The greenhouse effect: energy and evidence

Student activity • calculation and evidence workshop

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The question

How can infrared absorption change Earth's energy balance?

Build an annotated radiation model and test common explanations against it. Distinguish the natural greenhouse effect from its enhancement and from the warming of a sealed bottle.

Equipment

- Booklet, coloured pencils and ruler
- Optional reusable arrows/counters; no lamps, sealed bottles or gas generation

No laboratory chemicals, gases or heating. Use reusable model pieces normally and return them after the activity.

Course coverage: Shared core: 2.13. Carbon dioxide as a greenhouse gas; mechanism explained with radiation and energy balance. This is a model/evidence activity, not a gas-heating experiment.

Plan, model or apparatus sketch

Draw the Sun–surface–atmosphere radiation model with labelled arrows.

Method and reasoning

Read the whole sequence before starting

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1. Draw the Sun, surface, atmosphere and space. Use one colour for incoming shortwave solar radiation and another for outgoing longwave infrared radiation.

2. Label reflection separately from absorption. Show the warmed surface emitting infrared and greenhouse gases absorbing and emitting infrared in multiple directions.

3. Explain why emission toward the surface can reduce net energy loss without creating energy. Some infrared still escapes to space; do not draw an impermeable lid.

4. Classify CO_2, CH_4, H_2O vapour and N_2O as greenhouse gases. Compare with N_2 and O_2, which are not significant greenhouse gases in this school model.

5. Use the explicitly invented energy-budget cases: A receives 100 units and loses 100 per time interval; B receives 100 and initially loses 98. Calculate each change in stored energy and explain the direction of temperature change.

6. Critique the claims in the table. Explain why two warm bottles alone do not isolate the atmospheric infrared mechanism and why the ozone hole is a different issue.

Cleanup

- Keep annotated models and return shared materials.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Original toy model: A input/output = 100/100 energy units per interval; B = 100/98 initially. These are invented teaching values, not measured Earth fluxes or a temperature forecast. Natural greenhouse warming is part of Earth's energy system; added long-lived greenhouse gases disturb the balance. Real temperature response also involves feedbacks and ocean heat uptake.

Claim	Accept / revise	Scientific explanation
All infrared is trapped forever		
Greenhouse gases make energy		
A warm bottle proves the mechanism		
Ozone hole causes global warming		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Explain the different roles of incoming shortwave radiation and outgoing infrared radiation.

2. Why is “greenhouse gases reflect all heat back” an inaccurate description?

3. Calculate the net stored-energy change in model cases A and B and interpret it.

4. Name four greenhouse gases and distinguish CO_2 from carbon monoxide.

5. Why does a lamp-and-bottle experiment need more controls before it can support a claim about infrared absorption?

6. Distinguish natural greenhouse warming, an enhanced greenhouse effect and ozone depletion.