4.4 Climate change evidence, causes and effects

Name: _____ Class: _____ Date: _____ **Total: 19 marks**

KEY WORDS dendrochronology • enhanced greenhouse effect • global warming potential • extrapolation

Objective

Practise statements 5.16-5.22 with Core Practical 12: climate-change evidence and its reliability, greenhouse gases and the enhanced greenhouse effect, the carbon cycle, extrapolation of data, and effects of change.

1 Key knowledge and worked examples

■ Four lines of evidence

Direct temperature records (recent, instrumented); ice cores (ancient air bubbles give CO_2 of the past); **dendrochronology** (tree-ring width tracks growing conditions); pollen in peat layers (which plants lived when). Each has a resolution and a reliability limit – name it.

■ The enhanced greenhouse effect

Solar (short-wave) radiation arrives; Earth re-emits long-wave; CO_2, methane and nitrous oxide absorb and re-emit it downward. Differences that matter: **methane** is ~28× CO_2 per kg but lasts ~12 years; **CO_2** lasts centuries; nitrous oxide is potent AND long-lived. **Global warming potential** compares them per kg.

■ Extrapolation

Extending a trend beyond the data assumes the drivers stay the same. Always state the assumption and what would break it.

■ Worked example: comparing two leaks

A farm emits 1 tonne of methane; a power plant 20 tonnes of CO_2, per year. This decade the methane counts as $28 imes 1 = 28$ tonnes CO_2-equivalent – more than the plant's 20. Over a century the methane decays to near zero while the CO_2 mostly remains: short-term ranking $\neq$ long-term ranking.

2 Practice

2.1 Name two greenhouse gases and one source of each. [2]

2.2 Explain how an ice core provides evidence of past atmospheric CO_2. [2]

2.3 State one assumption made when extrapolating a temperature trend to 2100. [1]

3 Exam-style questions

3.1 Describe how greenhouse gases cause warming, making clear the difference between the incoming and outgoing radiation, and explain why the effect is described as enhanced by human activity. [5]

3.2 A graph of global mean temperature from 1880 to 2020 rises about 1.1 °C with decade-to-decade wobbles. A commentator claims a pause between 1998 and 2012 disproves the trend. Explain the weakness of the claim using the ideas of natural variation and trend length. [4]

3.3 Rising temperature speeds the respiration of cold-blooded organisms toward their enzyme optima in polar seas. Explain how this changes the balance of photosynthesis and respiration in those waters, and predict one consequence for the food web. [5]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 CO_2 – burning fossil fuels; methane – cattle/rice paddies/landfill.

2.2 Trapped air bubbles in ancient ice preserve the atmosphere's CO_2 concentration at the time the ice formed; deeper ice is older, giving a dated record.

2.3 The drivers (greenhouse-gas emissions, solar input) continue as in the fitted period.

3.1 Short-wave (visible/UV) solar radiation passes the atmosphere and warms the surface; the warm Earth emits long-wave (infrared) radiation; greenhouse gas molecules absorb this and re-emit it in all directions, including back down. Enhanced because human activity – fossil fuel burning, agriculture, deforestation – has raised greenhouse-gas concentrations above pre-industrial levels, strengthening the effect.

3.2 Natural variation (ocean cycles, volcanoes) wobbles the year-to-year values around the trend; a 14-year window is short compared with the 140-year record and can fall entirely within a wobble; the long-term fit still rises through the same window, so the claim confuses noise with the signal.

3.3 Faster respiration consumes more organic carbon, while photosynthesis in cold water rises less (light and nutrients limit it); the waters shift from net carbon sink toward carbon source; less fixed carbon means less energy for the food web – smaller plankton blooms, fewer fish and their predators.