ScienceCube

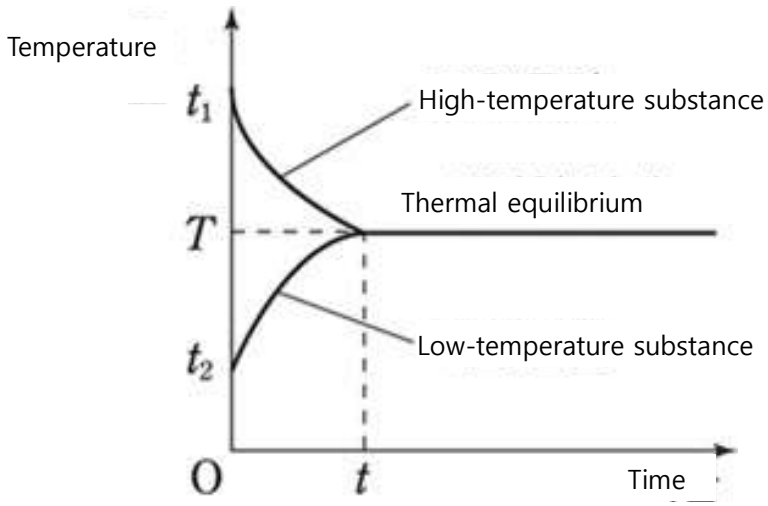
Thermal Equilibrium

Explaining the movement of heat when two liquids of different temperatures come into contact.

Fundamental Concept

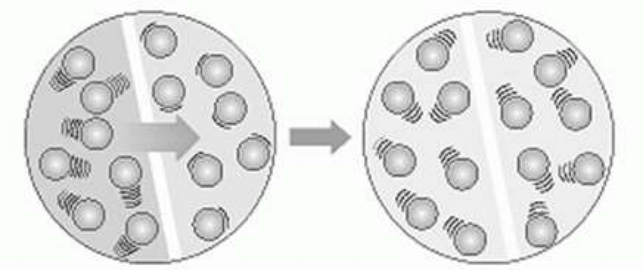
1. **Thermal Equilibrium**

   Heat moves between a hot object and a cold object that are in contact. After enough time, the temperatures of the two objects become equal, reaching a state where they no longer get hotter or colder. This state is called thermal equilibrium.



2. **Types of Heat Transfer**

   A. Conduction of Heat: When two objects are in contact, the molecules of the hotter object have higher kinetic energy and move faster, colliding with the molecules of the cooler object. This transfer of energy from the hot object to the cold object is called conduction.



B. Convection of Heat: In liquids or gases, when molecules are heated, they move more vigorously, causing the volume to expand and the density to decrease. The heated, lighter liquid or gas rises, while the cooler, denser part sinks. This circulation transfers heat throughout the liquid or gas. This process is called convection.

C. Radiation of Heat: Heat from a hot object is transferred in the form of light without needing a medium. This process is called radiation.

Experiment

Materials Needed

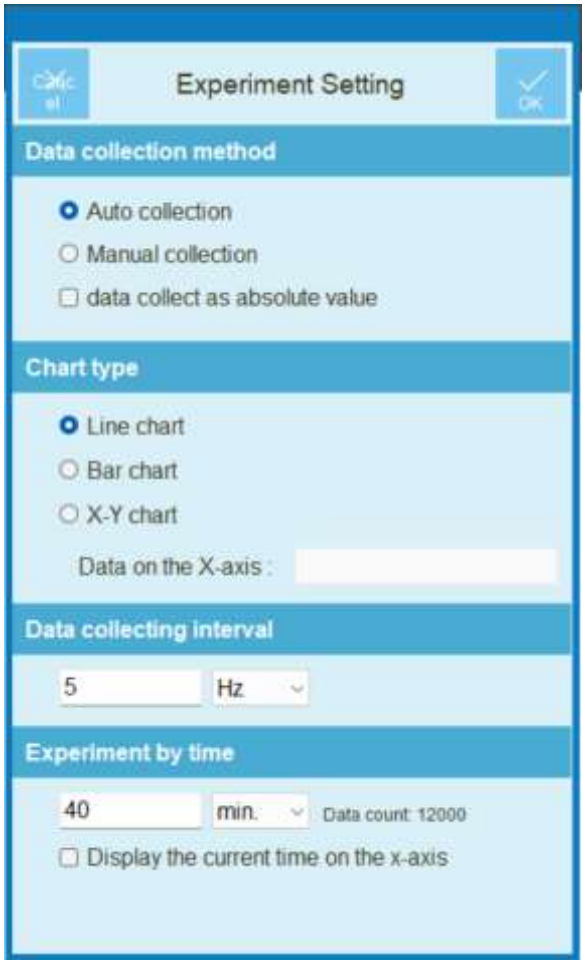
Interface, Science# program, 2 temperature sensors, Cylindrical styrofoam container, 100 mL graduated cylinder, Hot water, Cold water, Stand, Clamp, Rubber stopper

Experimental Setup

1. Pour 100 mL of hot water (about 45°C) into the styrofoam container.
2. Pour 100 mL of cold water (about 15°C) into the graduated cylinder.
3. Insert a temperature sensor through a hole in the rubber stopper and seal the mouth of the graduated cylinder.
4. Fix the other temperature sensor in the styrofoam container using the stand, ensuring the sensor does not touch the walls or bottom of the container.

