The Earth's early atmosphere

4.9.1.2 · Chemistry of the atmosphere · revision notes

One theory of how the Earth's first atmosphere and the oceans formed, what the early atmosphere contained, and why scientists cannot be certain about it. Expect recall and 'describe' questions, and questions where you use data you are given to interpret evidence and evaluate theories.

Key facts

- Age of the Earth: about 4.6 billion years
- Early atmosphere: mainly carbon dioxide, little or no oxygen (like Mars and Venus today)
- Oceans: water vapour from volcanoes condensed
- Evidence is limited because of the time scale of 4.6 billion years
- First billion years: intense volcanic activity released the gases
- Also nitrogen (built up gradually), and maybe small proportions of methane and ammonia
- Carbon dioxide dissolved in the oceans → carbonates precipitated → sediments

Notes

How the early atmosphere formed (one theory)

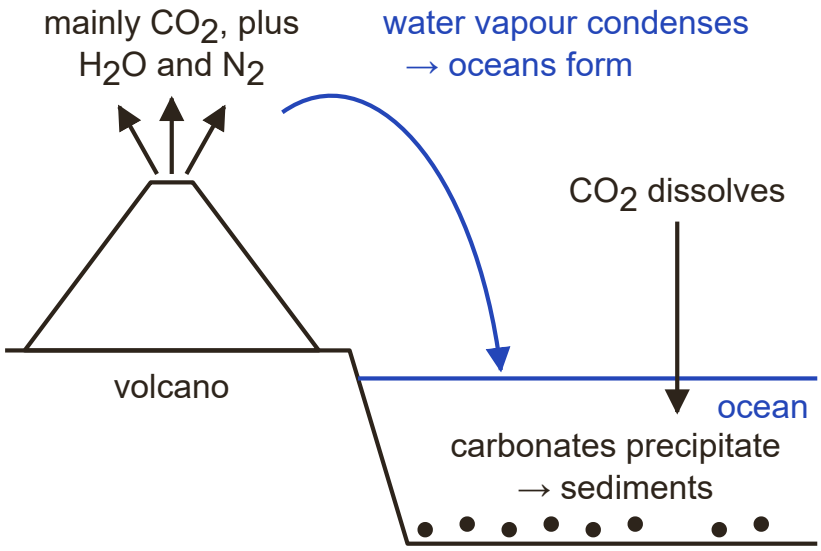
- The Earth is about **4.6 billion years** old.
- One theory suggests that during the **first billion years** of the Earth's existence there was **intense volcanic activity**. The volcanoes released the gases that formed the early atmosphere.
- Volcanoes also released **water vapour**, which **condensed** to form the **oceans**.
- You only need to know this one theory, but you may be given information about others and asked to compare them.

What the early atmosphere contained

- At the start of this period the atmosphere may have been like the atmospheres of **Mars and Venus** today: **mainly carbon dioxide**, with **little or no oxygen**.
- Volcanoes also produced **nitrogen**, which gradually built up in the atmosphere.
- There may also have been small proportions of **methane**, CH_4, and **ammonia**, NH_3.

The first fall in carbon dioxide

- When the oceans formed, carbon dioxide **dissolved** in the water.
- **Carbonates** were then **precipitated** (formed as insoluble solids) and settled to produce **sediments**.



Volcanic gases formed the early atmosphere; the oceans then took up some carbon dioxide.

- This reduced the amount of carbon dioxide in the atmosphere.

Why scientists are not certain

- Theories about the early atmosphere have changed and developed over time as new evidence has been found.
- Evidence is **limited** because of the huge time scale of **4.6 billion years**: no one was there to measure the atmosphere, and very little rock from that time survives unchanged.
- Scientists rely on indirect evidence, such as the chemicals in very old rocks, the gases that volcanoes release today, and comparisons with other planets.
- To evaluate a theory: say which evidence supports it, which evidence does not, and why the evidence is uncertain (for example, it is indirect or comes from only a few samples). Then give a conclusion.

How to answer each type of question

Recall and describe: the early atmosphere and the oceans 1 to 3 marks **Grade 4**

1. Main gas: carbon dioxide. Where it came from: volcanoes.
2. For the oceans, give the source (water vapour from volcanoes) and the process (it condensed).

Example. (a) Name the main gas in the Earth's early atmosphere.
(b) Describe how the oceans formed.

Model answer.

