2.28 The Atmosphere: Evolution and Greenhouse Gases: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

Piecing Together Earth's Early Atmosphere

Original text written for Revision Library.

The atmosphere that surrounds the Earth today, roughly four-fifths nitrogen and one-fifth oxygen, took billions of years to form, and scientists cannot observe this ancient history directly. Instead, the widely accepted theory is pieced together from indirect evidence: the composition of gases released by volcanoes today, the chemistry of very old rocks, and the fossil record of early life. During the Earth's first billion years, intense volcanic activity is thought to have released huge quantities of gas, forming an early atmosphere dominated by carbon dioxide, with little or no oxygen, alongside water vapour and nitrogen. As the young planet gradually cooled, water vapour condensed to form the oceans, into which much of the atmospheric carbon dioxide subsequently dissolved. Over enormous timescales, this dissolved carbon dioxide was converted into insoluble carbonates that settled as sediment, eventually forming sedimentary rocks such as limestone; later still, the buried remains of dead organisms were converted into the fossil fuels that lock away yet more carbon today. A second major change began around 2.7 billion years ago, when algae evolved in the oceans and began to photosynthesise, followed much later by plants on land. Because this process removes carbon dioxide and releases oxygen, it is thought to be the main reason oxygen levels climbed towards the 21% seen today, eventually allowing a protective ozone layer to form and enabling animal life to leave the oceans. Because these events happened so long ago and left only fragmentary evidence, scientists acknowledge considerable uncertainty over the precise timing and gas percentages involved at each stage, and the model continues to be refined as new evidence is found.

1 This question is about the composition of the Earth's atmosphere today.

(a) Which of these percentages is closest to the proportion of nitrogen gas in the Earth's atmosphere today? **(1)**

- ☐ A) 21%
- ☐ B) 78%
- ☐ C) 95%
- ☐ D) 0.04%

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(b) Which of these percentages is closest to the proportion of oxygen gas in the Earth's atmosphere today? **(1)**

- ☐ A) 0.04%
- ☐ B) 21%
- ☐ C) 50%
- ☐ D) 78%

(c) Name the gas that makes up almost all of the remaining 'other gases' fraction (about 0.9%) of dry air today, and state whether this gas is reactive or unreactive. **(2)**

(Total for Question 1 is 4 marks)

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2 The table below gives estimated percentages of three gases in the Earth's atmosphere at four points in its history. (Values are approximate; water vapour, also present throughout Earth's history, is not included in this table.)

Time (billion years ago): 4.6	2.7	1.0	0.2
Carbon dioxide (%): 95	40	5	0.04
Oxygen (%): 0	trace	10	21
Nitrogen (%): 4	10	60	78

(a) State the overall trend shown by the table for the percentage of carbon dioxide as time passed, from 4.6 billion years ago to today. **(1)**

(b) State the overall trend shown by the table for the percentage of oxygen over the same period. **(1)**

(c) Calculate the percentage decrease in carbon dioxide between 4.6 billion years ago and 1.0 billion years ago. Give your answer to 1 decimal place. **(2)**

.....

(d) Suggest which biological process most likely explains the rise in oxygen levels between 2.7 billion years ago and 1.0 billion years ago. **(1)**

.....

(Total for Question 2 is 5 marks)

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3 A sealed sample of dry air has a volume of 500 cm^3.

(a) Assuming this sample contains 21% oxygen gas by volume, calculate the volume of oxygen gas in the sample. **(2)**

.....

(Total for Question 3 is 2 marks)

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4 Higher tier only. Some models estimate that atmospheric oxygen rose from about 15% to its present-day value of 21% over the final 200 million years of Earth's history.

(a) Calculate the percentage increase in oxygen concentration over this period. Give your answer to 1 decimal place. **(3)**

(Total for Question 4 is 3 marks)

5 Describe how the Earth's atmosphere is thought to have changed from its earliest form to the atmosphere we have today, and evaluate how confident scientists can be in this account.

(Total for Question 5 is 6 marks)

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6 The natural greenhouse effect has existed for billions of years.

(a) Explain why the natural greenhouse effect is essential for life on Earth. **(2)**

(Total for Question 6 is 2 marks)

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7 The five statements below describe key stages in the evolution of the Earth's atmosphere, but they are not in the correct order.

