How oxygen increased

4.9.1.3 · Chemistry of the atmosphere · revision notes

How algae and then plants produced the oxygen in today's atmosphere by photosynthesis, and how this allowed animals to evolve. Expect the word equation for photosynthesis, the key dates, and 'describe' or 'explain' questions, sometimes as part of a 6-mark answer on how the atmosphere has changed.

Key facts

- Photosynthesis: carbon dioxide + water → glucose + oxygen (light needed)
- Algae first produced oxygen about 2.7 billion years ago
- Enough oxygen → animals could evolve
- Oxygen today: about 20% of the atmosphere
- Grade 7+ only $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
- Over the next billion years: plants evolved and oxygen gradually increased
- Photosynthesis adds O_2 AND removes CO_2

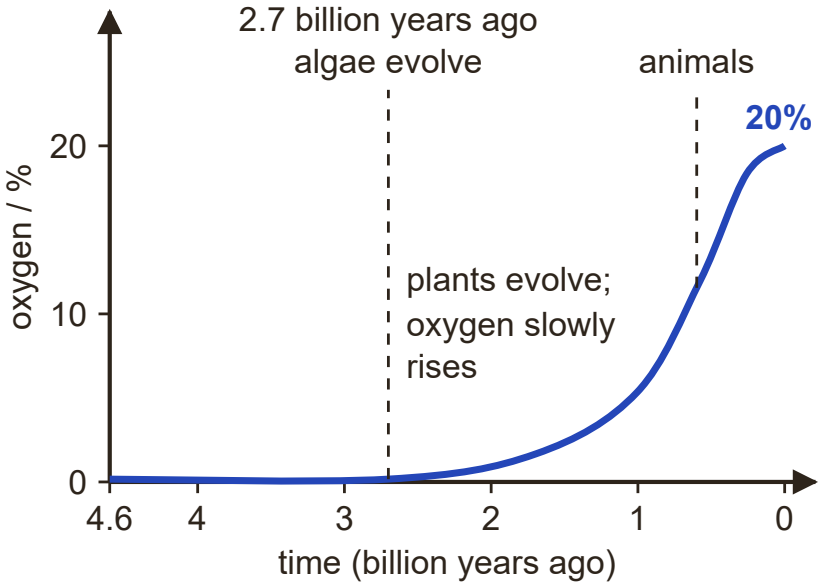
Notes

Photosynthesis made the oxygen

- The oxygen in today's atmosphere was produced by **algae and plants** through **photosynthesis**.
- Word equation: **carbon dioxide + water** → **glucose + oxygen**. Light is needed, so write 'light' above the arrow.
- Balanced symbol equation: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$. Check: 6 C, 12 H and 18 O atoms on each side. Grade 7+ only
- Photosynthesis **adds oxygen** to the atmosphere and **removes carbon dioxide** from it at the same time.
- An aquatic plant such as pondweed gives off bubbles of gas in daylight. The gas relights a glowing splint, which shows it is oxygen.

The timeline

- The early atmosphere had **little or no oxygen**.
- **Algae** first produced oxygen about **2.7 billion years ago**. Soon after this, oxygen appeared in the atmosphere.
- Over the **next billion years**, **plants evolved** and the percentage of oxygen **gradually increased**.
- Eventually the percentage of oxygen was high enough for **animals to evolve**. Animals need oxygen for respiration.



Sketch, not to scale: photosynthesis slowly raised oxygen to about 20%.

- Today oxygen is about 20% of the atmosphere, and the proportions of the gases have been much the same for about 200 million years.

Putting it in order

- Volcanoes release mainly carbon dioxide → algae evolve and photosynthesise → oxygen appears in the atmosphere → plants evolve → oxygen gradually increases → animals evolve.
- The increase was very slow: it took hundreds of millions of years.
- The dates are estimates, worked out from evidence in very old rocks and fossils.

How to answer each type of question

Complete the word equation for photosynthesis

1 to 2 marks | Grade 4

1. Reactants: carbon dioxide and water. Products: glucose and oxygen.
2. Use names, not formulae, when the question asks for a word equation.