Interface Setup

1. Run Science#.
2. Connect the 2 temperature sensors to the interface.
3. Press the button to set up the experimental environment as shown below or press the button for automatic setup.



Automatic etup

Data Collection

1. Press the button to start data collection.
2. Quickly place the graduated cylinder into the styrofoam container.

Data Analysis

Recording Data

1. Mix the cold and hot water and leave them for a sufficient time to reach thermal equilibrium. Draw a temperature change graph.

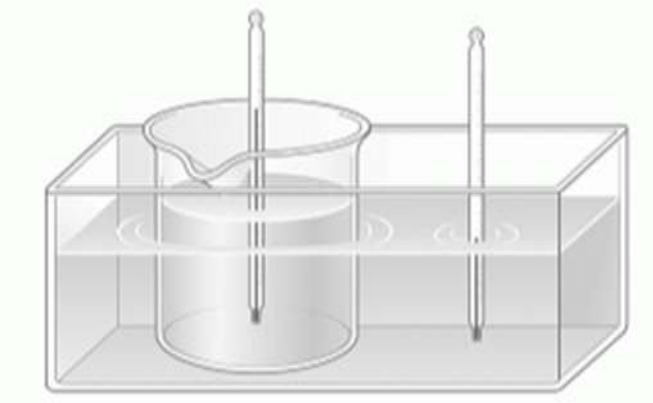
2. Explain the changes in temperature for the cold water and hot water based on the graph.

3. Record the time and temperature at which thermal equilibrium was reached.

4. Predict how the temperature at thermal equilibrium will change in the future..

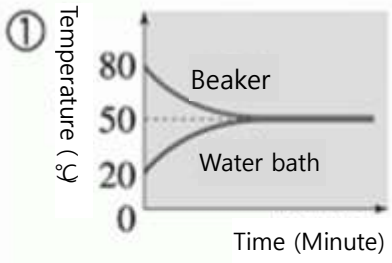
Data Application and Extended Activities

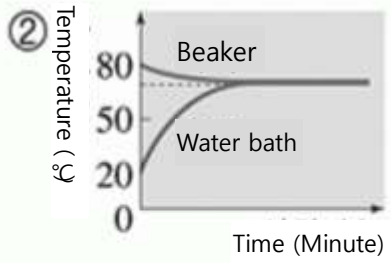
1. In the following diagram, 100 g of water in a beaker is placed in a container holding 400 g of water. The temperatures of the water in both the beaker and the container were measured.

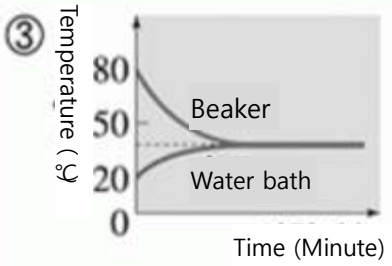


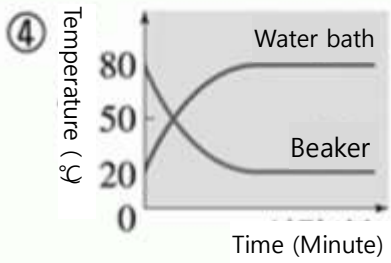
Which temperature graph over time is the most appropriate?

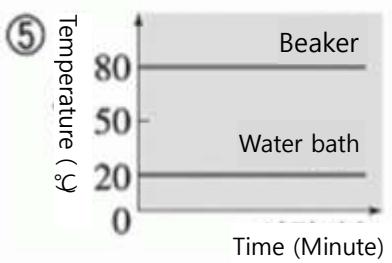
(Assume the container water was at 20°C and the beaker water was at 80°C.)

① 

② 

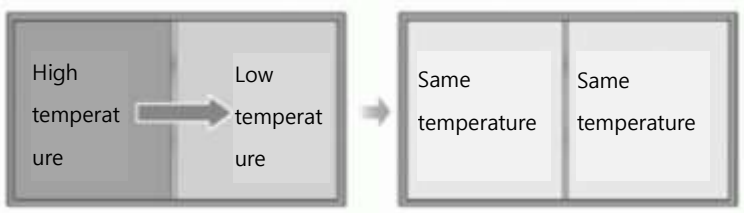
③ 

④ 

⑤ 

Answer:

2. In the following diagram, two solid objects of different temperatures were brought into contact and their temperatures equalized..



Write the correct explanation for this observation. (Assume no heat exchange with the environment.)

① The higher temperature object gained heat.

② If the masses of the two objects are equal, they will reach the same temperature.

③ Heat moved from the higher temperature object to the lower temperature object.

④ The temperature changes of both objects are always of equal magnitude.

⑤ Given enough time, the temperatures of the two objects will equalize.

⑥ The amount of heat lost by the higher temperature object equals the amount of heat gained by the lower temperature object.

Answer:

3. Select all items designed to reach thermal equilibrium quickly in daily life.

① Thermometer ② Double-pane windows ③ Cooler box

④ Frying pan bottom ⑤ Oven gloves

Answer:

4. Among objects A~E with different temperatures, identify the object with the lowest temperature based on the following heat transfer directions.

   A → C, E → D, D → A, C → B

   Answer: