How carbon dioxide decreased

4.9.1.4 · Chemistry of the atmosphere · revision notes

How the carbon dioxide that made up most of the early atmosphere fell to the tiny proportion in air today: dissolving in the oceans, photosynthesis, and carbon being locked up in sedimentary rocks and fossil fuels. This subtopic is also where 6-mark questions on how the atmosphere has changed, and on how limestone, coal, crude oil and natural gas formed, come from.

Key facts

- CO_2 removed by: dissolving in the oceans (carbonate sediments), photosynthesis, sedimentary rocks, fossil fuels
- Coal: remains of plants (mainly trees) buried and compressed
- Formation of fossil fuels: heat and pressure over millions of years
- Early atmosphere mainly CO_2 → about 0.04% CO_2 today
- Limestone: mainly calcium carbonate, $CaCO_3$, from the shells and skeletons of sea creatures
- Crude oil and natural gas: remains of plankton buried in mud on the sea bed
- Limestone and fossil fuels lock up carbon for millions of years

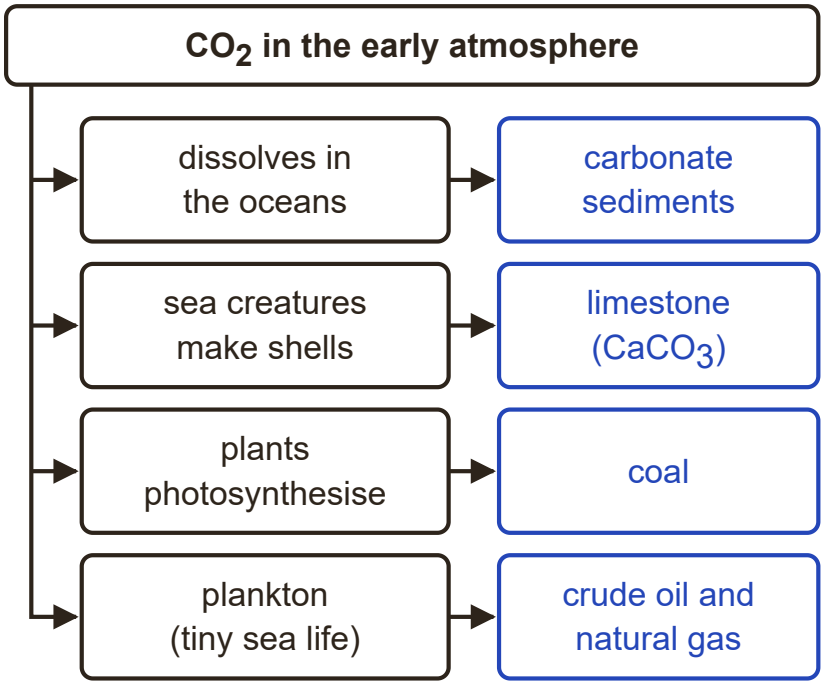
Notes

How carbon dioxide was removed

- The early atmosphere was mainly carbon dioxide. Today carbon dioxide is only about 0.04% of the air.
- **Dissolving in the oceans**: carbon dioxide dissolved and carbonates were precipitated, forming sediments.
- **Photosynthesis**: algae and plants took in carbon dioxide and gave out oxygen.
- **Sedimentary rocks**: carbon was locked up in rocks such as **limestone** (mainly calcium carbonate, $CaCO_3$).
- **Fossil fuels**: carbon was locked up in **coal**, **crude oil** and **natural gas**.

How the deposits formed

- **Limestone**: many sea creatures make shells and skeletons of calcium carbonate. When they died, these settled on the sea bed, were buried under more sediment and were compressed into limestone over millions of years.
- **Coal**: formed from the remains of plants, mainly trees in ancient swampy forests. They were buried before they could fully decay, then compressed over millions of years.
- **Crude oil and natural gas**: formed from the remains of **plankton** (tiny sea organisms) that were buried in mud on the sea bed. Heat and pressure over millions of years, with little or no oxygen, changed them into crude oil and natural gas.

