2.28 The Atmosphere: Evolution and Greenhouse Gases: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 The Earth's surface is warmed by energy transferred from the Sun.

(a) Name the three gases that contribute most to the natural greenhouse effect. **(3)**

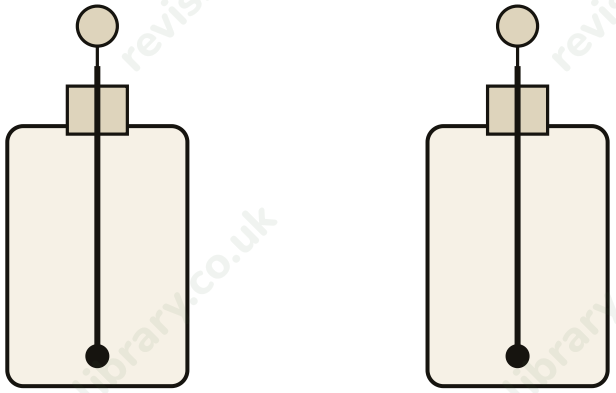
(b) Describe how these gases keep the Earth's surface warmer than it would otherwise be. **(4)**

(Total for Question 1 is 7 marks)

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2 Kwame and Isla investigated how the concentration of carbon dioxide affects the warming caused by the greenhouse effect. They set up two identical gas jars, A and B, each sealed with a rubber bung fitted with a thermometer. Jar A was filled with normal air. Jar B was filled with air containing a higher concentration of carbon dioxide, produced by reacting marble chips with dilute hydrochloric acid and collecting the gas by downward delivery. An identical lamp, representing energy from the Sun, was clamped at the same distance from each jar, and both lamps were switched on at the same time. The temperature inside each jar was recorded every two minutes for ten minutes. Their results are shown below.

Time (minutes): 0	**2**	**4**	**6**	**8**	**10**
Temperature in Jar A, normal air (°C): 20.0	21.0	21.8	22.4	22.8	23.0
Temperature in Jar B, extra carbon dioxide (°C): 20.0	22.0	23.6	24.8	25.6	26.0



Jar A (normal air) Jar B (extra CO_2)

(a) Identify the independent variable and the dependent variable in this investigation. **(2)**

(b) Give one variable, other than the distance of the lamp from the jar, that should be controlled in this investigation. **(1)**

(c) Explain why it is important that the lamp is placed at exactly the same distance from each gas jar. **(2)**

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(d) Suggest one advantage of using a data logger with a temperature probe, rather than reading a thermometer by eye, in this investigation. **(2)**

(e) Calculate the mean rate of temperature increase, in degrees Celsius per minute, for Jar A and for Jar B over the full ten minutes. **(4)**

(f) Use your answers to part (e) to explain what this investigation shows about the effect of carbon dioxide concentration on warming caused by the greenhouse effect. **(2)**

(g) Suggest one way in which this laboratory investigation is a limited model of the real atmosphere and the greenhouse effect. **(2)**

(Total for Question 2 is 15 marks)

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3 Higher tier only. Some estimates suggest the Earth's very early atmosphere contained around 95% carbon dioxide, compared with about 0.04% in today's atmosphere.

(a) Calculate how many times greater the percentage of carbon dioxide was in the early atmosphere compared with today's atmosphere. **(2)**

(Total for Question 3 is 2 marks)

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4 Today's atmosphere is made up of several different gases in fixed approximate proportions.

(a) Name the two gases that together make up about 99% of the Earth's atmosphere today. **(2)**

(b) State the approximate percentage of carbon dioxide in today's atmosphere. **(1)**

(Total for Question 4 is 3 marks)

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5 Earth formed about 4.6 billion years ago. For roughly the first billion years, intense volcanic activity released large amounts of gas, forming the Earth's early atmosphere.

(a) Name the gas that scientists believe made up most of the Earth's early atmosphere. **(1)**

(b) Name two other gases, besides carbon dioxide, that were released into the early atmosphere by volcanic activity. **(2)**

(c) State whether the Earth's early atmosphere is thought to have contained large amounts of oxygen gas. **(1)**

(Total for Question 5 is 4 marks)

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6 Since the Earth's early atmosphere formed, the percentage of carbon dioxide in the atmosphere has fallen enormously, from an estimated 95% to about 0.04% today. Two long-term processes helped to remove this carbon dioxide from the atmosphere.

