Testing Swimming Pool Covers

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS

FOR USE WITH FACT SHEET NO. 21: SOLAR WATER HEATERS FOR SWIMMING POOLS

TEXAS ESSENTIAL KNOWLEDGE AND SKILLS

TEKS utilized include: **SCI.** (b)(1) integrates the disciplines…in the topics of…energy transformation… and solution chemistry; (c) 2(A) plan and implement investigative procedures; 2(B) collect data and make measurements with precision; 6(B) investigate...the movement of heat through solids, liquids and gases by convection, conduction, and radiation; 7(A) investigate and identify properties of fluids...including...viscosity; 9(A) relate the structure of water to its function as the universal solvent; **ALG.** 1(D) represent relationships among quantities using… tables...diagrams, verbal descriptions; **ENG.** 4(F) compile written ideas and representations into reports, summaries, or other formats and draw conclusions; 13(B) locate information using…technical resources; **WORLD GEO.** 8(B) compare ways that humans...adapt to, and modify the physical environment...in a variety of…technological contexts; 19(A) evaluate...major technological innovations…that have been used to modify the physical environment; 22(A) draw... graphics such as…diagrams.

OVERVIEW

Students will distinguish differences in conduction, convection and radiation. Students will measure the rate of heat loss in a simulated swimming pool and learn the components needed for an efficient pool solar heating system. Students will look at the physical effects of polar bonding, as in water.

TIME FRAME

One 1-hour period

TEACHER GUIDE

Background Information

The rate of evaporation of isopropyl alcohol is much greater than that of water. Water "beads up" in a container, while isopropyl alcohol flattens out and evaporates quickly. The polar bonding of water is strong and therefore the molecules "hang together" more tightly. This bonding is responsible for the firmer surface tension, the round, tight shape of raindrops, and the higher specific heat value (heat capacity) of water. This heat capacity is unusual and allows our lakes and oceans to absorb great amounts of sunlight without evaporating huge quantities of water each day into the atmosphere.

Teaching Instructions

The teacher should read through the student activity first. Have students read Fact Sheet #21, *Solar Water Heaters for Swimming Pools*, before the activity. This activity uses pie pans with water to simulate two swimming pools, one covered and one uncovered. The cover can be made from a clear plastic bag; it should be cut into a circle to fit inside the pie pan, covering all the water in the pan. Students will test the two "pools" in a shady outdoor location, to be determined by the teacher. Students will record the temperature in the two pools over time. The second part of this activity requires a sidewalk area that has been exposed to the sun for 1 or 2 hours. Students will observe the differences in behavior of water and alcohol when they are poured into containers and evaporation begins. Students should read through the activity and the teacher can provide specific directions for:

a) where the activity will be performed, and
b) how the materials will be transported (with special caution for thermometers and for the isopropyl alcohol).

The teacher should carry and dispense the warm water, thermometers and isopropyl alcohol. Safety guidelines should be emphasized with proper handling of chemicals and equipment. The outside activity will be easier to perform by keeping students in unison for taking temperature readings and moving to the shade.

Have the students prepare a data table to record the temperature readings over time between covered and uncovered "pool" pie pan systems, comparing sunny and shaded locations. Students can share the data and discuss the benefits of a swimming pool cover, in terms of saving energy. The students should create a line graph for time versus temperature.

ASSESSMENT ANSWERS

Short Answer Questions

1. A cover would be more energy efficient and a side benefit would be a cleaner pool.
2. The heat loss was less for the covered pie plate "swimming pool," because the cover kept the heat from escaping.
3. The pans could be placed on an insulated block to prevent heat conduction to the ground underneath.
4. The water would heat faster and to a higher temperature.
5. The alcohol was flatter in the pan and evaporated more quickly, indicating it doesn't hold together as well; the water beads up higher and evaporates much more slowly, so the molecules cling together more strongly.

GLOSSARY

bonding – a description of how molecules or atoms hold together, like 2 water molecules holding together by positive/negative attraction

cohesion – the strong attraction of molecules of the same substance, like water molecules, caused by the negative ends of water molecules attracting the positive ends of other water molecules

collector – plastic panel with top and bottom headers connected by a large number of small tubes, through which the pool water flows

conduction – transfer or spread of heat through a solid material

convection – transport of heat by the movement of parts of a fluid (air or water); cool air is denser than warm air and as it settles the cool air pushes the warm air upward

evaporation – the process of a liquid gradually turning into a gas (water turning into steam)

heat capacity (or specific heat) – the amount of heat required to increase the temperature of a specific amount of a substance by 1 degree; the heat capacity for water is 1 calorie per gram (it takes 1 calorie of heat to raise the temperature of 1 gram of water 1 degree centigrade)

insulator – a material that resists the passage of heat

latitude – the angular distance on its meridian of any place on the earth's surface from the equator; latitude minus 10 –15 degrees is the position for a solar collector facing south

physical properties – properties of a substance that we can see and test fairly easily in a laboratory, such as color, melting point, boiling point, density, etc.

polar – having a positive end (pole) and a negative end (pole); a water molecule is polar

radiation – energy transmitted in the form of waves through open space (like sunlight)

surface tension – the cohesive forces at the top of a glass of water are strong enough to float objects on (such as a thin needle)

