C9aD The Atmosphere: Evolution and Greenhouse Gases: Exam Drill

Total Marks

AQA 8464 · Calculator allowed · about 90 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Early in Earth history the composition of the atmosphere was very different from today.

(a) Give two gases that were likely abundant in the early atmosphere but are much less abundant today. **(2)**

(Total for Question 1 is 2 marks)

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2 Name one gas that is a major greenhouse gas today and contributes to warming of the atmosphere.

(Total for Question 2 is 1 mark)

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3 Explain how greenhouse gases cause the greenhouse effect in the atmosphere.

(a) Give one statement of how energy from the Sun interacts with Earth and one statement of how greenhouse gases then warm the atmosphere. **(3)**

(Total for Question 3 is 3 marks)

4 Atmospheric carbon dioxide concentration rose from about 280 ppm in pre-industrial times to 410 ppm in recent decades.

(a) Calculate the absolute increase in CO2 concentration in ppm. **(1)**

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(b) Calculate the percentage increase in CO2 concentration from 280 ppm to 410 ppm. Give your answer to three significant figures. **(2)**

.....

(Total for Question 4 is 3 marks)

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5 Expressing concentrations: convert an atmospheric concentration given in ppm into percent by volume.

(a) Convert 410 ppm into percent by volume. Give your answer in percent to three significant figures. **(2)**

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(Total for Question 5 is 2 marks)

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6 Required practical style: investigating the effect of dissolved carbon dioxide on the pH of water using limewater indicator.

(a) Describe a simple experimental method to show that bubbling CO2 into water makes it more acidic. Include the key control variable that must be kept constant. **(2)**

(b) State one improvement to make the results more reliable. **(1)**

(Total for Question 6 is 3 marks)

7 A scientist measures CO2 concentration as 400.0 ppm with an uncertainty of plus or minus 0.5 ppm.

(a) Write the measured value including its uncertainty. **(1)**

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(b) If two measurements are 400.0 ppm ± 0.5 ppm and 400.6 ppm ± 0.5 ppm, state whether these agree within experimental uncertainty and justify your answer briefly. **(2)**

(Total for Question 7 is 3 marks)

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8 Fossil fuels release carbon dioxide when burned. Write the word equation for the complete combustion of methane.

(Total for Question 8 is 2 marks)

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9 Carbon capture and storage is proposed to reduce CO2 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 9 is 2 marks)

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10 A sample of air contains 0.012 moles of carbon dioxide in a 2.00 L container at room temperature. Calculate the concentration in mol per litre (mol L-1).

(a) Calculate the concentration of CO2 in mol L-1. Give your answer to three significant figures. **(3)**

.....

(Total for Question 10 is 3 marks)

11 Acid rain forms when nitrogen oxides and sulfur dioxide react in the atmosphere.

(a) State one consequence of acid rain on buildings or vegetation. **(1)**

(b) Explain why acid rain can damage limestone buildings. **(1)**

(Total for Question 11 is 2 marks)

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12 Sulfur dioxide can be removed from flue gases by reacting with calcium oxide in a scrubber. The reaction is $SO_2 + CaO \rightarrow CaSO_3$.

(a) Calculate the mass of CaO needed to remove 64.0 g of SO_2, assuming complete reaction. Mr: SO_2 = 64.0, CaO = 56.0. Show your working. **(3)**

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(b) State one limitation of assuming complete reaction when designing a scrubber. **(1)**

(Total for Question 12 is 4 marks)

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13 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 13 is 6 marks)

14 A simplified data set shows atmospheric CO2 readings at two sites over five years. Site A: 395, 397, 400, 402, 405 ppm. Site B: 396, 398, 399, 401, 403 ppm.

(a) Calculate the average rate of increase in ppm per year at Site A over the five year period. Show your working. **(2)**

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(b) State which site shows a more consistent year-to-year increase and give one reason from the data to support your answer. **(1)**

(Total for Question 14 is 3 marks)

Mark scheme · C9aD The Atmosphere: Evolution and Greenhouse Gases: Exam Drill

Question 1

- (a) **B1** carbon dioxide
- (a) **B1** water vapour (H2O) or methane or ammonia, accept one of these
- **(a) Answer: Carbon dioxide and water vapour (or methane or ammonia).**

Question 2

- **B1** carbon dioxide (CO2) or methane (CH4) or water vapour or nitrous oxide (N2O), accept any one
- **Answer: Carbon dioxide (CO2).**

Question 3

- (a) **B1** shortwave radiation from the Sun reaches Earth and is absorbed by the surface (statement of incoming energy)
- (a) **B1** Earth emits longwave infrared radiation back towards space (statement of outgoing energy)
- (a) **B1** greenhouse gases absorb and re-emit some of the outgoing infrared, causing warming of the lower atmosphere (mechanism)
- **(a) Answer: Sunlight is absorbed at the surface; the Earth emits longwave infrared; greenhouse gases absorb and re-emit some infrared, trapping heat and warming the lower atmosphere.**

