International Young Naturalist’s Tournament

Problem № 10

Greenhouse

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The task

A hot object placed in the open air would gradually cool down. We can slow down this process by containing the object in a greenhouse. Compare different mechanisms of heat loss by the object and explain how the presence of a greenhouse affects them.
Goal

Compare different mechanisms of heat loss by the object and explain how the presence of a greenhouse affects them

Tasks

• Investigate the heat loss due to mechanisms of
  o Convection
  o Conduction
  o Radiation

• Conduct the experiment in lab and outside
Theoretical part
### The greenhouse

**Without greenhouse**
- $T_0$: outer space
- $T_1$: heated object
- Object loses heat

**With greenhouse**
- $T_0$: outer space
- $T_2$: greenhouse
- $T_1$: heated object
- Greenhouse slows down the cooling
- Transparent walls from plastic film
The mechanisms of heat transfer

- **Conduction**: Contact between molecules
- **Convection**: Motion of molecules in liquid or gas
- **Radiation**: Electromagnetic waves
Conduction

\[ Q = kS\Delta T \]

Q – heat loss  
k – coefficient of conductivity  
S - area  
\( \Delta T \) - difference in temperatures

The rate of heat loss due to conduction decreases because the difference of temperature \( T_1 - T_2 < T_1 - T_0 \)
The rate of heat loss due to convection decreases, because structure is not open to the atmosphere, so the warmed air cannot escape.
Radiation

The rate of heat loss due to radiation decreases, because infrared radiation reflects from the plastic-glass walls.

Without greenhouse

With greenhouse

The infrared waves
Experimental part
Equipment

• 4 vessels with covers
• Hot water: \( m = 300 \text{ g} \), \( T_{\text{water}} = 80^\circ\text{C} \)
• Greenhouses
• Black dye
• Thermometer
Laboratory experiment

- Thermometer
- Cover
- Water
- Greenhouse
- Aluminum vessel
The greenhouses

- **The control**
  - 0.2 m x 0.2 m x 0.2 m
  - Transparent polyethylene film
  - Width of the film: 0.1 mm

- **Black polyethylene film**
  - 0.2 m x 0.2 m x 0.2 m
  - Width of the film: 0.1 mm

- **Polypropylene walls**
  - 0.2 m x 0.2 m x 0.2 m
  - Width of the walls: 0.1 mm

- **D = 0.2 m, H = 0.2 m**
  - Polypropylene walls
  - Width of the walls: 0.1 mm
The temperature VS time

Temperature, °C

Time, s

Control
Transparant film
Black film
Plastic cylinder
Black vessels VS reflecting vessels

Black vessel: heat loss due to radiation increases
The temperature VS time

Control
Transparant film
Black film
Plastic cylinder
Black VS Reflecting

- Control (black)
- Control (reflecting)
- Plastic (black)
- Plastic (reflecting)
Real-life experiment

Camera records the thermometer reading

Calorimeter in the greenhouse

Calorimeter in the outer space
The equipment

- Hot water, $m = 300 \text{ g}, T_{\text{water}} = 80^\circ \text{C}$
- 2 calorimeters
- greenhouse:
  - Length=1,5 m
  - Height=0,85 m
  - Width=1m
  - material
- Thermometer
- Camera
Experimental process

- 2 calorimeters with hot water are placed:
  - One in the greenhouse
  - Other near the greenhouse
- The temperature of water is recorded on camera.
- The temperature dependence over time is investigated.

\[ T_0 = +4^\circ C \]

Experiment lasted for 120 min
The experimental results

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The graph shows the temperature in degrees Celsius (°C) over time in minutes for two conditions: without and with a greenhouse. The temperature decreases over time, with the line for the greenhouse showing a slightly lower temperature compared to the line for the condition without a greenhouse. The y-axis represents temperature, ranging from 0 to 90 °C, and the x-axis represents time, ranging from 0 to 120 minutes.
Conclusion

• We explained how the greenhouse slows down the cooling of heated object by the mechanisms of:
  o Convection
  o Conduction
  o Radiation

• We experimentally investigated the change of temperature over time in greenhouses with different parameters
Thank you for your attention!
Наша команда
Наша команда

I
Руководители команды
The temperature VS time
Conduction

1. **hot air**

2. **hot object**

3. **conduction**