(a) Describe how the formation of the oceans helped to reduce the amount of carbon dioxide in the atmosphere. **(2)**

(b) Describe how the formation of fossil fuels helped to reduce the amount of carbon dioxide in the atmosphere. **(2)**

(Total for Question 6 is 4 marks)

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7 Carbon capture and storage is proposed to reduce CO_2 in the atmosphere.

(a) State one major challenge for implementing carbon capture and storage on a large scale. **(1)**

(b) Suggest one way to reduce the cost or increase the feasibility of carbon capture. **(1)**

(Total for Question 7 is 2 marks)

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8 Today's atmosphere contains approximately 78% nitrogen and 21% oxygen by volume.

(a) Calculate the ratio of nitrogen to oxygen in today's atmosphere. Give your answer in its simplest whole-number form. **(2)**

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(Total for Question 8 is 2 marks)

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9 Extended response 6 marks. Evaluate whether volcanic eruptions or human burning of fossil fuels are the greater cause of the recent rise in atmospheric carbon dioxide concentration. In your answer consider rates of emission, timescale, and evidence such as isotopes or long-term records.

(Total for Question 9 is 6 marks)

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Mark scheme · 2.28 The Atmosphere: Evolution and Greenhouse Gases: 1-hour Pack

Question 1

(a) water vapour cao **B1**

(a) carbon dioxide cao **B1**

(a) methane cao **B1**

(a) Answer: Water vapour, carbon dioxide and methane

(b) radiation from the Sun (mostly short-wavelength) passes through the atmosphere and is absorbed by the Earth's surface, warming it oe **B1**

(b) the warmed surface re-radiates energy as longer-wavelength infrared radiation oe **B1**

(b) greenhouse gas molecules in the atmosphere absorb this infrared radiation oe **B1**

(b) the greenhouse gases re-radiate this energy in all directions, including back towards the Earth's surface, keeping it warmer oe **B1**

(b) Answer: Short-wavelength radiation from the Sun warms the Earth's surface; the surface re-radiates longer-wavelength infrared radiation, which greenhouse gases absorb and re-radiate in all directions, including back to the surface, keeping it warm

Question 2

(a) independent variable: the concentration of carbon dioxide in the jar (which jar/gas mixture is used) oe **B1**

(a) dependent variable: the temperature inside the jar oe **B1**

(a) Answer: Independent variable: carbon dioxide concentration in the jar. Dependent variable: temperature inside the jar

(b) any one sensible control variable, e.g. starting temperature of the gas in each jar, power/wattage of each lamp, volume of each gas jar, time the lamps are left on oe **B1**

(b) Answer: Any one of: starting temperature, lamp power/wattage, jar volume, time the lamps are switched on

(c) so that each jar receives the same intensity/amount of radiation from the lamp oe **B1**

(c) making it a fair test, so that carbon dioxide concentration is the only factor affecting the temperature change oe **B1**

(c) Answer: So each jar receives the same intensity of radiation, making it a fair test where CO_2 concentration is the only variable affecting the result

(d) can take readings automatically/continuously/more frequently without needing to open the jar (which would disturb the results) oe **B1**

(d) reduces human error in reading and timing the thermometer, e.g. avoids parallax error oe **B1**

(d) Answer: A data logger can take frequent, automatic readings without disturbing the set-up, and avoids human reading/timing errors

(e) Jar A: (23.0 - 20.0) / 10 oe **M1**

(e) Jar A = 0.3°C per minute cao **A1**

(e) Jar B: (26.0 - 20.0) / 10 oe **M1**

(e) Jar B = 0.6°C per minute cao **A1**

(e) Answer: Jar A: 0.3°C/min; Jar B: 0.6°C/min

(f) Jar B, with the higher carbon dioxide concentration, warmed at twice the rate of Jar A (ft from their values in part e) oe **B1**

(f) this supports the idea that increasing the concentration of a greenhouse gas increases the rate/amount of warming caused by the greenhouse effect oe **B1**

(f) Answer: Jar B warmed at twice the rate of Jar A, supporting the idea that a higher greenhouse gas concentration increases the warming caused by the greenhouse effect

(g) any one sensible limitation, e.g. the carbon dioxide concentration used is far higher than in the real atmosphere oe **B1**

(g) further development of the same or another sensible limitation, e.g. a sealed jar traps warmed air and prevents convection in a way the open atmosphere does not, or the investigation only runs for a short time compared with the real, long-term effect on the climate oe **B1**

(g) Answer: For example, the carbon dioxide concentration used is far higher than in the real atmosphere, and the sealed jar prevents convection/heat loss in a way the open atmosphere does not

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Question 3

(a) 95 / 0.04 oe **M1**

(a) 2375 cao (accept awrt 2400, or 2.4 x 10^3) **A1**

(a) Answer: 2375 times greater (approximately 2400)

Question 4

(a) nitrogen cao **B1**

(a) oxygen cao **B1**

(a) Answer: Nitrogen and oxygen

(b) 0.04% (accept any value between about 0.03% and 0.05%) **B1**

(b) Answer: About 0.04%

Question 5

(a) carbon dioxide cao **B1**

(a) Answer: Carbon dioxide

(b) water vapour oe **B1**

(b) nitrogen oe (accept small amounts of methane or ammonia) **B1**

(b) Answer: Water vapour and nitrogen (small amounts of methane and ammonia may also have been present)

(c) no - there was little or no oxygen gas oe **B1**

(c) Answer: No, there was little or no oxygen gas present

Question 6

(a) carbon dioxide dissolved into the oceans oe **B1**

(a) where it was used by marine organisms to form insoluble carbonates (e.g. in shells), which were deposited as sediment and became sedimentary rock such as limestone oe **B1**

(a) Answer: Carbon dioxide dissolved in the oceans and was converted into carbonates (e.g. in shells), which formed sedimentary rock such as limestone

(b) the remains of dead plants and animals were buried oe **B1**

(b) and, over millions of years, were converted into fossil fuels such as coal, crude oil and natural gas, locking the carbon away oe **B1**

(b) Answer: Dead plants and animals were buried and, over millions of years, converted into fossil fuels, locking the carbon away

Question 7

(a) high cost, or storage safety/leak risk, or energy required, accept one **B1**

(a) Answer: High cost of capture and the energy required.

(b) develop cheaper capture materials, use capture at source like power stations, or sell captured CO_2 for industrial use **B1**

(b) Answer: Capture CO_2 at large point sources like power stations and develop cheaper sorbents to reduce cost.

Question 8

(a) 78 : 21 identified and divided by a common factor oe **M1**

(a) 26 : 7 cao **A1**

(a) Answer: 26 : 7

Question 9

Level 3 Detailed evaluation. Candidate compares volcanic and human CO_2 sources, uses evidence on rates and timescale, and reaches a supported conclusion that addresses isotopic or long-term data. **5-6**

Level 2 Some evaluation. Candidate describes both sources and gives some evidence or reasoning but the conclusion is partial or not fully supported. **3-4**

Level 1 Basic statements about volcanic eruptions or fossil fuel burning without comparison or supporting evidence. **1-2**

Indicative content:

- Human burning of fossil fuels emits several billion tonnes of CO_2 per year; volcanic emissions are much smaller in annual CO_2 mass.
- Timescale: human emissions have increased rapidly since the industrial revolution while volcanic eruptions are episodic.
- Isotopic evidence: rise in C-12/C-13 ratio consistent with plant-derived fossil carbon rather than mantle carbon.
- Ice core and atmospheric records show steady increase in CO_2 coincident with industrial activity.
- Volcanoes can affect climate in short term via aerosols causing cooling rather than sustained CO_2-driven warming.
- Conclusion: modern rise in CO_2 is mainly due to human fossil fuel burning, supported by quantitative and isotopic evidence.

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