Question 4

- (a) **B1** 130 ppm (410 - 280)
- **(a) Answer: 130 ppm**
- (b) **M1** substitutes into percentage change formula: (410 - 280) / 280 x 100
- (b) **A1** 46.4% cao
- **(b) Answer: 46.4%**

Question 5

- (a) **M1** convert ppm to fraction: 410 / 1 000 000 then x 100 to get percent
- (a) **A1** 0.0410% cao
- **(a) Answer: 0.0410%**

Question 6

- (a) **M1** bubble CO2 through a sample of distilled water containing universal indicator or limewater using a syringe or tube and a source of CO2
- (a) **A1** observe the indicator change colour to show lower pH; control variable: keep volume of water and temperature constant (one required)
- **(a) Answer: Bubble CO2 through a measured volume of distilled water containing indicator; observe the indicator turning towards acidic colours. Keep the volume of water and temperature constant.**
- (b) **B1** repeat the experiment and calculate a mean or use a pH probe for continuous pH measurement
- **(b) Answer: Repeat the experiment and take the mean pH, or use a pH probe for more precise readings.**

Question 7

- (a) **B1** 400.0 ppm ± 0.5 ppm
- **(a) Answer: 400.0 ppm ± 0.5 ppm**
- (b) **M1** recognises overlapping ranges: first range 399.5 to 400.5, second range 400.1 to 401.1
- (b) **A1** they overlap (400.1 to 400.5) so the measurements agree within uncertainty
- **(b) Answer: They agree because ranges 399.5 to 400.5 and 400.1 to 401.1 overlap (400.1 to 400.5).**

Question 8

- **B1** methane + oxygen -> carbon dioxide + water
- **B1** equation must represent complete combustion with CO2 and H2O as products
- **Answer: Methane + oxygen -> carbon dioxide + water**

Question 9

- (a) **B1** high cost, or storage safety/leak risk, or energy required, accept one
- **(a) Answer: High cost of capture and the energy required.**
- (b) **B1** develop cheaper capture materials, use capture at source like power stations, or sell captured CO2 for industrial use
- **(b) Answer: Capture CO2 at large point sources like power stations and develop cheaper sorbents to reduce cost.**

Question 10

- (a) **M1** substitutes concentration = moles / volume: 0.012 / 2.00
- (a) **A1** 0.00600 mol L-1 cao
- (a) **B1** unit stated as mol L-1 or mol per litre
- **(a) Answer: 0.00600 mol L-1**

Question 11

- (a) **B1** damage to limestone buildings or corrosion of metal or harm to freshwater ecosystems or damage to leaves
- **(a) Answer: Damage to limestone buildings (etching) or harm to plants and freshwater life.**
- (b) **B1** acid reacts with calcium carbonate in limestone to form soluble calcium compounds that wash away, causing erosion
- **(b) Answer: Acid reacts with calcium carbonate in limestone to form soluble compounds that are washed away, causing erosion.**

Question 12

- (a) **M1** calculate moles of SO2: 64.0 / 64.0 = 1.00 mol
- (a) **M1** use 1:1 stoichiometry so moles CaO = 1.00
- (a) **A1** mass of CaO = 1.00 x 56.0 = 56.0 g cao
- **(a) Answer: 56.0 g**
- (b) **B1** reaction may be incomplete, some SO2 may pass through; impurities; mass transfer limitations
- **(b) Answer: In reality the reaction may be incomplete so some SO2 will remain; this affects the amount of CaO required.**

Question 13

- **Level 3** (5-6): Detailed evaluation. Candidate compares volcanic and human CO2 sources, uses evidence on rates and timescale, and reaches a supported conclusion that addresses isotopic or long-term data.
- **Level 2** (3-4): Some evaluation. Candidate describes both sources and gives some evidence or reasoning but the conclusion is partial or not fully supported.
- **Level 1** (1-2): Basic statements about volcanic eruptions or fossil fuel burning without comparison or supporting evidence.
- **Indicative content:**
  - Human burning of fossil fuels emits several billion tonnes of CO2 per year; volcanic emissions are much smaller in annual CO2 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 CO2 coincident with industrial activity.
  - Volcanoes can affect climate in short term via aerosols causing cooling rather than sustained CO2-driven warming.
  - Conclusion: modern rise in CO2 is mainly due to human fossil fuel burning, supported by quantitative and isotopic evidence.

Question 14

- (a) **M1** calculate change: 405 - 395 = 10 ppm and divide by number of years 4 (intervals)
- (a) **A1** 2.50 ppm per year cao
- **(a) Answer: 2.50 ppm per year**
- (b) **B1** Site A is more consistent because its yearly changes are mostly +2 or +3 ppm while Site B has a year with +1 ppm (399 from 398) showing more variability, or vice versa with explanation
- **(b) Answer: Site A is more consistent; its increases are steady (e.g. mainly +2 to +3 ppm) whereas Site B includes a smaller step of +1 ppm, showing more variability.**