What's Cooking 2

Student Objective
The student:
- will be able to calculate the calorie heat gain for several different containers
- given containers of several different materials will be able to determine which will work the best in a solar oven.

Materials
- box cooker from previous What's Cooking investigation
- containers made of various substances such as: foam cup, clear plastic glass, colored glass, metal can, ceramic mug, glass beaker, ½ pint milk carton, milk carton painted black (per group)
- graduated cylinder
- thermometers (5 per group)
- plastic wrap
- pot holders

Key Words:
conduction
convection
dependent variable
independent variable
radiation
solar collector
solar thermal
thermal conductivity

Time:
1 class period

Background Information

The transfer of heat is accomplished by convection, conduction and/or radiation. **Convection** requires the movement of a substance (or mass) from one position to another. The movement of air or water is an example of heat transfer by convection. The transfer of heat energy by air and water currents is essential in distributing heat energy over the Earth's surface.

Conduction is the transfer of heat energy by molecular activity. The kinetic energy of the molecules is transferred from one molecule to another through collisions. The heat flows from the higher temperature to the lower temperature, with the rate of flow being directly proportional to the temperature difference. Some substances are very good conductors of heat, others are not. The thermal conductivity of a substance is a measure of its ability to conduct heat with the better conductors having a higher thermal conductivity value.

Radiation is the process of transferring heat energy through space by means of electromagnetic waves. These waves carry energy and can travel through a vacuum, such as the energy of the sun traveling through the vacuum of space to our Earth. Heat energy in the form of

electromagnetic waves is both absorbed and reflected when it hits a surface.

Procedure

1. Place box of various containers in the front of the room.
2. Divide students into groups of 4 - 5 students in each group.
3. Explain procedure to the class:
   - each group will be testing four containers for their ability to gain heat in their solar box cooker
   - pour 100 ml water into each container
   - put the thermometer in the water and record the temperature in the chart in their Science Journal
   - cover the top around the thermometer with plastic wrap
   - place the cooker in the sun. Put the containers in the cooker, as well as one thermometer that is in the oven but not in a container
   - record the temperature after 45 minutes and calculate the heat gain
4. Help students as needed during the experiment
5. Write the formula for calorie heat gain on the board

   Heat gain/loss = mass (Q ^{a} T)

   Where Q is the specific heat gain of a substance
6. Students should complete their Laboratory Manuals.

Related Research

1. Test additional types of containers.
2. Check the temperature each hour. Does the rate of heat gain change? Explain.
3. What will happen if the clear containers had a black bottom or a black outside? Investigate.
4. What will happen if the containers were placed on a wire rack? Investigate.
5. Will one large container reach the same temperature as fast as several smaller containers with the same total amount of water? Investigate.

Related Reading

- ***Cooking With the Sun: How to Build and Use Solar Cookers*** by Beth Halacy & Dan Halacy (Morning Sun Press, 1992)

  Cooking With the Sun gives simple directions for solar cookers and solar hot plates along with a host of recipes including pizza, chicken and pecan pie.

Internet Sites

http://solarcooking.org/

Solar Cooking International, solar cooking archive includes solar cooking plans, documents and a list of resources and manufacturers.

http://www.sunoven.com/

Sun Ovens International. Includes solar oven history, recipes, and photos.

EnergyWhiz

See if you can 'ace' the solar thermal crossword puzzle at **http://energywhiz.com/**.

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Benchmark SC.A.1.4.3 - The student knows that a change from one phase of matter to another involves a gain or loss of energy.

Benchmark SC.B.1.4.1 - The student understands how knowledge of energy is fundamental to all the scientific disciplines.

Benchmark SC.B.1.4.2 - The student understands that there is conservation of mass and energy when matter is transformed.

Benchmark SC.B.1.4.3 - The student knows that temperature is a measure of the average translational kinetic energy of motion of the molecules in an object.

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conduction - the movement of heat or cold through materials that are solid

convection - the movement of heat through air or in liquids

dependent variable - a condition of the experiment that is found by testing different values of the manipulated condition. The values of the dependent variable are the effects that are seen from manipulating the independent variable.

independent variable - a condition of the experiment whose values are specified first or before an experiment is performed and are used to find other values or results. Changing the values of the independent variable can be said to cause what happens to the dependent variable.

radiation - the way we receive heat from the sun each day. The energy is emitted in the form of waves/particles, and can move from one object to another without heating the area in between.

solar collector - a device that collects and traps solar energy

solar thermal - using the Sun's energy to heat something

thermal conductivity - the measure of a substance's ability to conduct heat. The higher the value, the more conductive the substance.

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1. Record your results below. Fill in the first column with the types of containers you tested. To calculate the heat gain, use the formula:

Heat gain/loss = mass (Q ^{a} T)

Q is the specific heat of a substance.

Specific heat of common substances	Specific heat J/Kg - K
aluminum	903
brass	376
copper	385
glass	664
iron	450

Container type	Temp (start)	Temp (45 min)	Calories of Heat Gain
Control (air in box oven)			

2. Did any containers reach the same temperature as the air in the solar box cooker? Why do you think this is occurred?

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For the problems below, use the formula for heat gain and the values for specific heat listed below.

Heat gain/loss = mass (Q ^{a} T)

Where Q is the specific heat of a substance.

Specific heat of common substances	Specific heat J/Kg - K
aluminum	903
brass	376
copper	385
glass	664
iron	450

1. How much heat must be added to these cooking containers, each made of 5 kg of material to raise their temperatures from 25° C to 100° C?

   a) aluminum
   b) brass
   c) copper
   d) glass
   e) iron

2. Which container from the question above would heat up faster?

3. 1 kg of 25° water is put in each container from question 1. The containers are placed in ovens that reached 125° C (and remain at that temperature for several hours). In what order would the water in the containers boil?

4. A container of unknown metal absorbs 5016 J of heat when its temperature changes from 20° C to 30° C. Calculate the specific heat of the metal.