CO□ convection under a bell jar

FizziQ activity · Middle and high school · 30 min

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Three CO2 sensors at different heights under a bell jar record how hot combustion gases rise before denser CO2 sinks, logged with FizziQ on smartphone or tablet.

Learning objectives

- Observe the convective transport of hot combustion gases
- Measure CO_2 concentration at three heights simultaneously
- Understand why hot CO_2 rises despite being denser than air at the same temperature
- Identify the chronological sequence of CO_2 arrival at different heights
- Connect the observations to atmospheric convection and gas behavior

Instruments and sensors

CO_2 concentration meter · Temperature logger · SCD40 sensor (CO_2 and temperature)

Materials

- Smartphone or tablet with the FizziQ Connect app
- Three M5 Stack modules with SCD40 sensors
- A large glass bell jar
- A candle
- A vertical support (lab stand)
- Optional: 3 smartphones for simultaneous recording
- Note: the protocol remains adaptable to any comparable gas/temperature data-acquisition tool.

Protocol

1. Prepare three M5 Stack modules, each equipped with an SCD40 sensor. Turn them on and verify each displays CO_2 concentration and temperature.
2. Mount the three modules on a vertical support (lab stand, camera tripod) at three distinct heights: bottom (a few cm from the base), middle (halfway up), and top (near the top of the bell jar).
3. Place the candle at the center of the base, next to the support. The flame should be below the middle sensor.
4. Connect each M5 Stack to FizziQ Connect (you can use three smartphones/tablets, or record sequentially from each module).
5. Note the initial CO_2 and temperature values for all three sensors in ambient air. They should be close to each other.
6. Light the candle, then carefully place the bell jar over the entire setup (candle + support + sensors).
7. Start recording simultaneously on all three modules (or use the REC mode on each M5 Stack).
8. Record for 60 to 80 seconds, until the candle goes out from lack of O_2.
9. Stop the recording and export the data from each module in FizziQ Connect.
10. Superimpose the three $CO_2(t)$ curves and the three temperature(t) curves on the same graph to compare the chronological arrival of CO_2 and heat at each height.

Expected results

The upper sensor detects CO_2 first (up to 18,000 ppm) and the highest temperature (up to 26°C), followed by

the middle sensor (up to 14,000 ppm, 25°C), then the bottom (up to 10,000 ppm, 24°C). After candle extinction, CO_2 gradually redistributes and concentrations begin to equalize. The chronological sequence clearly demonstrates upward convective transport.

Questions

- Why does the upper sensor detect CO_2 first even though CO_2 is denser than air?
- What happens to the CO_2 after it cools at the top of the bell jar?
- How would the results change if the candle were at the top instead of the bottom?
- Why does the candle go out after about a minute under the bell jar?
- What role does convection play in the Earth's atmosphere and weather?
- How is this experiment related to the principle of a hot air balloon?

Going further

- Repeat with the candle at the top of the bell jar and observe the difference in CO_2 distribution
- Use dry ice at the bottom instead of a candle and observe how cold CO_2 behaves differently
- Compare the results with and without the bell jar to see the effect of confinement
- Add a small fan inside the bell jar to disrupt convection and observe the effect on CO_2 distribution
- Use different colored candles and check whether the burn rate or CO_2 production varies