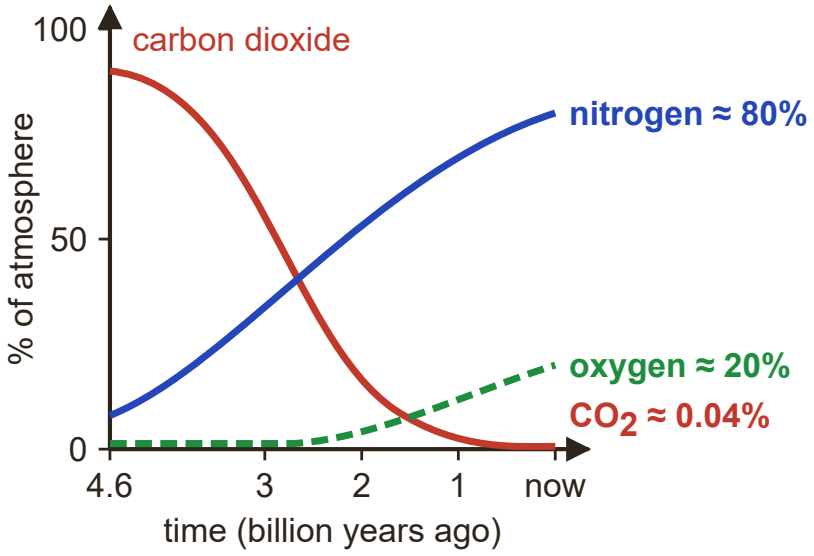


Buried and compressed over millions of years, the carbon was locked away in rocks and fossil fuels.

- Why this removed carbon dioxide: the carbon in these organisms came from carbon dioxide (taken in by photosynthesis, or dissolved in sea water). Burying their remains locked that carbon away for millions of years.

The main changes over time

- **Carbon dioxide**: from most of the atmosphere to about 0.04%, because of dissolving in the oceans, photosynthesis, and the formation of sedimentary rocks and fossil fuels.
- **Oxygen**: from little or none to about 20%, because of photosynthesis by algae and then plants.
- **Nitrogen**: released by volcanoes and gradually built up to about 80%. Nitrogen is very unreactive, so it stayed in the atmosphere.
- **Water vapour**: most of it condensed to form the oceans.



Sketch of one theory, not to scale.

How to answer each type of question

Give ways that carbon dioxide decreased 2 marks **Grade 4**

1. Choose two DIFFERENT processes from: dissolving in the oceans, photosynthesis, sedimentary rocks, fossil fuels.
2. Name the organisms or rock where you can, e.g. 'photosynthesis by algae and plants'.

Example. Give **two** processes that reduced the percentage of carbon dioxide in the Earth's early atmosphere.

Model answer.

Any two from:

photosynthesis by algae and plants	(1)
carbon dioxide dissolving in the oceans / carbonates precipitating as sediments	(1)
formation of sedimentary rocks such as limestone	(1)
formation of fossil fuels such as coal	(1)

Describe how a deposit formed

2 to 3 marks | **Grade 6**

1. Name the organisms: plants for coal, plankton for crude oil and natural gas, shells and skeletons of sea creatures for limestone.
2. Say where they were buried: in swamps for coal, in mud on the sea bed for crude oil and natural gas.
3. Add the conditions and time: compressed, or heat and pressure, over millions of years.

Example. Describe how crude oil was formed.

Model answer. Plankton died (1) and their remains were buried in mud on the sea bed (1). Over millions of years, heat and pressure changed the remains into crude oil (1).

Explain how forming rocks or fuels removed carbon dioxide

2 marks | **Grade 7**

1. Trace the carbon back to carbon dioxide (photosynthesis, or carbon dioxide dissolved in sea water).
2. Say that burying the remains locked the carbon away for millions of years.

Example. Limestone is a sedimentary rock made mainly of calcium carbonate.
Explain how the formation of limestone reduced the amount of carbon dioxide in the atmosphere.

