems?

The real world is incredibly complicated. This is why we break it down into **syst**

Systems include many different parts which are all related. They occur because the

The driver is usually the sun.

Sometimes, larger systems can be sub-divided into sub-systems.

The parts of a system include:

- Stores (components)
- Inputs and outputs

Earth has four main interlinked **open** systems. They all affect each other.

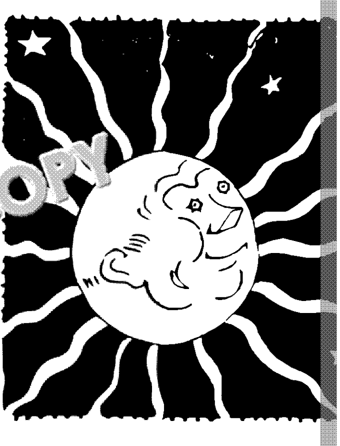
They are:

Atmosphere

Hydrosphere

Lithosphere

Biosphere



There are three types of system, based on whether energy and matter can be tr
system.

Closed system

☑ Transfer energy

☒ No matter is transferred

- E.g. The

☑ Tr

☑ Tr

- E.g

The third ty n **isolated** system. These usually only occur in labs, rather thar
there are no inputs or outputs of either material or energy.

Dynamic equilibrium

Systems have **inputs** and **outputs**. Inputs are energy and matter.
In a **closed** system, the outputs and inputs simply cycle around one store (usual
In an **open** system, inputs enter and flows take place between stores. Eventually

Dynamic equilibrium is where the system is stable – the inputs and c
sometimes something changes which changes the equilibrium.

Positive and negative feedback

Sometimes, the equilibrium changes. The inputs and outputs change, and the s
no longer in balance.

There are two types:

Positive feedback

- Pushes the system further away from the previous equilibrium.
- E.g. rising air temperature melts permafrost releasing CO_2 (greenhouse gas), further increasing temperature.

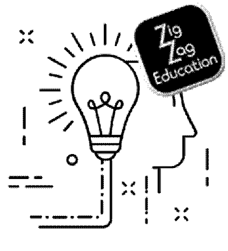
Nega

- Restores the system
or reduces the effe
- Burning fossil fuels
warming the plane
oceans and plants.

Applications of the water and carbon cycles

- We couldn't live without the water and carbon cycles.
- They are both interrelated, open systems.
- The water cycle can be sub-divided into drainage basins
- However, on a global scale, they are closed systems

If you only remember these three th



❶ Systems include stores and components, and can be op

❷ Earth as a whole is a closed system because there are n

❸ If the inputs and outputs are balanced, the system is at
feedback makes the system deviate away from the cur
feedback helps to restore the system back to its previo

Activities

Consolidation questions

1. Give an example of:
   - an input
   - an output

....

....

2. What is transferred in or out of a closed system?

....

....

3. Are the water and carbon cycles open or closed?

....

....

4. What is the term given to a stable system where the inputs and outputs are

....

....

5. Removing forest increases the atmospheric CO_2 levels, increasing warming. might this cause?

....

....

Take it further

Take a look at the article on winter storms: **zzed.uk/9582-beaches**
Can you explain the feedback processes involved in restoring the beaches?

Student checks

Topic	What Do I Know?	No Idea ☹	Nearly 😐	Sure ☺	
What are cycles?	What are systems?				
	Dynamic equilibrium				
	Positive and negative feedback				
	Links to the water and carbon cycles				

The Water Cycle 1: Sto
processes

Keywords

- ✓ **Lithosphere:** Rock environments – ca[illegible] as [illegible]store of water.
- ✓ **Hydrosphere:** The store of [illegible] the Earth's surface.
- ✓ **Cryosphere:** The ice [illegible]s upon Earth.
- ✓ **Atmosphere:** [illegible] stored as gas (vapour) within the air, or is condensed
- ✓ **Cascading system:** Several linked systems which all affect each other.
- ✓ **Soil w[illegible]** Liquid located just below the Earth's surface in loose, unconsolida bedrock.
- ✓ **Groundwater:** Water located below the Earth's surface, stored in the pores
- ✓ **Surface water:** Water located above ground; for example, in lakes, streams
- ✓ **Permafrost:** Ground which is permanently frozen for at least two years in a
- ✓ **Evaporation:** State change of water from a liquid to a gas.
- ✓ **Condensation:** Change in state from a gas to a liquid – e.g. water vapour
- ✓ **Sublimation:** A direct change in state from solid (ice) to gas (water vapour)
- ✓ **Residence time:** The average period of time that water molecules stay in a (or a specific lake) before they flow away, or evaporate.

Key Points

- Most of our water is in the oceans – 97%. Most of the freshwater is locked below the ground. There is very little surface wa[illegible] Earth!
- Water is found in all four 'spheres' – the lithosphere, hydrosphere, cryosphe
- Soil water is located in the soil [illegible] groundwater within rock. Some of that is
- Most water in the atmosphere is invisible – water vapour.
- Water exists [illegible] in all three states – liquid, solid and gas.
- Wat[illegible]nsferred between the three states.
- The le[illegible]f time that water remains in a store is called its residence time.
- Stores and processes can occur naturally – such as through ice ages. Humans result of human-caused climate change.

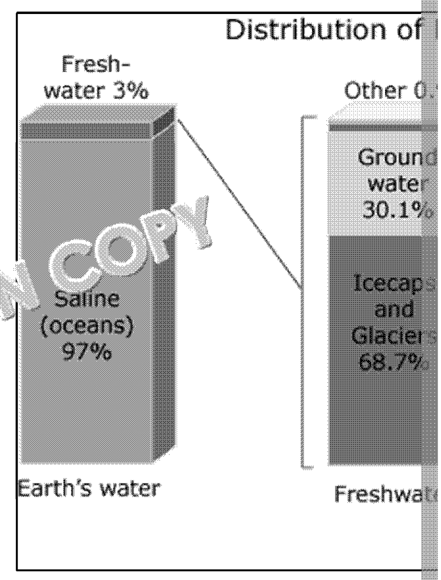
Where is our water?

Unsurprisingly, most of Earth's water is in the oceans – estimated at around 1,338,000,000 km^3.

! You'll see variations in all the sources you look at because the figures are estimates, or are rounded !

In fact, 71% of the surface is covered with water. This ocean water is salty (saline). We can't drink it, unless [illegible]d energy and therefore r[illegible] removing the salt.

The diagram on the right shows the stores.



We can divide the Earth's water stores into the following 'spheres'. They are exa

The **lithosphere:**
Water within soil and rocks.

- **Soil water** within non-saturated soil and unconsolidated material – dependent on soil type, time of year and water [illegible].
- **Groundwater** – saturated rock below the water table – called aquifers.

E.g. Found throughout the world – Northwestern Sahara, Great Artesian Basin (Australia) and the Arabian Aquifer System.

The **hydrosphere:**
This is the liquid w
The main form is c
salty sea water w
consists of fresh su
lakes, rivers and w

E.g. All of the w
rivers inclu
Yangtze, and ma
Caspian Sea, Lak
Superior.

The **cryosphere:**
This is all of the frozen water on Earth, including:

- Ice caps, ice sheets, ice shelves, sea ice and glaciers.
- **Permafrost** – ground frozen for 2 or more years.

E.g. Greenland and Antarctica, winter sea ice, permafrost in Canada and Siberia, Alpine glaciers, etc.

The **atmosphere:**
Water within the a
- Gaseous wate
source).
- Clouds (wate
crystals).

E.g. Everywhe
all around
temperature – but w

Note that technically, the hydrosphere is a term which encompasses all of the Ea
the term terrestrial water to mean all water on and below the surface.

Biological water is found in living things. The sap of plants and trees, and in hum
60% water!

Here's the full breakdown in a table.

Can you work out which 'spheres' each category falls into?

Water source
Oceans, seas and bays
Ice caps, glaciers and permanent snow
Groundwater
Fresh
Saline
Soil moisture
Ground ice and permafrost
Lakes
Fresh
Saline
Atmosphere
Swamp water
Rivers
Biological water

Water transfers

Water exists in th
- Liquid
- Solid (ice)
- Gas (vapour

- Water can change states.
- State changes take in, or give out, latent heat.

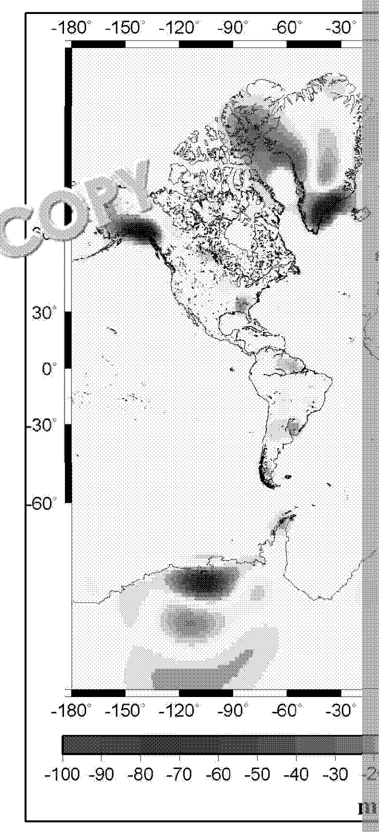
Examples include:

- **Evaporation** of liquid water (liquid → water vapour or gas) because of heat fr
  - There are various determinants, such as temperature (the warmer the a can hold – the relative humidity), the availability of water, and the amo the air (is it already saturated? – if so, it can't hold any more).
  - We use the phrase evapotranspiration to include the water vapour lost transpired from plants.
- **Condensation** – water vapour back into liquid water.
  - E.g. formation of **clouds** as warm air rises and cools to its dew point – o around condensation nuclei. Can occur due to heating of the ground, c at weather fronts, etc.
  - Dew forms in the evening as the ground surface temperature drops an dew point. Radiation fog can also occur.
- **Sublimation** (below freezing).
  - Glacier ice directly to water vapour.
  - Frost direct from water vapour to ice.
- **Melting and freezing**
  - On cold winter nights, puddles and lakes freeze, and the surface soil als
  - When the weather warms up, or the sun comes up in the morning, the

How have things changed?

One of the largest changes that our planet sees is in the development of ice ages. During cold periods, ocean levels drop, as ice builds up on the land (several kilometres thick), spreading from the poles to the equator.

Humans are also causing changes to the hydrological cycle through climate change – causing change to stores of ice and increasing evaporation. Changes in water stores for 2002–2[illegible] shown on the map.

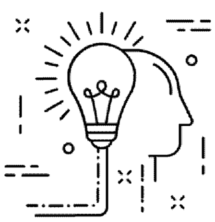


Storage length

The amount of time that water is stored is called the '**residence time**'. This is cal
within a store by the transfer rate (both in and out) of the store. Of course, these

- Each store has a different timescale, varying from less than two weeks (the a
ocean [illegible]
- Deep underground water might last for 10,000 years.
- Ice caps have a residence time of around 800 years.
- Lakes might be several years, and soil water might be replaced within a yea

If you only remember these three th



❶ 97% of the Earth's water is saline sea water. Only a ti
fresh water is actually located on the surface.

❷ Each of the 'spheres' stores water, which exists in all th
between the three states.

❸ Stores and transfers of water can change over time –
glacial cycles, and as a result of human activity – clim

Activities

Consolidation questions

1. How much of the Earth's fresh water is locked up as ice?

....

....

2. Which is the largest component of atmospheric water?

....

....

3. What is the name of the process when a gas becomes a solid (or soil becom phase?

....

....

4. During an ice age, how do the stores of water change?

....

....

5. Which stores have the shortest and the longest residence time?

....

....

Take it further

Why does it rain? This short web page and video from the Met Office explains w
zzed.uk/9582-met-office-rain
For a longer read, take a look at this site, which explains how climate change is a supplies in the US.
zzed.uk/9582-water-supply

Student checks

Topic	What Do I Know?	No Idea ☹	Nearly 😐	Sure ☺
The water cycle part	Stores of water			
	Transfers between stores			
	Natural and human changes to stores and transfers			
	Residence time			

The Water Cycle 2: The
basin, runoff and human

Keywords

- ✓ **Drainage basin:** The area of land drained by a river and the river's tributa
- ✓ **Watershed:** The boundary between two drainage basins.
- ✓ **Transpiration:** The flow of water from the soil to the atmosphere via plants.
- ✓ **Infiltration:** The process where water enters the soil from the surface of the
- ✓ **Percolation:** The movement of water from soil into the rock below.
- ✓ **Groundwater flow:** The movement of water through the bedrock, towards
- ✓ **Stemflow:** Surface water movement through streams and rivers.
- ✓ **Infiltration excess overland flow:** Rainfall is too intense for the water to infil enough. Therefore, water will pool and run across the surface. **Saturated ov** travels over the land's surface because all pore spaces (voids) within the soil
- ✓ **Potential evaporation:** The maximum evaporation that could occur with an
- ✓ **River regime:** The trends in flow throughout the year, based on climate, and drainage basin.
- ✓ **Storm hydrograph:** Graphical representation of a river's response following
- ✓ **Urbanisation:** Development of towns and cities. Settlements affect the shape quickly enters channels through drains, culverts and runoff from concrete surf
- ✓ **Water abstraction:** The removal of water from a source, such as a stream, la us with a water supply.

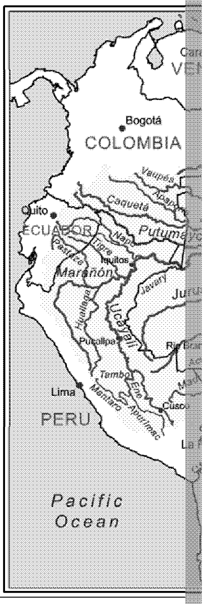
Key Points

- Land is divided up into drainage basins, which contain a river and its tributa
- We apply the well-known hydrological cycle to the drainage basins.
- The water cycle is driven by the sun. Water is transferred between each sto including through the four spheres, and includes all phases of water.
- We can model the inputs and outputs of a drainage basin using the water b use this model for soil). The inputs and outputs change throughout the year d and temperature, and therefore the potential evaporation. Groundwater is
- We represent how a river responds to precipitation by plotting the data on
- If the lag time is short, and the peak flow is high, then we call it a flashy hyd
- There are natural and human factors which make the hydrograph flashy.
- Humans change the stores and flows within a drainage basin through farmin (cutting down trees and building cities), and abstracting water from the envi

What are drainage basins?

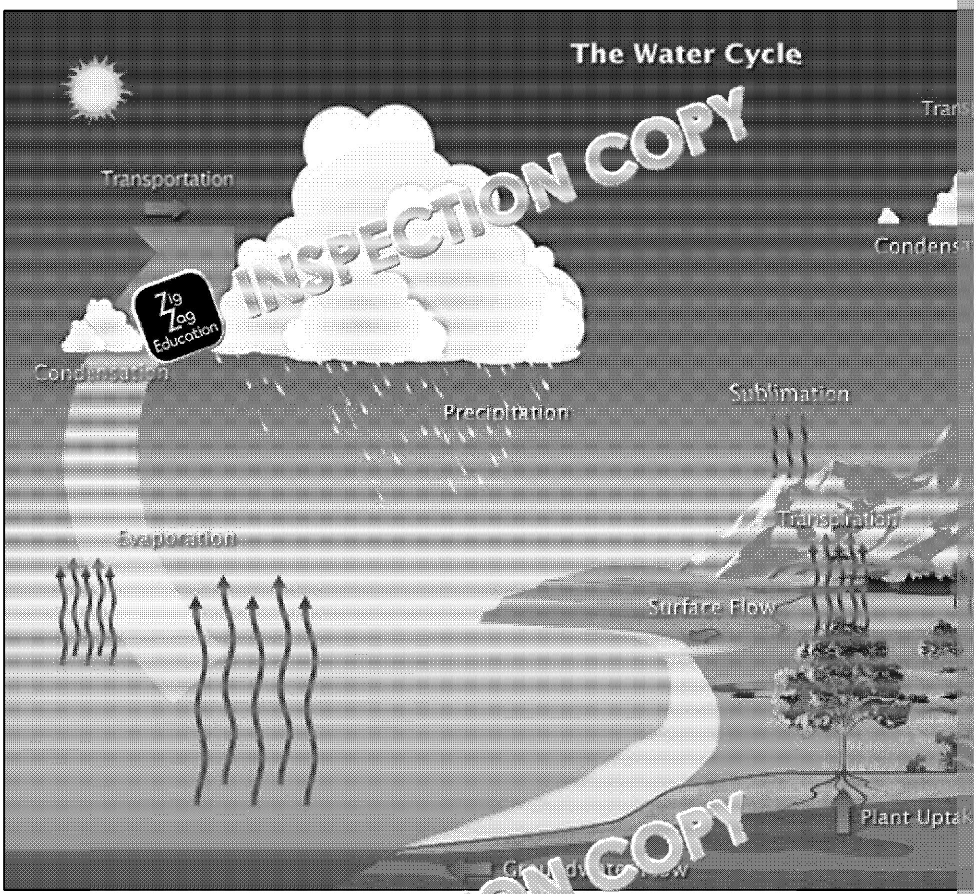
The overall water cycle can be represented in the smaller scale **drainage basins**. This is the area drained by a river and its tributaries, and they are <u>open systems</u>.

Drainage basins can be small, separated by ridges of high ground called **watersheds**. Some drainage basins, such as the Amazon, span several countries.



How do we model drainage basins?

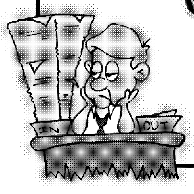
Below is a common representation of the hydrological cycle. There are several fl



Let's break it down:

- Water **evaporates** from the oceans and the land surface (driven by the sun) via vegetation, to become part of the atmosphere.
- At height, the water vapour **condenses** into clouds and falls back to Earth a
- The water is stored and transmitted in several ways:
    - On high ground, or towards the poles, the water will fall as ice and cou cap.
    - Some of the water **infiltrates** into the soil. Movement of water throug When it **percolates** (reaches) the water table, it moves as **groundwat** stored within voids in the soil (soil water).
    - Some of the water is intercepted by vegetation. It flows to the ground leaves and twigs.
    - If the precipitation is intense and/or there is little interception, or the s can't infiltrate and **overland flow (surface flow)** occurs.
    - Overland flow and groundwater (base flow) contribute to river flow. Ri Rivers generally flow into the oceans.
    - Rivers may flow in and out of lakes.

Therefore:



Inputs include
- → Energy from the sun
- → Precipitation

Evapo

Note that water doesn't have to reach the oceans every time – it can evaporate
rain over the land surface once again.

The water balance (budget)

The water balance is the balance between the inputs and

We use the equation:

$$Precipitation = discharge + evapotranspirati$$

It can be written as $P = Q + E \pm \Delta S$

The flow in a river changes throughout the year as the seasons change. Factors in **evaporation**) and weather patterns – e.g. rainfall. This is called the **regime**. Som in the summer – that's why some villages include 'Winterbourne' or 'Bourne' in thei

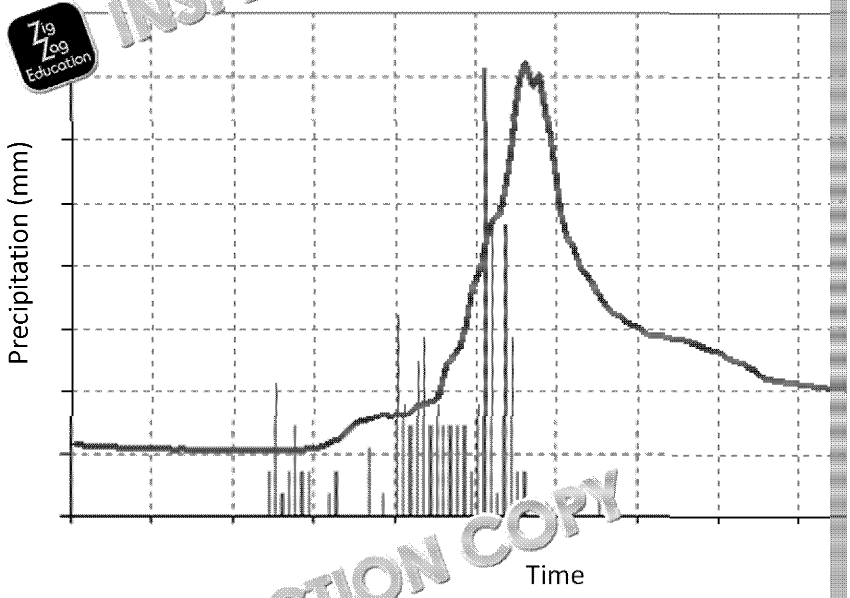
The water balance is often used to measure soil water.

In the UK, for example:

- Precipitation is greatest in the winter – it rises in the autumn and falls over
- Potential evaporation is very low in the winter, and rises to a peak in the su
- During the autumn, when precipitation exceeds evaporation, groundwate
- There is a groundwater surplus in the spring, utilisation in the early summe summer.

The flood hydrograph

We can represent precipitation and river flow on a graph. This allows us to see precipitation. Planners can use these to plan river engineering projects.



This is a classic **hydrograph**.

The precipitation is shown by the vertical bars and measured on the left axis.
The discharge – usually measured in cumecs (m^3/s) – is shown by the continuous lin axis.

The graph clearly shows the **rising** and **receding limbs** as the water rises and fa
The **lag time** is the duration between peak precipitation and peak discharge.
Before the precipitation is the **base flow** (from ground and soil water).

Flashy?
If there is a very short lag time with high discharge, it means that the river respo
to precipitation. We call this a **flashy** hydrograph.

There are many factors – both natural and human – which cause a flashy hydrog
them are outlined below.

Impermeable rock or soil
Overland flow occurs as water cannot infiltrate soil or percolate into bedrock easily.

Deforestation
Reduced interception and transpiration – especially if downslope.

Agriculture
Compacted soil, bare soil in winter fields, downslope ploughing all increase overland flow.

Lots of streams
Water reaches the river from many tributaries.

Sudden temperature change in winter (melting snow)
Rapid snowmelt will quickly increase river flow.

Urbanisation
Most urban surfaces don't absorb water and storm drains quickly transport the water into rivers.

River engineering can also increase downstream flood risk.

Lack of vegetation
Reduced interception and transpiration causes overland flow.

Circular basin
Water flows to the river from all parts of the basin quickly.

We can reduce the flashiness of a hydrograph – for example, by planting trees (a
or employing different farming practices, and through sustainable urban drainag

Changes to the water cycle

Local-scale hill slope basins can be affected by natural and human factors.

Weather phenomena can temporarily affect a drainage basin – such as extreme
drought.

E.g. Flooding in Cumbria in December 2015 (Storm Desmond), floodi
February 2009 as the result of snowmelt, and drought in the sum
low river flows.

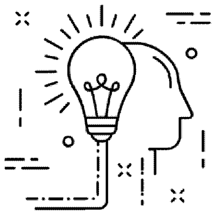
Humans can cause changes as follows:

- Farming
  - Harvesting crops means that the soil is not protected by vegetation – t
interception. Overland flow and soil erosion can occur, and machinery
soil, reducing infiltration. Wind can also erode soil.
  - Ploughing can increase infiltration, although downslope ploughing ca
water down towards streams.
  - Soil and wetlands can be drained – water runs into ditches.

- Land-use change and urbanisation
  - Urbanisation seals the land, meaning that water cannot infiltrate.
  - Deforestation increases runoff and reduces evapotranspiration. On a la scale, deforestation can reduce the overall precipitation and therefore of rivers.

- Water abstraction
  - Last time you turned on the tap, your water might have come from a ri reservoir or from the ground. If you live in London, some of that water i desalinised at Beckton. We use water in our homes, in industry and for
  - Abstracting river water reduces streamflow, and reduces the water qua
  - Building dams and reservoirs floods land and streamflow below the da
  - Pumping out groundwater lowers the water table. In coastal areas, sali the aquifer. Baseflow of rivers is also reduced.
  - Therefore, the Environment Agency regulates water abstraction in the much.

If you only remember these three th



❶ We can model the water cycle using the drainage basi shows all of the stores and flows of water.

❷ We can model the inputs and outputs of a drainage basi water balance equation – the stores change throughout t

❸ We measure the flow of water in a river on a hydrogr combine to affect the shape of the graph – such as acti peak flow.

Activities

Consolidation questions

1. On what scales are drainage basins?

2. Name the processes where water enters the soil and rock.

3. Are rivers stores of water, transfers of water, or both?

4. At what time of year is potential evaporation the greatest?

5. Why does deforestation result in a 'flashy' hydrograph?

Take it further

Read and watch the [illegible] at **zzed.uk/9582-nz-humans-water** – from New Zeal

Student checks

Topic	What Do I Know?	No Idea ☹	Nearly 😐	Sure ☺	
The water cycle part 2	Drainage basins				
	The water cycle				
	The water balance				
	The flood hydrograph				
	Human changes to the water cycle				

The Carbon Cycle 1: St
flows

Keywords

- ✓ **Carbon:** Black (when solid) non-metallic element with the atomic number 6, th Earth, many rocks and fossil fuels.
- ✓ **Carbon stores:** Within the carbon cycle, carbon can be removed from flux fo of time, e.g. [illegible] rock, or within oceans.
- ✓ **Carbon sinks:** Store(s) of carbon – more carbon is added than lost. For exa atmos[illegible] rocks, soils and forests.
- ✓ **Carbon sources:** Store(s) of carbon where more carbon is lost from the store
- ✓ **Carbon fluxes:** The movement of carbon between stores.
- ✓ **Fast and slow carbon cycles:** Both are flows and stores of carbon between different mechanisms – both biological and non-biological. The fast cycle oc exchange between the ocean and atmosphere, while the slow carbon cycle fluxes from geological stores.
- ✓ **Decomposers:** After plants and animals die, their remains are broken down Carbon is released back into the atmosphere.
- ✓ **Weathering:** Process which removes CO_2 from the atmosphere as it dissolves carbonate rock, which is transported to the oceans and is buried as sedimen
- ✓ **Respiration:** Living things produce CO_2 as sugars are broken down to produ reverse of photosynthesis.
- ✓ **Photosynthesis:** Chemical process – plants derive their energy source from t to create glucose sugar from carbon dioxide and water.

Key Points

- Carbon is found above and below ground, and in the air – as rocks, soils, di oceans, [illegible] frozen permafrost, and within living things.
- Anim[illegible] very good at driving changes.
- Sinks are accumulating stores of carbon, sources are stores which release ca sequestered.
- Carbon moves:
  - between the oceans and the atmosphere.
  - between rocks and the atmosphere (volcanoes and plate margins).
  - between ocean sediments and the lithosphere.
- Plants remove CO_2 from the atmosphere through photosynthesis. Plants, anim that carbon back to the atmosphere via respiration.
- Atmospheric CO_2 concentrations have changed over time – and are respons interglacial periods.

What is carbon?

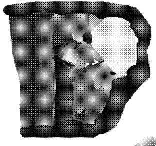
Carbon is a black element. It is vitally important to us – but we don't usually se its pure form. Living things use carbon as a building block – you and me, and th plants and trees outside. It's found in carbonate rocks and in diamond rings. It's fuel for your car, we [illegible] heat our homes and to generate electricity. There's carbon in t[illegible], and its dissolved in the oceans. Most of the carbon is com with other elements – like oxygen, hydrogen and calcium.

Like the water cycle, carbon has stores and transfers. Carbon passes between th and non-living world. Humans are great at releasing stores of carbon back into t atmosphere. And that's a problem. And we need to do something about it.

Where are the stores of carbon?

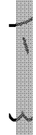
Apart from within this piece of paper, and in the toner (ink) on this paper…

Lithosphere



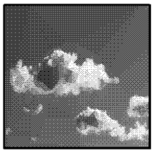
- Sedimentary rocks (carbonate rocks) ($CaCO_3$) such as limestone and chalk.
- Fossil fuels such as coal, oil and gas, and also shale.
- Marine sediments.

Hy



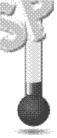
- The oceans contai
- Living plants and a contain carbon.
- Shells and carbon- ocean floor and be becoming rock an lithosphere.

Atmosphere



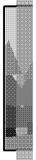
- Carbon dioxide – CO_2 – is a greenhouse gas. It is released at plate margins and through volcanoes, and by living things.
- Recently, humans have added CO_2 by burning fossil fuels and through deforestation.

Cryosphere



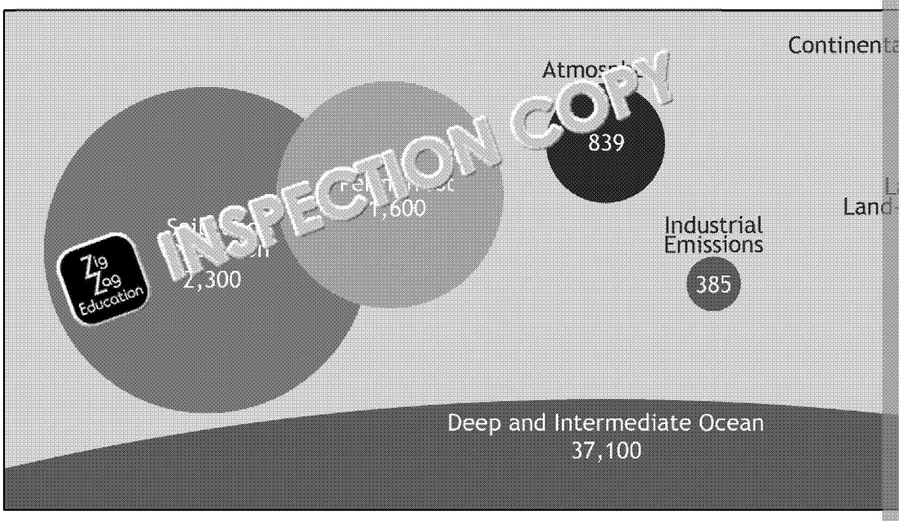
- Frozen ground called permafrost. Contains organic matter because bacteria can't decompose the material at such low temperatures.

B



- Biomass in plants a
- Biomass in animals to flows).
- The litterlayer of th
- Organic soil mater
- Peat.

Here are the amounts of carbon in each store. As with the water cycle, all of the f see slight variations between sources.



We measure the **stores** in gigatonnes of carbon.
We measure **fluxes** (movement between stores) in gigatonnes of carbon per ye
We measure atmospheric CO_2 in parts per million (ppm).

Sink or source?

Sinks take in carbon – more is added to the store than i
Sources release carbon – more carbon is lost than is added t

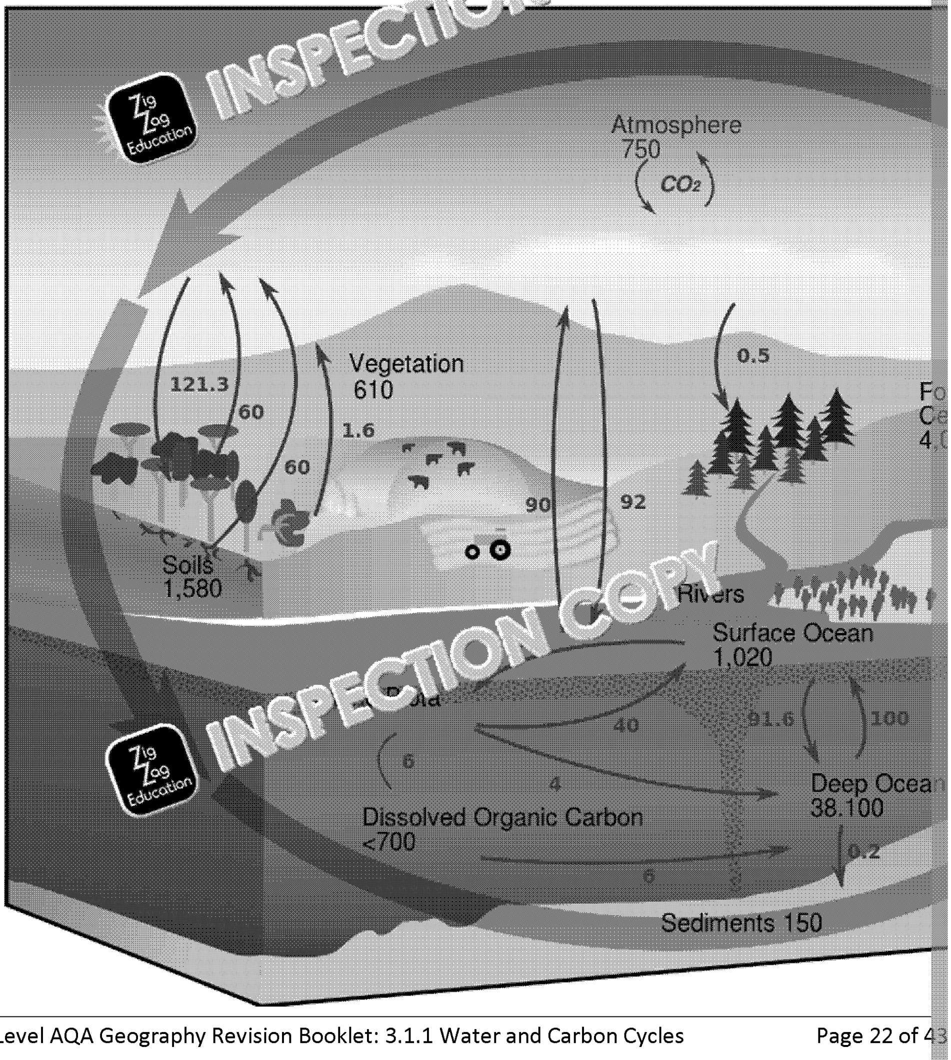
The fast and slow carbon cycles

There are two parts to the overall carbon cycle – the **fast** cycle and the **slow** cycle. The fast cycle lasts at most for centuries. The slow cycle takes place over millennia. The cycles are always occurring.

Within each of the fast and slow cycles, there are two components.

Fast 1 (non-organic) Transfer of CO_2 between the oceans and atmosphere.	**Fas** Exchange ca
Slow 1 (non-organic) Formation of rock and the release of CO_2 at plate margins.	**Slo** Oce

Here is the classic diagram of the carbon cycle, showing the stores of carbon an
are caused by humans.



Movement of carbon (fluxes)

Here's a rundown of the fluxes in the **fast** carbon cycle.

Photosynthesis – plants remove CO_2 from the air, turning it into glucose and oxygen. The carbon becomes part of the plant's biomass. This is called **sequestration**. Plants are eaten by animals.

Respiration – both plants and animals reverse the process of photosynthesis, returning stores of glucose back into atmospheric CO_2.

Plant matter falls to the ground, where it forms a litter layer on the surface. Some of the material is **decomposed**. The decomposers respire, but in low-oxygen conditions, they produce methane – CH_4 which is a more potent greenhouse gas than CO_2. Not all of the matter is decomposed, and the carbon becomes part of the soil humus.

Plant material burns (**combustion**). Wildfires burn forests and grasslands, releasing CO_2 back into the atmosphere.

Here's a rundown of the

The largest store of car
lithosphere. Carbon is
years.

The **oceans** are major
and absorb CO_2. They
absorb more CO_2 than
helping to offset anthr
This is a form of a carb
of ocean currents.

Marine organisms, star
sequester carbon. Whe
to the sea floor. What i
eventually becomes ro
have a carbonate exos
sea water from weathe
can be formed from co

Rainwater is slightly ac
dissolved CO_2 (**weathe**
calcium bicarbonate th
becomes a precipitate
skeletons of creatures
buried.

Changes over time

The amount of CO_2 in the atmosphere has fluctuated. We've see
negative feedback loops have contributed to the changes. For e
negative feedback response, reducing CO_2 in the atmosphere a

Positive feedback can help warm the planet, by increasing atmospheric CO_2. We
process.

There can be large-scale or global events which release CO_2 into the atmosphere
Changes can also occur on a local scale, as the result of weather changes and ha

If you only remember these three th

❶ Carbon is stored in all of the 'spheres', the greatest sto
between the stores as fluxes. The fluxes occur naturally
human activity.

❷ There are two 'carbon cycles'. These are cycles betwe
timescales, and have both organic and inorganic comp

❸ The carbon cycles can change naturally through feedb
contributing to this natural process.

Activities

Consolidation questions

1. Which is the largest store of carbon?

....

....

2. Name a store of carbon within the biosphere.

....

....

3. Which process is essentially the 'reverse' of photosynthesis?

....

....

4. Why are oceans important within the carbon cycle?

....

....

5. Give a large-scale, cataclysmic event which can release CO_2 from rock into t

....

....

Take it further

Learn more about carbon sources and sinks here: **zzed.uk/ 9582-carbon-sinks**

Student checks

Topic	What Do I Know?	No Idea ☹	Nearly 😐	Sure ☺	
The carbon cycle part 1	What is carbon?				
	Carbon stores				
	The fast and slow carbon cycle				
	Carbon fluxes				
	Changes over time				

The Carbon Cycle 2: Cha human activity

Keywords

- ✓ **Carbon budget:** The overall inputs and outputs of carbon in part of the carb example, the carbon stored in the troposphere, or oceans, or soil, etc.
- ✓ **Albedo:** The reflection of sunlight from a surface – light-coloured surfaces re have a high albedo whereas dark surfaces have a low albedo because they
- ✓ **Greenhouse gases:** Gases which include carbon dioxide and methane, etc. th absorbing and re-emitting outgoing radiation.
- ✓ **Radiative forcing:** Mismatch between incoming and outgoing energy from th
- ✓ **The natural greenhouse effect:** Gases within the atmosphere, such as carbon retaining outgoing infrared radiation. Humans are increasing greenhouse gas atmosphere – which causes the **enhanced greenhouse effect**.

Key Points

- In the past, all sources of CO_2 were natural – emitted by volcanoes and wild
- Humans release stores of carbon into the atmosphere as part of everyday li fuels to generate electricity, to heat our homes and to drive our cars.
- This means that we generate far more CO_2 than natural sources.
- Farming generates CO_2, as does land-use change, deforestation and popula
- The carbon budget is the difference between the inputs and outputs of carbo increased atmospheric CO_2 levels from 280 ppm, to over 400 ppm.
- Changing the carbon budget has effects on the ocean, land and atmosphere. negative consequences to humans
- The increase in atmospheric CO_2 is causing radiative forcing, warming our pl
- This process is called the enhanced greenhouse effect – greenhouse gases ab radiation, reflecting some back to the surface.

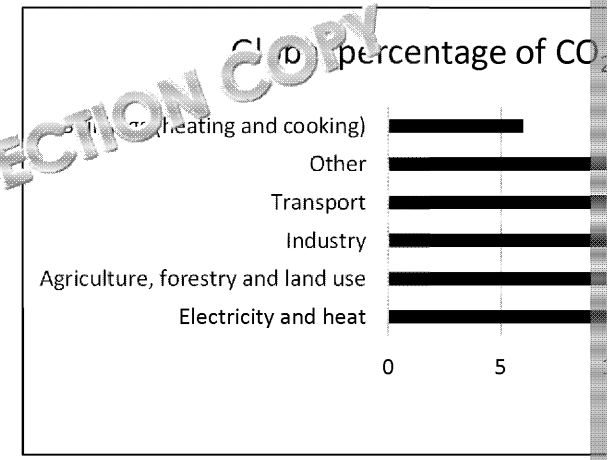
What are the natural emitters of CO_2?

Volcanoes release CO_2. But they release a tiny amount compared to human acti caused major climate change in the past, they don't today.

Wildfires occur naturally in forests and grasslands, for example caused by lightn Ecosystems are adapted to surviving fires. However, humans are now starting fir and deliberately, releasing CO_2 back into the atmosphere.

How are we influencing the carbon cycle?

Here's a graph showing the global sources of CO_2 emissions. Most of these sources are from burning fossil fuels such as coal, oil and gas.



For example, we burn fossil fuels to:

- generate electricity
- run our cars, buses, trains, ships and aeroplanes
- heat our homes and buildings
- cook with
- manufacture goods

Fossil fuels

As noted above, we use fossil fuels every day. You might have travelled to school this morning on a bus or in a car. There's probably a light switched on in the room.

Fossil fuels release CO_2 that was sequestered by plants millions of years ago, returning the CO_2 into today's atmosphere.

Land-use cha

We're very good at c
was once covered
rainforests are under
for their timber, and to
are burned as c

Not only is the carbon
carbon is also diminis
trees to seq

Population growth and urbanisation

The human population is growing at a rapid rate, and countries are developing. We're manufacturing and consuming more stuff, and building large cities.

We use cement to build with (cement is also used in concrete). This produces CO_2 and equals 5% of human greenhouse gas emissions.

And those cities need more land to be cleared, a cause of deforestation.

And more food needs to be grown!

And more transport is necessary.

The carbon budget

Carbon budgets

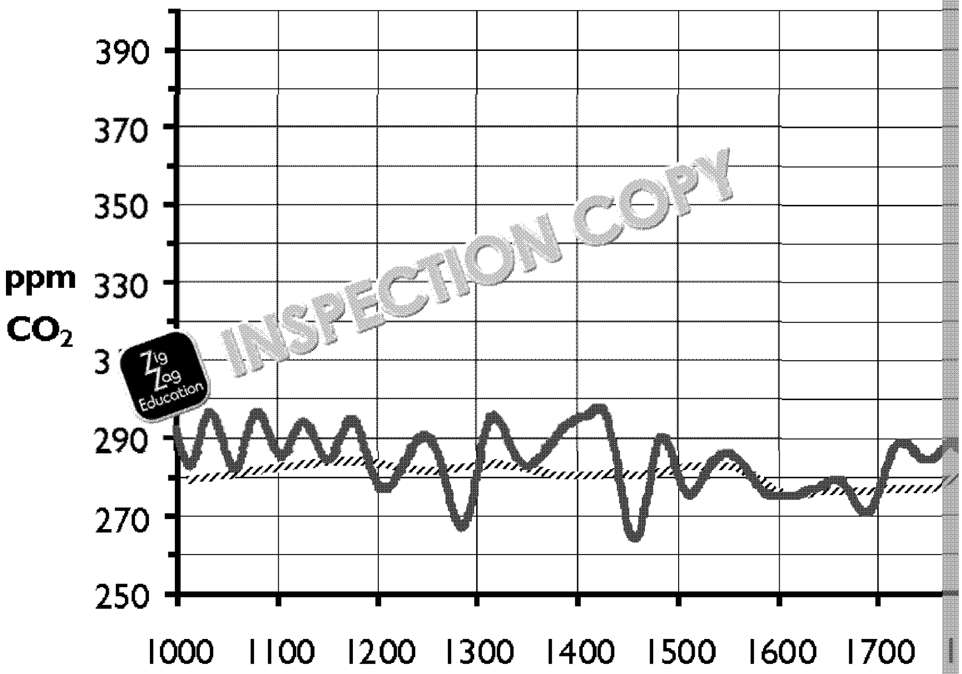
The carbon budget is the difference between the inputs and outputs of carbon w
are the figures shown on the diagram in the previous chapter, however, the bud
examples.

Note that you may see the term 'carbon budget' used when referring to a count
under an environmental or international agreement. We are not using

In the past, the fluxes of carbon between the stores were due to natural process
the fluxes, and therefore the budget.

Despite natural negative feedback loops, such as increased ocean uptake and pl
has risen. Before industrial times, the CO_2 was 280 ppm. It rises every year. In 201
ppm.

This graph shows how atmospheric CO_2 has risen.



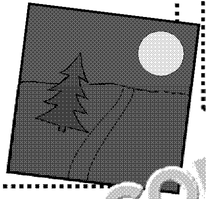
The dashed line shows the concentration of CO_2 in ppm. The graph also highlig concentration and global temperature. If we went further back in time, we woul

Burning fossil fuels reduces the stores of underground carbon, while increasing

So what are the effects of changing the carbon budget?

The land

- More CO_2 means that there is more potential for plant growth.
- Climate change could lead to increased drought and forest fire risk.
- Decreases in carbon store (permafrost) as a result of climate change.
- Shifting agriculture – some areas may become too dry. Other, cooler areas might open up for agriculture.
- Biomes and ecosystems are likely to be affected – decrease in cold.
- Habitats and migration of (invasive) species towards the poles.
- Coastal flooding, resulting from sea level rise.



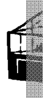
T

- Sea level rise fro expansion – ocea lead to coral blea protect coastlines surges), and redu absorb more CO_2
- As oceans absorb Shells are thinner produce and mair
- Reduced winter se **albedo**.
- Reduced salinity c ocean currents du of fresh water fro

The atmosphere

- Increasing CO_2 store!
- Temperature rise due to enhanced greenhouse effect (see below).
- Shifting weather patterns – e.g. increase in droughts, extreme weather, strong

Climate and (enhanced) greenhouse effect



There are many different **greenhouse gases**. They act to warm the planet. They are important because they raise the temperature enough to allow life on Earth.

But we're releasing extra greenhouse gases into the atmosphere, and creating a **effect**'.

This enhanced effect leads to positive feedback cycles and **radiative forcing** – w the incoming and outgoing radiation. The planet will warm if the value is g gained than lost) and cool if more is lost than gained.

