

9.1 Atmospheric proportions, evidence and carbon stores

Name: _____ Class: _____ Date: _____

Total: 26 marks

KEY WORDS photosynthesis • fossil fuel

Objective

Explain changes in the atmosphere using evidence, gas proportions and carbon stores. Original practice with authored marking guidance for 4.9.1.1–4.9.1.4, both tiers. Source questions and official schemes are separate.

1 Key knowledge and worked examples

Today's air is roughly four-fifths nitrogen and one-fifth oxygen, with small amounts of other gases. Use one consistent set of approximate proportions. Modern dry-air figures of about 78% and 21% leave about 1% for the other gases; this is not all CO₂.

The early **atmosphere** is inferred from limited evidence over 4.6 billion years. One theory links it to volcanoes: mainly CO₂, water vapour and nitrogen, with little/no oxygen. Ancient ice is not a record of the first atmosphere. Cooling → water **condenses** → oceans; CO₂ dissolves and carbonates form sediments.

Photosynthesis by algae began producing oxygen about 2.7 billion years ago. Later plants also removed CO₂ and released O₂. **Limestone** stores carbonate; coal forms from buried plants; oil/gas mainly from buried small marine organisms over millions of years. Burial stores carbon outside the air but not literally forever.

Worked proportion. For 300 cm³ air at fixed temperature/pressure, use the syllabus fractions:

$$V(\text{N}_2) = \frac{4}{5}V = \frac{4}{5} \times 300 \text{ cm}^3 = 240 \text{ cm}^3$$

$$V(\text{O}_2) = \frac{1}{5}V = 60 \text{ cm}^3$$

Worked explanation. Photosynthesis removes CO₂ to make biomass and releases O₂. Some remains are buried before full decay; later fossil-fuel formation stores that carbon. Do not claim photosynthesis directly makes coal or supplies nitrogen.

2 Practice

2.1 Name the process that raised atmospheric oxygen. [1]

2.2 What happened to most early water vapour as Earth cooled? [1]

2.3 Give today's two main gases with their approximate proportions. [2]

2.4 A 500 cm³ air sample is represented by 78% nitrogen, 21% oxygen and 1% other gases. Calculate the nitrogen volume and the volume of other gases, at unchanged temperature/pressure. [3]

3 Exam-style questions

3.1 Give two reasons why scientists cannot be certain of the first atmosphere's exact composition. [2]

3.2 Describe two processes that lowered atmospheric carbon dioxide. Explain how each removes or stores carbon. [4]

3.3 Explain the oceans' role in the change from the early atmosphere. Include their formation and carbon removal. [3]

3.4 Compare the formation of limestone and coal. For each, explain the original carbon-containing material and how it becomes a long-term store. [4]

3.5 Explain how crude oil and natural gas form. A student says they are made instantly when carbon dioxide dissolves in seawater. Correct this statement. [3]

3.6 A report says: "A modern volcano releases CO₂ and steam, so Earth's first atmosphere was exactly 90% CO₂." Evaluate the observation and conclusion. Give one additional kind of evidence that could strengthen a theory, without claiming certainty. [3]

Solutions

Authored marking guidance for these original questions.

2.1 Photosynthesis.

2.2 Water vapour condensed into liquid water, forming oceans; not evaporation or freezing CO₂.

2.3 Nitrogen about four-fifths/78–80%, oxygen about one-fifth/20–21%. State approximations consistently.

2.4 $V = fV_{\text{total}}$ and divide percentages by 100; $V(\text{N}_2) = 0.78 \times 500 = 390 \text{ cm}^3$; other gases = $0.01 \times 500 = 5 \text{ cm}^3$. Oxygen would be 105 cm^3 ; all three total 500 cm^3 . Do not label the 5 cm^3 entirely CO₂.

3.1 The events were billions of years ago, with no direct measurements; evidence is limited and materials/processes have changed over that time, so inference is indirect. Modern other-planet/volcanic observations can support a theory; ancient ice does not sample the first atmosphere.

3.2 Any two linked routes, two marks each: CO₂ dissolves in oceans and carbonate sediments remove/store carbon; algae/plants remove CO₂ by photosynthesis and store its carbon in biomass; burial of carbon-containing remains limits return by decay and forms fossil fuels over geological time. Do not double-count one route stated twice.

3.3 Cooling causes water vapour to condense/form oceans; CO₂ dissolves in the oceans, reducing the atmospheric amount; carbonate precipitation/organism shells form sediments/rock storing carbon. Oceans do not directly supply the oxygen increase by evaporation.

3.4 Limestone: calcium carbonate sediments, including marine shells/skeletons, accumulate and become carbonate rock storing carbon. Coal: buried plant remains whose carbon originally came from photosynthesis, compressed/changed over millions of years with limited complete decay. Neither store is literally permanent.

3.5 Mainly small marine organisms supply organic remains; burial under sediments with heat/pressure over millions of years forms oil/gas; CO₂ dissolving alone does not instantly form hydrocarbons, and this omits biological material and geological processing.

3.6 Modern gases support the possibility of volcanic gas release supplying an early atmosphere; one modern observation does not measure an ancient percentage, so the exact 90% conclusion is unsupported; an independent geological/rock record or comparison with other planetary atmospheres could add evidence, with its age/limitations considered. Do not award an invented exact historical percentage.