

9.2 Greenhouse mechanism, climate evidence and carbon footprints

Name: _____ Class: _____ Date: _____

Total: 34 marks

KEY WORDS greenhouse gas • global climate change

Objective

Explain the greenhouse mechanism, evaluate climate evidence and compare full-service footprints. Original practice and authored marking guidance for 4.9.2.1–4.9.2.4, both tiers. All numerical datasets below are fictional teaching data, not current climate measurements.

1 Key knowledge and worked examples

Greenhouse gases include CO₂, methane and water vapour. Short-wavelength sunlight warms the surface; the surface emits longer-wavelength infrared. These gases absorb some infrared and emit it in all directions, including back to the surface. Some energy escapes. The gases are not a solid lid or mirrors.

Burning fossil fuels and deforestation raise CO₂; cattle farming, landfill decay and rice cultivation can raise methane. **Peer review** checks methods/evidence but does not guarantee perfection. Complex climate systems require simplified models; distinguish a long-term trend from one year's weather. Four potential effects are sea-level rise, rainfall change, extreme-weather change and habitat shifts. Explain scale and risk, not just a list.

A **carbon footprint** includes CO₂ and other greenhouse gases over the full life cycle. Compare the same service and boundary, including materials/manufacture, transport, use and disposal. Give both an emission-reduction action and a practical limitation.

Worked footprint, equal service. Given common greenhouse-gas comparison units, option A emits 12+8+60+5=85 kg; B emits 25+10+20+5=60 kg.

$$\% \text{ reduction} = \frac{F_A - F_B}{F_A} \times 100 = \frac{85 - 60}{85} \times 100 \approx 29.4\%$$

B has a lower total despite higher manufacturing emissions. A larger use requirement could change the comparison. Lower footprint does not automatically mean lower water demand or waste.

2 Practice

2.1 Name three greenhouse gases. [3]

2.2 Which radiation do these gases absorb in the greenhouse mechanism: short-wave from the Sun or longer-wave infrared from Earth? [1]

2.3 Give two human activities that raise methane levels. [2]

2.4 Define a carbon footprint. Include the gases and time boundary. [2]

3 Exam-style questions

3.1 Explain the greenhouse effect using radiation entering and leaving the atmosphere. [4]

3.2 A report says CO₂ and temperature rise together, so one graph proves the full climate explanation. Explain the limitation and how scientists strengthen the evidence. [3]

3.3 Give four potential effects of global climate change. For one, explain a consequence for a named type of place or ecosystem. [5]

3.4 Fictional equal-service totals are supplied in kg of a common greenhouse-gas comparison unit. A: manufacture 20, transport 5, use 45, disposal 10. B: manufacture 35, transport 5, use 15, disposal 5. Calculate each total and the percentage reduction by choosing B instead of A. State one assumption needed for the recommendation. [5]

3.5 Report A uses 30 years of global mean measurements with uncertainties, explains its model and has peer review. Report B gives one cold day in one town and no methods, claiming “warming has stopped”. Evaluate the evidence and give one uncertainty that Report A should still discuss. [4]

3.6 A town considers insulating homes and capturing methane from landfill. Explain how each can reduce greenhouse-gas emissions, then give a separate practical limitation for each. Explain why burning captured methane does not mean zero emissions. [5]

Solutions

Authored marking guidance for these original questions.

2.1 Carbon dioxide, methane, water vapour. Nitrogen/oxygen are not these greenhouse gases.

2.2 Longer-wavelength infrared emitted by the warm Earth.

2.3 Any two: cattle farming, decay of organic matter in landfill, flooded rice cultivation. Do not give fossil-fuel combustion as the standard methane answer here.

2.4 Total CO₂ and other greenhouse gases emitted over the full life cycle of a product, service or event. Not just use-stage CO₂.

3.1 Short-wavelength sunlight passes through and warms the surface; surface emits longer-wavelength infrared; greenhouse gases absorb some of it; emit in all directions including towards the surface, keeping it warmer than without them. Some escapes; reflection by a solid layer is not the mechanism.

3.2 Correlation alone cannot exclude a shared cause/chance or establish the complete causal account; measured infrared absorption and other independent observations test the mechanism; evaluation across multiple datasets/studies with peer review is stronger than one graph. Uncertainty does not erase the measured mechanism.

3.3 Sea-level rise, changed rainfall, changed frequency/severity of extreme weather, habitat/species distribution changes; one linked consequence, e.g. low coastal farmland may flood and lose crops. Avoid counting melting ice and sea-level rise as two independent categories here.

3.4 $F_A = 20 + 5 + 45 + 10 = 80$ kg; $F_B = 35 + 5 + 15 + 5 = 60$ kg. Reduction = $F_A - F_B = 20$ kg. Percentage reduction = $(20/80) \times 100 = 25\%$. Assumption: same delivered service/lifetime and stages included, or use estimates represent actual use. B's greater manufacturing emissions alone do not decide the total; dividing by 60 uses the wrong baseline for reduction from A.

3.5 A's global long-term data are more relevant to global climate than one local day's weather; stated methods/uncertainties allow checking and peer review examines reasoning; B's selected day cannot establish a global long-term trend; A should still discuss measurement coverage/uncertainty or future emissions/model/feedback assumptions. Peer review is not a guarantee, and a cold day can occur during a warming trend.

3.6 Insulation reduces heat loss and the heating energy/fossil fuel needed, lowering CO₂; limitation such as initial installation cost or unsuitable buildings. Capturing landfill methane prevents its direct release and may provide useful energy; limitation such as collection cost, leaks or incomplete collection. Burning methane produces CO₂ and water, so emissions are not zero. Give mechanisms and distinct limitations, not "expensive" repeated without context.