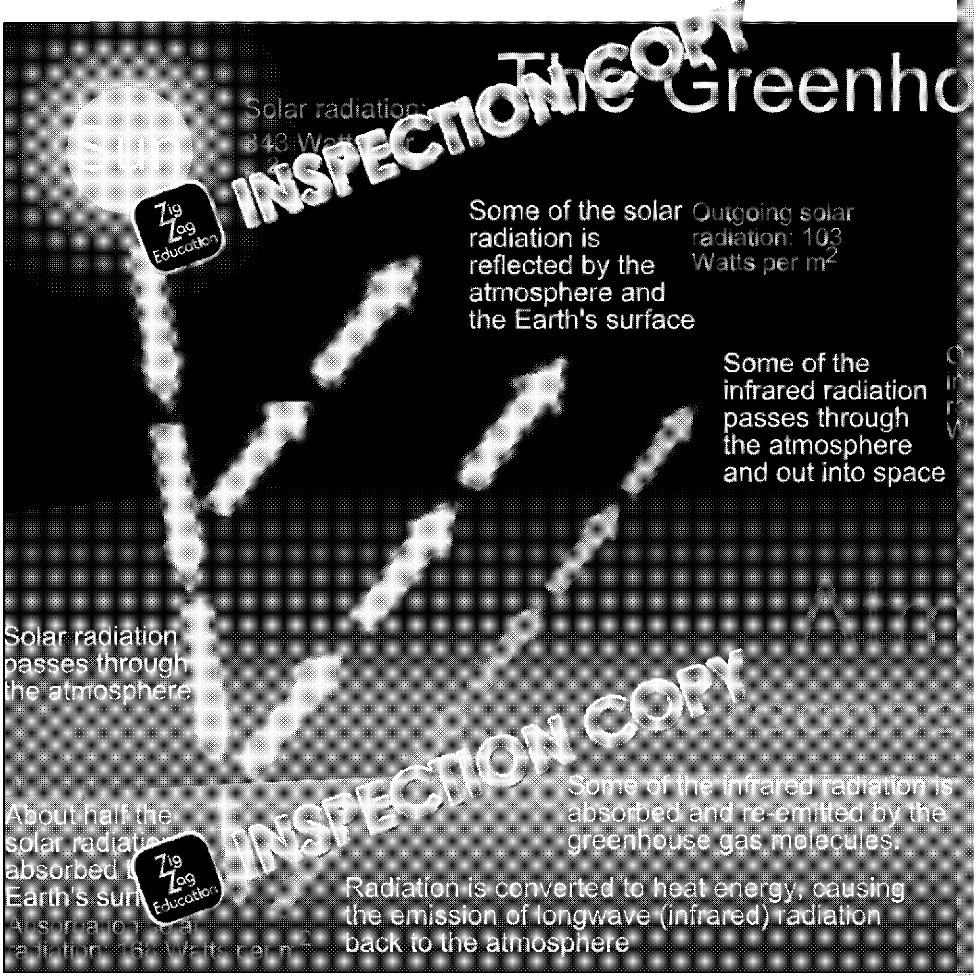
Greenhouse gases include water vapour, carbon dioxide (CO_2), methane (CH_4), n Each of the greenhouse gases has a residence time in the atmosphere.

- Most of the air is nitrogen and oxygen. They aren't greenhouse gases.
- Greenhouse gases only make up a tiny fraction of the atmosphere, but are very important.
- Water vapour has a short residence period (maybe a week). We don't need to worry about it too much.
- Some say that the effects of CO_2 emitted today will have a warming effect for centuries (and maybe even millennia to come).

CO_2 is
such
poten

When
can use
them

This is the typical model showing the greenhouse effect.



Here are the steps of the diagram:

1. The sun emits shortwave ultraviolet radiation. While some is reflected back and land, most passes through the atmosphere and is absorbed by the Eart
2. The Earth's surface is warmed.
3. The Earth's surface releases the energy as outgoing longwave infrared ene
4. While some of this energy passes back through the atmosphere and back i space, some of the energy is absorbed and re-emitted by greenhouse gas molecules.
5. The greenhouse gases emit the energy in all directions – some is therefore reflected back to the surface.

The more greenhouse gases we add to the atmosphere, the greater the radiativ forcing, and the greater the warming. There is also greater potential for positive

If you only remember these three th

❶ In the past, natural emitters such as volcanoes provide atmosphere. Nowadays, we are releasing vast quant fossil fuels, agriculture and land-use change. As the p develop, even more CO_2 is generated.

❷ Humans are therefore changing the carbon budget – effect on the land, the oceans and the atmosphere.

❸ Humans are warming the Earth through the enhanced forcing is taking place, meaning that more heat enters

Activities

Consolidation questions

1. Which natural source of CO_2 altered climate in the past?

………

2. How does farming release greenhouse gases?

………

………

3. Until the Industrial Revolution (around 1760 onwards), the atmospheric CO_2 relatively stable. What was the approximate concentration?

………

………

4. Give one impact of raising CO_2 concentration in the oceans.

………

………

5. Why is CO_2 a greenhouse gas?

………

………

Take it further

In the UK, [illegible] phasing out the use of coal to generate our electricity. We still us mainly in [illegible]er. We also use a lot of gas to generate electricity.

Visit this website to find out how we're currently generating electricity: **zzed.uk/ 9** **templar** Use the graphs to see how coal and gas consumption changes throughout

Do you think it's possible to completely phase out coal by 2025? **zzed.uk/ 9582- uk-stop-coal** and **zzed.uk/ 9582-coal-comeback**

Student checks

Topic	What Do I Know?	No Idea ☹	Nearly 😐	Sure ☺	
The car[illegible] cycle p[illegible]	Natural emitters of CO_2				
	Human causes of greenhouse gases				
	The carbon budget and its effects				
	The greenhouse effect				

The Importance of Water a
and Mitigating Climate

Keywords

- ✓ **Feedback loops**: Positive and negative ways in which a system is brought ba or the equilibrium is changed.
- ✓ **Lag time**: The time it takes between the cause and the effect is seen – e.g. th increased CO_2 levels [illegible] warming of the Earth.
- ✓ **Aerosols**: Tiny atmospheric particles which reflect heat back away from Eart
- ✓ **Renewable energy**: Type of energy that cannot be depleted; for example, to dri[illegible] and power photovoltaic cells.
- ✓ **Non-renewable energy**: Type of energy where the supply is finite – once th gone forever – e.g. fossil fuels which formed millions of years ago.
- ✓ **Biomass/biofuels**: Sugar cane, wood and other recently living resources use seen as a renewable form of energy.
- ✓ **Carbon capture and storage (CCS)**: Process where CO_2 is removed from wa underground geological formations.
- ✓ **International agreement**: Legally binding or voluntary set of rules that count such as the Kyoto Protocol or the Paris Agreement.
- ✓ **Mitigation**: Implementing measures to decrease risk or effect; for example, t
- ✓ **Emissions trading / cap and trade**: Businesses are allocated rights to emit c too much, they can buy credits from countries producing less than their quota are reduced. In terms of cap and trade, industrial sectors, such as aviation, h
- ✓ **Geoengineering**: often large-scale projects to alter the Earth's climate to miti introducing aerosols into the stratosphere.

Key Points

- Water and carbon are vitally important to life on Earth. We're made of bot on them for our every[illegible]
- The carbon and water cycles are linked and controlled by one another. There and [illegible] feedback loops between them.
- Climate change will have serious and significant consequences to humans – a water supply, the economy, our way of life, and our health.
- We need to significantly reduce the level of CO_2 emissions that we produce.
- This can be done in many ways, such as:
  - individuals reducing their impact.
  - reducing emissions from power generation – using renewables and CCS.
  - land-use changes.
  - international agreements and government policy.
  - geoengineering.

How does water and carbon support life?

- We're made up of water and carbon, along with small amounts of many oth elements.
- We need an adequate supply of fresh drinking water, and we also gain wat from our food.
- We need water for the functioning of our bodily processes and reactions. W need water for respiration and to excrete waste.
- We gain carbon from the food we eat – we need glucose for respiration, wh we get from the carbohydrates we consume. We need to consume proteins fats – all contain carbon.
- Plants require CO_2 for photosynthesis to produce biomass, and for their ow respiration. Photosynthesis is how carbon enters the food chain.
- Unlike other animals, humans use water in other ways too – to irrigate crop within industrial processes, and to bathe.
- We need the natural greenhouse effect to allow life on Earth.

Links between the carbon and water cycles

The water and carbon cycles are strongly linked.
For example:

- Water vapour (a greenhouse gas) can increase global temperature – but CO determines temperature, which in turn determines the ability of air to hold amount of evaporation.

There are many different **feedback loops** which include:

- Melting of permafrost and land ice as a result of warming, release of carbon and water stores, decreasing albedo – **+ve** feedback.
- Cloudiness due to condensation nuclei from phytoplankton (dimethyl sulphi but increased cloudiness decreases phytoplankton – **-ve** feedback!
- Warming oceans increase evaporation rates, increasing atmospheric water vapour – **+ve** feedback.
- Water temperature determines the amount of CO_2 stored by the oceans – warmer oceans mean that more CO_2 is emitted by the oceans – **+ve** feedba
- Atmospheric CO_2 concentration affects acidity of rainwater. Combined with chemical weathering – **+ve** feedback.