Example. Complete the word equation for photosynthesis.
carbon dioxide + _____ → glucose + _____

Model answer.

water (1)
oxygen (1)

Describe how the percentage of oxygen increased

3 to 4 marks | Grade 5

1. Start with who: algae, by photosynthesis.
2. Add when: about 2.7 billion years ago.
3. Then plants evolved over the next billion years and oxygen gradually increased.
4. Finish with the result: enough oxygen for animals to evolve.

Example. The Earth's early atmosphere had little or no oxygen.
Describe how the percentage of oxygen in the atmosphere increased.

Model answer. Algae evolved and produced oxygen by photosynthesis (1), starting about 2.7 billion years ago (1). Over the next billion years plants evolved and the percentage of oxygen gradually increased (1), until there was enough oxygen for animals to evolve (1).

Explain how living things changed the atmosphere

3 to 5 marks | Grade 7

1. Name the process: photosynthesis.
2. Give BOTH effects: carbon dioxide used up, oxygen released.
3. For animals, link to their need for oxygen for respiration.

Example. (a) Explain how the evolution of algae changed the composition of the atmosphere.
(b) Suggest why animals evolved only after plants had existed for a long time.

Model answer.

(a) Algae photosynthesised (1). This used carbon dioxide, so the percentage of carbon dioxide in the atmosphere decreased (1), and released oxygen, so the percentage of oxygen increased (1).
(b) Animals need oxygen for respiration (1), and it took a long time for photosynthesis to raise the percentage of oxygen to a high enough level (1).

Balance the symbol equation for photosynthesis

1 mark | Grade 7

1. Glucose, $C_6H_{12}O_6$, has 6 C, so put 6 in front of CO_2.
2. It has 12 H, so put 6 in front of H_2O.
3. Count O on the left (12 + 6 = 18) and balance the O_2 on the right: 18 − 6 = 12 atoms, so $6O_2$.

Example. Balance the equation for photosynthesis.
$__CO_2 + __H_2O \rightarrow C_6H_{12}O_6 + __O_2$

Model answer. $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ (1)

Don't lose marks

- Saying plants produced the first oxygen. Algae came first, about 2.7 billion years ago; plants evolved later.
- Saying the oxygen came from volcanoes. The volcanic early atmosphere had little or no oxygen.
- Writing the photosynthesis equation the wrong way round (that is respiration).
- Adding 'energy' as a product of photosynthesis. Light energy is taken in, so write 'light' above the arrow.
- Mixing up billion and million: algae about 2.7 billion years ago, today's proportions for about 200 million years.

More tips

Memory tricks

- Order of life: A-P-A, Algae, then Plants, then Animals.
- Balance photosynthesis with 'six, six, one, six'.
- Photosynthesis is the reverse of respiration: swap the two sides of the word equation.
- One process, two effects: photosynthesis puts O_2 in and takes CO_2 out.

Exam technique

- In 'describe how oxygen increased' answers, give the organisms, the process and the time scale.
- If asked for a word equation, don't write formulae; if asked for a balanced symbol equation, don't write words.
- In 6-mark questions on the history of the atmosphere, link each change to its cause, e.g. 'oxygen increased because algae and plants photosynthesised'.

What each grade needs

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

Grade 3 — **Name the process that produced the oxygen**
Photosynthesis by algae and plants produced the oxygen that is now in the atmosphere.

Grade 4 — **Write the word equation for photosynthesis**
carbon dioxide + water → glucose + oxygen, with light as the energy source.

Grade 5 — **State when algae first produced oxygen**

Algae first produced oxygen about 2.7 billion years ago, and oxygen appeared in the atmosphere soon after.

Grade 5 **Describe how the percentage of oxygen increased**

Over the next billion years plants evolved and oxygen gradually increased to a level that let animals evolve.

Grade 5 **Explain two effects of photosynthesis on air**

Photosynthesis adds oxygen to the atmosphere and removes carbon dioxide from it at the same time.

Grade 7 **Balance the symbol equation for photosynthesis**

The balanced equation is $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$.

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