Multiple Choice Questions

1 d 2 d 3 a 4 d 5 b 6 d
7 d 8 d (best answer) 9 c 10 b

STUDENT ACTIVITY #21: TESTING SOLAR HEATERS FOR SWIMMING POOLS

Key Vocabulary
define the following terms:
bonding, cohesion, collector, conduction, convection, evaporation, heat capacity, insulator, latitude, physical properties, polar, radiation, surface tension

Materials
Part A
- goggles
- 2 aluminum pie pans
- 2 thermometers
- 1 clear plastic "swimming pool cover," cut from a clear plastic bag to fit inside the pie pan
- a timer
- 2 containers, such as large styrofoam cups, with 300 ml each warm water
- a beaker or graduated cylinder to measure 300 ml
- 2 paper towels

Part B
- goggles
- 10 ml of isopropyl alcohol (as teacher directs)
- 10 ml of water (estimate)

Performing the Activity
Part A
1. As the teacher directs, gather the Part A materials your group requires to use outside. The teacher will distribute the thermometers.
2. Go to the outdoor area selected by your teacher to conduct the experiment. Go to your workstation as instructed. Obtain the thermometers from the teacher.
3. Place the 2 pie pans in a shaded area. Wait for your teacher to pour 300 ml of warm water into each pan.
4. Immediately place a thermometer in each pan and record the temperature. Use caution handling the thermometers.
5. The aluminum pans are your 2 "swimming pools." Take the plastic cover and place it directly on top of the water in one pan (with thermometer); this is the covered swimming pool. Make sure there is no air between the water and the cover, and that it covers all the water in the pan.
6. Both pie plates with water (1 covered, 1 not covered) should be sitting on the concrete in the shade.
7. Record the temperatures in each pan every 2 minutes for 14 minutes.

Part B (optional, wear goggles)
1. After finishing Part A, pour a small amount of the water (about 10-15 ml) from one pan back into 1 paper cup. Spill out the rest of the water and dry the pan with a paper towel. Spill all of the water from the second pie pan and dry that pie pan also. Return the thermometer as directed by your teacher.
2. Obtain a small amount of isopropyl alcohol from your teacher (10-15 ml) in the other paper cup.
3. Take both dry pie pans and 1 cup with 10 ml of isopropyl alcohol and the second cup with water to a sunny paved area.
4. Place the 2 pie pans side by side.
5. Into one pie pan pour the 10 ml of water and into the second pie pan pour the 10 ml of isopropyl alcohol.
6. Observe the 2 liquids carefully and watch for any differences in the shapes of the puddles they make and in the rate of evaporation. Record your observations.
7. Collect your materials and follow the teacher's instructions for returning to your classroom.

Post Activity
Using the data for temperature readings for the covered pie pan and the uncovered pie pan, develop a line graph showing the temperature changes in the sun. Using the data for both pans in the shade, develop a second line graph showing the temperature changes for the covered and uncovered pie pans.

Discuss and summarize the differences observed.

ASSESSMENT

Short Answer Questions

1. Based on your experiment, would you want a swimming pool with a cover or an uncovered pool? Why?
2. What difference was there for the heat loss for both pie plates. Why?
3. What could be done to reduce the heat loss from the pans?
4. What would happen if the bottom of a swimming pool were painted black?
5. What differences were observed between the alcohol and water? What might account for these differences?

Multiple Choice Questions

1. The number of solar collectors required to heat a swimming pool depends on:
   a) pool shading
   b) size of pool
   c) number of swimmers
   d) answers a and b

2. If the pool covers 600 sq. feet, the collector should be at least:
   a) 100 sq. feet
   b) 50 sq. feet
   c) 800 sq. feet
   d) 300 sq. feet

3. Collectors should face:
   a) South
   b) North
   c) East
   d) West

4. Swimming pools can lose heat by:
   a) radiation
   b) evaporation
   c) conduction
   d) all answers a, b, and c

5. To dramatically reduce heat loss due to evaporation:
   a) face the collector east
   b) use a pool cover
   c) increase water temperature
   d) use fewer collectors

6. A covered container of water in the sun compared to an open container of water:
   a) loses heat more slowly
   b) heats up to a higher temperature
   c) heats and cools exactly the same as the open container
   d) both a and b

7. Water molecules:
   a) attract each other
   b) have a positive end and a negative end
   c) evaporate easier than isopropyl alcohol
   d) a and b

8. If you had a swimming pool in a cold climate:
   a) you would consider using a heater and a cover
   b) you would allow the water temperature to be changed by the weather alone
   c) you would consider using a solar collector
   d) a and c

9. The term polar means:
   a) a description of Alaska
   b) cold
   c) having 2 ends, one positive and one negative
   d) symmetrical

10. The sun heats the water in the pie pan "pool" by:
    a) conduction
    b) radiation
    c) evaporation
    d) condensation

InfinitePower.org

Financial Acknowledgement This publication was developed as part of the Renewable Energy Demonstration Program and was funded 100% with oil overcharge funds from the Exxon settlement as provided by the Texas State Energy Conservation Office and the U.S. Department of Energy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS