Radiative effect of CO□

FizziQ activity · High school · 90 min

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Two chambers under one lamp, one enriched in CO_2: SCD40 sensors track temperature and CO_2 while FizziQ records both curves. High school climate experiment.

Learning objectives

- Design and perform a model experiment with a control
- Measure temperature and CO_2 concentration simultaneously in two chambers
- Observe the enhanced warming of a CO_2-enriched atmosphere
- Critically discuss the limitations of the classroom model
- Understand the difference between the radiative greenhouse effect and convective confinement

Instruments and sensors

CO_2 and temperature logger (FizziQ Connect) · SCD40 sensor (CO_2 concentration in ppm and temperature in °C)

Materials

- Smartphone or tablet with FizziQ Connect
- Two M5 Stack modules with SCD40 sensors
- Two identical transparent containers
- Two bottles of the same soda (one degassed overnight)
- A powerful lamp (halogen preferred)
- Plastic wrap
- Note: the protocol remains adaptable to any comparable CO_2 and temperature data-logging tool.

Protocol

1. The day before, open a bottle of soda and leave it open overnight to let the gas escape completely.
2. On the day of the experiment, prepare a second identical bottle, freshly opened and still carbonated.
3. Equip each M5 Stack module with an SCD40 sensor. Turn them on and verify they display CO_2 (ppm) and temperature (°C).
4. Pour the flat soda into the first container and the carbonated soda into the second. Use identical volumes.
5. Place an SCD40 sensor in each container, above the liquid (not submerged). Cover with plastic wrap to seal.
6. Note the initial CO_2 and temperature values for both chambers. The CO_2 in the carbonated chamber should be much higher.
7. Place both containers side by side, at the same distance from the lamp. Start recording on both modules.
8. Turn on the lamp (halogen preferred for strong infrared emission). Record for 60 to 90 minutes.
9. Stop the recording and export the data from each module in FizziQ Connect.
10. Compare the temperature and CO_2 curves for both chambers. Discuss the results, taking into account the model's limitations.

Expected results

With carbonated soda, the CO_2 in the enriched chamber quickly reaches 40,000+ ppm (sensor saturation), while the flat soda chamber stays at a few hundred ppm. The temperature in the CO_2-enriched chamber rises

1-3°C more than the control after 60-90 minutes. The difference is small but reproducible.

Questions

- Can we conclude that the observed temperature difference is solely due to infrared absorption by CO_2?
- Why are results more convincing with a halogen lamp (more infrared) than an LED lamp?
- What are the limitations of this model compared to the real atmospheric greenhouse effect?
- Why is the term 'greenhouse effect' somewhat misleading?
- How does the enhanced greenhouse effect from human activities differ from the natural greenhouse effect?
- What evidence from satellite data confirms the atmospheric greenhouse effect?

Going further

- Compare results with a halogen lamp (more infrared) and an LED lamp (less infrared)
- Test with Coca-Cola and Fanta to compare CO_2 release rates
- Use dry ice instead of soda for a higher CO_2 concentration
- Record over several hours and compare the thermal equilibrium temperatures
- Add a third chamber with methane (from a lighter refill, with safety precautions) to compare greenhouse gases