(a) Carbon dioxide (1)

(b) Volcanoes released water vapour (1), which condensed to form the oceans (1)

Explain how the oceans reduced carbon dioxide 2 marks **Grade 5**

1. Say that carbon dioxide dissolved in the ocean water.
2. Say that carbonates were precipitated and formed sediments, so the carbon was removed from the atmosphere.

Example. Explain how the formation of the oceans reduced the amount of carbon dioxide in the Earth's early atmosphere.

Model answer. Carbon dioxide from the atmosphere dissolved in the ocean water (1). Carbonates were precipitated and settled as sediments, so the carbon was locked away and not returned to the atmosphere (1).

Explain why evidence is limited 2 marks **Grade 6**

1. Link your answer to the time scale: about 4.6 billion years.
2. Give a second, different reason, e.g. no direct measurements, or little unchanged rock survives.

Example. Scientists are not certain what the Earth's early atmosphere contained.
Give **two** reasons why.

Model answer.

Any two from:

it existed billions of years ago / about 4.6 billion years ago (1)

no one was there to measure it / no samples of it exist (1)

very little rock from that time survives unchanged, so there is little evidence (1)

Interpret evidence and evaluate a theory

3 to 4 marks | Grade 7

1. Quote data from the table or text you are given.
2. Link each piece of data to a part of the theory it supports.
3. Give at least one limitation of the evidence.
4. Finish with a conclusion: does the evidence support the theory, and how strongly?

Example. The table shows the approximate percentages of the gases released by a volcano today.

Gas	Percentage (%)
water vapour	60
carbon dioxide	25
sulfur dioxide	10
nitrogen	3
other gases	2

A scientist says this is evidence for the theory that the Earth's early atmosphere formed from volcanic gases.
Evaluate the scientist's claim.

Model answer. Volcanoes release a large percentage of carbon dioxide (25%), which fits an early atmosphere that was mainly carbon dioxide (1). They release a lot of water vapour (60%), which could have condensed to form the oceans, leaving carbon dioxide as the main gas (1). They release nitrogen (3%), which could have built up gradually (1). However, volcanoes today may not release the same gases as volcanoes billions of years ago, so this evidence supports the theory but does not prove it (1).

Don’t lose marks

- Saying the early atmosphere was mainly oxygen or nitrogen. It was mainly carbon dioxide with little or no oxygen.
- Saying the oceans formed from 'rain' without saying that water vapour from volcanoes condensed.
- Saying carbon dioxide 'turned into' the oceans. It dissolved in the oceans, and carbonates were precipitated as sediments.
- Giving vague reasons for uncertainty such as 'they don't know'. Say why: the time scale, no direct measurements, little evidence survives.
- Getting the order wrong: volcanoes and carbon dioxide came first, and oxygen appeared only much later, after algae evolved.

More tips

Memory tricks

- Story in one line: volcanoes → gases (mainly CO_2) → water vapour condenses → oceans → CO_2 dissolves → carbonate sediments.
- Early Earth's air was like Mars and Venus today: mostly CO_2, almost no O_2.
- Early gases: 'Cows Never Make Any Waves': Carbon dioxide (most), Nitrogen, Methane, Ammonia, Water vapour.
- Why uncertain? Think TIME: 4.6 billion years ago, no one there to measure, rocks since changed.

Exam technique

- When you are given data about Mars and Venus, or about volcanic gases, quote the numbers in your answer.
- 'Evaluate' means give evidence for and against, then a conclusion.
- Use the key words examiners look for: volcanic activity, condensed, dissolved, precipitated, sediments.
- Only one theory is on the specification, so answer using it unless the question gives you information about another.

What each grade needs

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

Grade 3

Say where the early atmosphere came from

Intense volcanic activity during the Earth's first billion years released the gases that formed it.

Grade 4

Name the main gas in the early atmosphere

It was mainly carbon dioxide with little or no oxygen, like the atmospheres of Mars and Venus today.

Grade 4

Describe how the oceans formed

Water vapour released by volcanoes condensed to form the oceans.

Grade 5

Name other gases in the early atmosphere

Nitrogen from volcanoes gradually built up, and there may have been small proportions of methane and ammonia.

Grade 5

Explain how the oceans removed carbon dioxide

Carbon dioxide dissolved in the oceans and carbonates were precipitated, forming sediments.

Grade 6

Explain why evidence about it is limited

The time scale is about 4.6 billion years, so no one could measure it and little evidence survives.

Grade 7

Use given evidence to evaluate a theory

Say which evidence supports the theory, which does not, and why the evidence is uncertain, then give a conclusion.

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