There is a **lag time** between CO_2 rise and temperature rise due to the time need build. Warming is also offset by **aerosols** (particles) within the atmosphere.

There are various implications from warming the oceans and atmosphere, which

- Shifting weather patterns.
- Shifting biomes.
- Changes to northern, ice-bound shipping routes.
- Water availability.
- Health implications – increase in heat stroke etc.
- Changes to ways of life – could be disastrous for people living in cold environments, marginal lands and places already at risk of droughts.

How can you reduce your impact?

Everyone produces CO_2. And everyone will be affected in some way by climate c simple changes to your lifestyle to reduce the amount you produce.
For example, you could:

- Switch off lights and appliances when you're out of the room.
- Travel on public transport, cycle or walk.
- Ensure you recycle waste, including green waste.
- Buy local, and avoid next-day delivery options.

Reducing emissions from power generation

The UK is committed to reducing carbon emissions. For example, the UK has co generate electricity by 2025. In 2016, the government committed to reducing e 1990 levels.

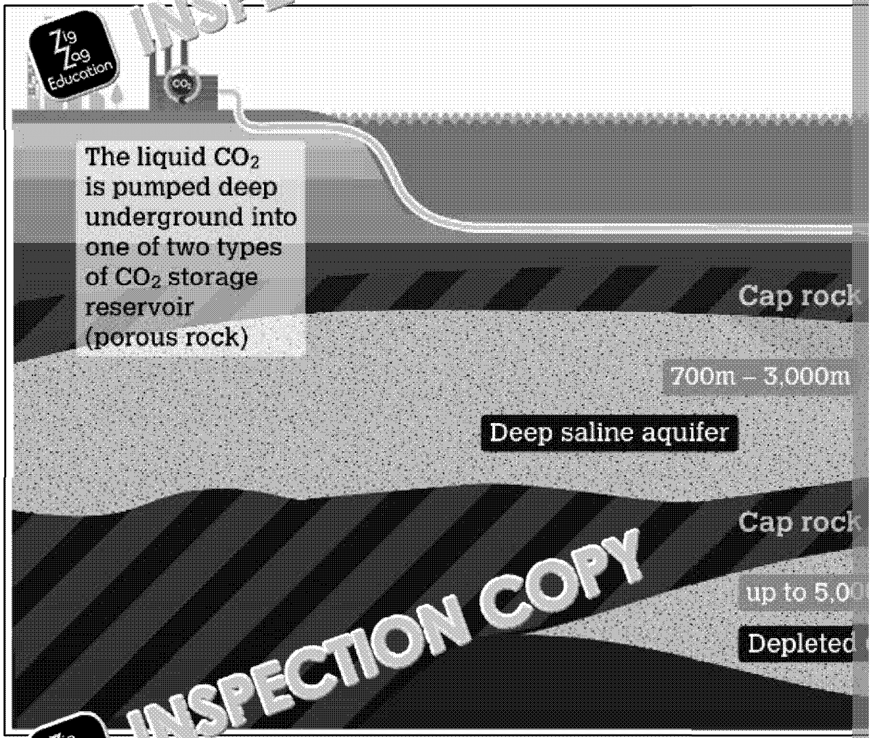
CO_2 generation from electricity production can be reduced by:

Renewables
Using naturally occurring sources of energy such as solar, wind and hydro. These sources will always be there, and they're carbon free.

Biomass
Burning plant material or waste, the carbon was only recently removed from the atmosphere, rather than having been removed millions of years ago (coal, gas, etc.).

More on CCS

- CO_2 is captured from the source – e.g. the chimney from a coal-burning po
- The gas is compressed and liquified.
- It is then transported and pumped into permament storage such as non-us and the deep ocean.
- The process is very expensive, and the technology is still developing.
- There may not be many suitable sites.
- Injecting the CO_2 into oil and gas fields allows enhanced recovery – but tha renewable source.
- Ocean acidification may be caused if the CO_2 is pumped into the deep oce

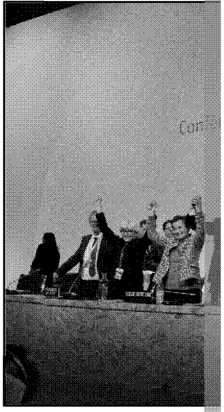


Land use

Removing trees, and farming techniques produce greenhouse gases. There are CO_2 can be offset, such as:

- Reafforestation (replanting trees).
- Improved farming techniques – reducing ploughing, increasing soil carbon, overgrazing.

Large-scale agreements and emissions trading sch



You've probably heard of the Kyoto Protocol. This was a voluntary, but legally binding agreement for countries to reduce their CO_2 emissions, while allowing other countries to develop. In 2015, the Paris Agreement was drafted with the aims to reduce emissions stopping dangerous climate change (2 °C below industrial levels), ideally limiting temperature rises to [illegible]

Each year, conferences are held by the UN. This is sometimes called COP – Conference of the Parties. They agree and set emissions targets, and were responsible for the Kyoto Protocol (1997), the Doha amendment (2012) and the Paris Agreement (2015). There have been 195 signatories to the Paris Agreement, including an EU ratification.

One mechanism to achieve CO_2 reduction is a **carbon trading** scheme (**cap an**
industries in each country are given a set number of carbon credits. If a compan
credits, they can be sold to others who need them – or that company is fined. A
go down, it's not crucial where they are saved. Each year the number of availab

The process of reducing the effects of climate change is called **mitigation**.

National, regional schemes and others

In order to meet (and sometimes exceed) the targets that countries have signe
need to implement national strategies. These could affect industries – such as po
generation, or energy efficiency targets within homes and buildings.

There are also other ways that energy can be saved, such as efficient design of a
and transport.

In the EU, appliances such as white goods, appliances and lightbulbs have an e
based on efficiency. Europe have phased out the use of incandescent bulbs, an
bulbs are following.

Geoengineering

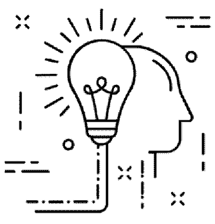
Geoengineering is large-scale climate change mitigation. In some cases, we kee
ways of reducing its effects.

Some of the technologies are unproven, experimental, expensive, and raise eth
are unlikely to happen, and may not work.

Examples include:
- Absorbing CO_2 using artificial trees.
- Fertilising the oceans.
- Causing global dimming by adding aerosols to the atmosphere.
- Reflecting heat away using space mirrors.

Concerns include:
- Unforeseen consequences.
- It doesn't stop us from producing the CO_2 in the first place.
- There are still problems such as ocean acidification.

If you only remember these three th



❶ The water and carbon cycles are essential for life on
heavily linked – there are flows and feedbacks.

❷ Increasing atmospheric CO_2 is having consequences o
need to stop emitting as much CO_2 to stop significant
create large-scale problems to the economy, health a

❸ There are many ways that CO_2 emissions can be red
agreements, national policies, cap and trade, increas
individual's actions.

Activities

Consolidation questions

1. Which gas determines temperature – water vapour or CO_2?

……

……

2. How is atmospheric CO_2 concentration linked to the amount of water vapo

……

……

3. Give an example of how climate change could affect humans.

……

……

4. How does CCS work?

……

……

5. Give an example of an international agreement on climate change.

……

Take it further

Watch this video which shows a speech by US President, Donald Trump, withdraw
Agreement: **zzed.uk/95[illegible]-trump-paris** (BBC News 3:34)

The US is bound by the agreement until November 2020. Do you think that the U
withdraw from the agreement? What other plans could be made to reduce CO_2 e
message does this withdrawal send to other countries? How do you think other co
UK, reacted to the news?

Student checks

Topic	What Do I Know?	No Idea ☹	Nearly 😐	Sure ☺	
The importance of water and carbon, mitigating climate change	The importance of water and carbon				
	Links between the water and carbon cycles				
	Reducing your impact				
	Reducing emissions from energy generation				
	International agreements and trading schemes				
	National schemes				
	Geoengineering				

Case studies

Part 1: Tropical rainforest

Location of your chosen rainforest:	*e.g. Amazon rainforest*	
	Water Cycle	**C**
Changes from deforestation	- Reduced evapotranspiration – large-scale deforestation could result in less rainfall (fewer clouds and fewer condensation nuclei), reducing river flow. - Increased overland flow – reduced interception.	- Loss of stores from burning soil erosion. - Therefore gre atmosphere. - Climate chan scale. - In Indonesia, and burned.
Relationships between the cycles	- Increased CO_2 might mean that tree life cycles are shorter Implications to both the water and carbon cycles. - Reduced albedo – the air at the ground is warmer. There i cooling. This can change weather systems, e.g. less rainfal - Warming could change river ecosystems – warmer water aquatic life. - Slash and burn creates smaller aerosols, reducing rainfall.	
How human activity affects the rainforest	- Greater silting of rivers. - Flash floods from intense precipitation on bare ground. - Lower flows mean less available water for indigenous peoples. - Dam building affects local hydrology and river flow.	- Loss of veget clearance, an Possibility of f from climate - Logging coul companies, e Indigenous p exploited. - Slash and bu - Cattle ranchi - Ecotourism c opportunitie building of in airports, and as paths.
Mitigating human activity	- For both water and carbon, local, national and international agreements are possible. - For example, watershed management (REDLACH) in the Amazon. - Changing farming techniques – e.g. continuous tree cover could maintain higher levels of interception than total logging.	- Protection of or schemes b stop/reduce l parks. - Developmen paying peopl