Model answer. Sea creatures used carbon dioxide dissolved in sea water to make shells and skeletons of calcium carbonate (1). When they died, the shells and skeletons were buried and compressed into limestone, locking the carbon away in rock for millions of years (1).

6-mark: describe how the atmosphere changed over time 6 marks (level of response) **Grade 5**

1. Plan a timeline first: volcanoes → oceans → algae → plants → rocks and fuels → today.
2. For each change, give the cause straight after it (use 'because' or 'by').
3. Include numbers where you can: 4.6 billion years, 2.7 billion years, 200 million years, 80% nitrogen, 20% oxygen.
4. Finish with today's atmosphere.

Example. Describe how the composition of the Earth's atmosphere has changed since it first formed. Give the likely causes of the changes.

Model answer.

Model answer: During the Earth's first billion years, intense volcanic activity released gases that formed an atmosphere of mainly carbon dioxide, with little or no oxygen, like Mars and Venus today. Volcanoes also released nitrogen, which gradually built up, possibly small amounts of methane and ammonia, and water vapour, which condensed to form the oceans. Carbon dioxide dissolved in the oceans and carbonates were precipitated as sediments. About 2.7 billion years ago algae began to photosynthesise, which removed carbon dioxide and produced oxygen. Over the next billion years plants evolved and the percentage of oxygen gradually rose until animals could evolve. More carbon dioxide was locked up in sedimentary rocks such as limestone, formed from shells and skeletons, and in fossil fuels formed from buried plants and plankton. For about the last 200 million years the atmosphere has been about 80% nitrogen and 20% oxygen, with small amounts of other gases including about 0.04% carbon dioxide.

Level 3 (5 to 6 marks): the changes to carbon dioxide, oxygen and nitrogen described in a logical order, each linked to its cause.

Level 2 (3 to 4 marks): several changes described, with causes for some of them.

Level 1 (1 to 2 marks): one or two simple statements, e.g. 'carbon dioxide went down' or 'plants made oxygen'.

Don’t lose marks

- Saying crude oil formed from dinosaurs or other large animals. It formed from plankton.
- Saying coal formed from sea creatures. Coal formed from plants.
- Saying carbon dioxide 'turned into' oxygen. Photosynthesis uses carbon dioxide and water to make glucose and oxygen.
- Leaving out the time scale and conditions: 'millions of years' and 'heat and pressure' are often marking points.
- In 6-mark answers, listing changes without their causes, or writing them out of order.

More tips

Memory tricks

- Where did the CO_2 go? 'Dissolved, Photosynthesised, locked in Rocks and Fuels'.
- Coal from trees (on land); oil and gas from plankton (in the sea); limestone from shells (in the sea).
- Every lump of coal and piece of limestone is stored carbon from the ancient air. Burning fossil fuels sends it back as CO_2.

Exam technique

- For the 6-mark 'changes over time' question, jot down a quick timeline before you write, then follow it.
- For each deposit, say what the organisms were, where they were buried, and what happened over millions of years.
- Use numbers when you can: about 2.7 billion years, 200 million years, 80% nitrogen, 20% oxygen, 0.04% carbon dioxide.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Name a process that removed carbon dioxide**
Photosynthesis by algae and plants took carbon dioxide out of the atmosphere.

Grade 4 — **Name rocks and fuels that lock up carbon**
Sedimentary rocks such as limestone, and the fossil fuels coal, crude oil and natural gas.

Grade 5 — **Describe how limestone formed**
Shells and skeletons of sea creatures, made of calcium carbonate, settled, were buried and were compressed into rock.

Grade 5 — **Describe how coal formed**
Remains of plants, mainly trees, were buried and compressed over millions of years.

Grade 5 — **Describe the atmosphere's main changes and causes**
Write a logically ordered account linking each change in carbon dioxide, oxygen and nitrogen to its cause.

Grade 6 — **Describe how crude oil and natural gas formed**
Remains of plankton buried in mud on the sea bed were changed by heat and pressure over millions of years.

Grade 7 — **Explain how these deposits removed carbon dioxide**
The carbon in the organisms came from carbon dioxide, and burying them locked it away for millions of years.

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