1. Green plants become widespread on land, further increasing the percentage of oxygen.
2. Volcanic activity releases a carbon-dioxide-rich atmosphere containing little or no oxygen.
3. Algae evolve in the oceans and begin to photosynthesise.
4. Water vapour condenses as the Earth cools, forming the oceans.
5. The atmosphere reaches approximately today's composition of 78% nitrogen and 21% oxygen.

(a) Write down the numbers 1 to 5 in the correct chronological order, starting with the earliest stage. **(3)**

(Total for Question 7 is 3 marks)

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Mark scheme · 2.28 The Atmosphere: Evolution and Greenhouse Gases: 30-minute Pack

Question 1

(a) B (78%) **B1**

(a) Answer: B (78%)

(b) B (21%) **B1**

(b) Answer: B (21%)

(c) argon cao **B1**

(c) unreactive/inert (it is a noble gas) oe **B1**

(c) Answer: Argon; it is unreactive (a noble gas)

Question 2

(a) the percentage of carbon dioxide decreased/fell over time oe **B1**

(a) Answer: It decreased over time

(b) the percentage of oxygen increased/rose over time oe **B1**

(b) Answer: It increased over time

(c) (95 - 5) / 95 x 100 oe **M1**

(c) 94.7% cao (accept 94.6-94.8%) **A1**

(c) Answer: 94.7%

(d) photosynthesis (by algae, and later plants) oe **B1**

(d) Answer: Photosynthesis, by algae and later plants

Question 3

(a) 500 x 0.21 oe **M1**

(a) 105 cm^3 cao **A1**

(a) Answer: 105 cm^3

Question 4

(a) (21 - 15) oe = 6 seen **M1**

(a) divides by the original value (15) and multiplies by 100 oe **M1**

(a) 40.0% cao **A1**

(a) Answer: 40.0%

Question 5

Level 3 A detailed and logically sequenced description of how the atmosphere changed, correctly covering its volcanic origin, the formation of the oceans and removal of carbon dioxide, and the role of photosynthesis in raising oxygen levels, together with a clear and well-linked evaluation of the uncertainty in the evidence for this account. **5-6**

Level 2 Accurate description of at least two or three stages in the change of the atmosphere, with some correct detail, and some comment (which may be limited or generic) on the uncertainty of the evidence. **3-4**

Level 1 Basic, isolated statements about how the atmosphere has changed, with little or no reference to the strength or limitations of the evidence. **1-2**

Level 0 No relevant content. **0**

Indicative content:

- The early atmosphere formed from gases released by volcanic activity and is thought to have been mostly carbon dioxide, with little or no oxygen, alongside water vapour and nitrogen.
- As the Earth cooled, water vapour condensed to form the oceans.
- Much of the atmospheric carbon dioxide dissolved into the oceans and was converted into carbonates that formed sedimentary rock such as limestone; carbon was later also locked away in fossil fuels.
- Algae evolved around 2.7 billion years ago and began photosynthesising, followed later by land plants, removing carbon dioxide and releasing oxygen.
- This gradually decreased carbon dioxide to about 0.04% and increased oxygen to about 21%, allowing an ozone layer to form and block harmful UV radiation.
- Nitrogen gas, being largely unreactive, gradually built up to around 78% of the atmosphere.
- Evaluation: because these events happened billions of years ago, scientists rely on indirect evidence such as rock chemistry, present-day volcanic gases and the fossil record rather than direct measurement, so there is significant uncertainty about the exact timings and percentages involved, and the model continues to be refined as new evidence is found.

Question 6

(a) without the greenhouse effect, the Earth's average surface temperature would be much lower/far too cold oe **B1**

(a) the natural greenhouse effect keeps the Earth at a temperature suitable to support liquid water and living organisms oe **B1**

(a) Answer: Without it, the Earth would be far too cold for life; the natural greenhouse effect keeps the planet at a temperature suitable for liquid water and living organisms

Question 7

(a) 2 and 4 correctly placed as the first two stages, in this order **B1**

(a) 3 correctly placed before 1 **B1**

(a) fully correct order: 2, 4, 3, 1, 5 **B1**

(a) Answer: 2, 4, 3, 1, 5

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