Part 2: Local catchment

Name of river catchment:	*e.g. Thames Basin*	
Describe the catchment:	River is 346 km long, has 38 main tributaries and million people live within the basin, the river flow towns such as Reading.	
How is the river linked to the water cycle?	**Inputs**	Upper source is in the Cotswolds, an of England. Land use is mixed – passi Climate is drier in the southeast – abo England's average.
	Flows	Upper course: 17.6 m^3/s Middle course: 39.7 m^3/s Lower course: 65.9 m^3/s
	Stores	Replenished by rainfall, including the flows from stores such as chalk aquif
	Outputs	The Thames' mouth flows into a broa the sea. Some water will also flow into the be London clay is impermeable.
	Flooding	The Thames floods due to: • High or intense rainfall • Antecedent conditions • Storm surges
How does the catchment relate to the carbon cycle?	Increase in urbanisation alters the carbon cycle th deforestation reducing biomass and carbon/soil s resulting from urbanisation.	
How does water abstraction affect the river?	The Thames supplies towns and villages with wat There is a desalination plant at Beckton, near the diminishing the flow of the Thames.	
How does flood mitigation affect the river?	The Thames Barrier is at the river's mouth to prev downstream flow meeting high tides, and upcom The river has been channelised between embank flood walls in place. Within the catchment, river diversion has taken p during periods of high flow.	

Case studies

Part 1: Tropical rainforest

Location of your chosen rainforest:		
	Water Cycle	
Changes from deforestati		
Relationships between the cycles		
How human activity affects the rainforest		
Mitigating human activity		

Part 2: Local catchment

Name of river catchment:		
Describe the catchment:	You could discuss the physical characteristics such as size, g settlements within the catchment.	
How is the river linked to the water cycle?	**Inputs**	
	Flows	
	Stores	
	Outputs	
	Flooding	
How does the catchment relate to the carbon cycle?	You could discuss land use change.	
How does abstraction affect the river?		
How does flood mitigation affect the river?		
Fieldwork: **This section is optional, depending on whether you have completed fieldwork relating to rivers.**	**Present some of your fieldwork data in this box.**	
	What does the data show, and how does it relate to your findings or hypothesis?	

Exam Advice

Time management

If you open the paper and see a question you didn't expect: don't panic! Take a follow the steps below. Whatever you do, don't just start writing down everythi

Before you rush headlong into the exam, take a moment to look at the questio

Reading the whole paper

- Remember to take your time at the beginning, reading through all of the questions.
- You don't have to answer them in any particular order, but be aware that sometimes AQA order the questions for a reason, and earlier questions might help you answer later ones.

Reading th

- Too often stude and lose marks
- It might be usef command words what the questi

Planning

- After reading through the question, make sure you plan your answer.
- This stage is key to getting higher marks, so make sure you don't skip it. Planning can help you:
  - structure your answer
  - answer the question properly
  - save time
- You may do any rough work and planning in your exam paper, but make sure to ~~put a line through~~ to indicate it is not to be marked

- Remember to p spelling, gram as content.
- You can use as need, but try to quantity when i be put off by h around you.
- Any mistakes y don't use corre
- If you get stuck go onto anothe back to it at the
- Adopt a formal and concisely.
- Your introducti issue at hand, g information.
- The body of you evidence for yo the points you r For long-answe demonstrate yo recommendatio need to present viewpoints.

Checking

- Leave some time after to go through your answers, correcting spelling, grammar and terminology errors and making sure you haven't left anything out.
- Finally, double check that your candidate details are on any extra sheets you may have, and put them in the correct order with your answer book, using a treasury tag to attach them if you need to.
- Put a cross through any pages you don't want marked, e.g. planning pages.

Writing

Geographical terms

One of the points you are being assessed on is the correct and appropriate use c geographical terms. You should have assembled a list of key terms that might b useful for this exam, so make sure you learn them and think about how you mig include them in your answers. If you are scared of forgetting these words when start writing your answers, you could try writing them all down as soon as you ar permitted to start writing, remember to cross them out at the end though!

However, don't use geographical terms if they are unnecessary or you are unsur include them [illegible] they are relevant and useful.

Getting the tone right

As well as using key geographical terms in your answers, your writing should str This helps your answers appear considered and professional.

Do ✓	Do not ✗
• Write out abbreviations in full the first time you use them • Be clear when a statement is a personal opinion as opposed to fact • Use linking words: thus, therefore • Try to include the source of a fact if you can, e.g. according to the WHO, the death toll from the tsunami was 1,200.	• Write in the first person • Use contractions: don't, • Use slang terms and oth language • Use rhetorical questions

It might help to think of yourself talking to your examiner, or a geography teach don't know you, so you need to make sure you are clear, but they do know abou to explain every key term [illegible] it's not necessary.

Ask your teacher if you are unsure about your current 'tone', but don't worry abo are more focused on how you answer the question.

Spelling, punctuation, grammar and legibility

It can often be hard to think about these in the exam hall, but proper spelling, pu and grammar really help keep your meaning clear. They also keep your sentenc getting too long, which aids with clarity and readability.

While examiners are used to reading all sorts of handwriting, it is good to try to k answers as legible as possible. One way to do this is to slow down while writing, letters are an appropriate size. The final read-through of your answers before fir any words which are especially tricky to read.

! **Quality over quantity:** writing skills are only important in that they he and communicate your geographical knowledge and understanding. and clear answer than [illegible] answer stuffed with complex words th

In the event of emergencies!

- All your planning and preparation means this isn't going to happen... But if
  the first rule is always to try and relax!
- Take a minute for some deep breaths, close your eyes and imagine a lush g
  woodland... clear your mind.
- Now read over the question, think over what you haven't said yet, and conti

'Thinking like a geographer' and 'synopticity'

Learning to 'think like a geographer' is crucial for exam success and important f

As you are aware, the world is a complicated place – cause and effect, and a
pull information together, join up the dots, and work out why things happen in
include space, place, environment and scale.

Don't be afraid to draw on your own knowledge and other modules to help illus
creative, original and innovative, but use this skill wisely. Make sure you use tha
question rather than going off on a tangent or writing down *everything* you kno
called '*synopticity*'.

Here are a few tips on thinking like a geographer:

Consider the many aspects of the issue from many

- Think across the social/natural divide, using your knowledge of b
  geography
- Involve many aspects of the issue: historical context, cultural pers
- SPEED can be a useful tool for thinking synoptically: social, politic
  environmental, and demographic. But don't forget to consider cul
  material factors when appropriate.
- Try to see the issue from many viewpoints: work on your empathy
- Don't be afraid to think outside the box!

Spatial concepts

- Geographical perspectives often focus on the importance of space, l
  issues at hand
- Think about movements and flows of people, goods, ideas, etc.
- Think about the effects of 'scale': local, regional, global

Be Creative

As long as your approach is logical and well justified, you can think in

Exam preparation:

My take-home tips:

✓ Before the exam (Eat a good BREAKFAST)
✓ During the exam (Read the question CAREFULLY)
✓ Planning (HIGHLIGHT key words and concepts)
✓ After the exam (Take some time to RELAX!!!)

Answers to Consoli Questions

What are Cycles?

1. Allow energy and material, could be related to water and carbon cycles
2. Matter
3. Open (but closed on a global scale)
4. Dynamic equilibrium.
5. Positi[illegible]

The Water Cycle 1: Stores and processes

1. 68.7%
2. Water vapour
3. Sublimation
4. Decreased ocean water, ice is deposited on the land surface
5. Shortest = atmosphere; longest = oceans

The Water Cycle 2: The drainage basin, runoff and h

1. It depends – some are small-scale, others are hundreds to thousands of squ
2. Soil = *infiltration*; rock = percolation
3. Both
4. During the summer
5. Reduced interception increases the overland flow, meaning that the water

The Carbon Cycle 1: Stores and flows

1. The lithosphere [illegible] continental crust and upper mantle.
2. Any suitable example, e.g. biomass, litter, soil and peat.
3. Respira[illegible]
4. Transfer CO_2 between oceans and atmosphere – mopping up some of the e
   Marine life transfers carbon to ocean sediments and therefore to the geolog
5. Asteroid impact.

The Carbon Cycle 2: Changes and human activity

1. Volcanoes
2. Soil ploughing, methane from livestock production and paddy fields.
3. 280 ppm
4. Acidification – impact on carbonate shells and coral. Sea level rise. Other eff
   bleaching.
5. CO_2 absorbs and re-emits the outgoing radiation, meaning that some of the
   Earth.

The Importance of Water and Carbon, and Mitigatin

1. CO_2
2. Temperature of the air – warmer air can hold more water than cold air
3. Allow a suitable example – e.g. extreme weather events, droughts or floo
   / changed lifestyles or economic effects, etc.
4. CO_2 is captured from a power station and injected into geological storage s
   field
5. E.g. Kyoto, Paris, etc.