topic V

TOPIC V - ENERGY IN EARTH PROCESSES

What Is the Role of Energy in Earth Processes?

Time Emphasis: 7 days

TOPIC OUTLINE

INVESTIGATION		A-1a	A-2a	B-1a	B-1b	C-1a	LTI - #5	FE - #5
Time Emphasis (Periods)		2	1½	1½	1	2		

A. Electromagnetic energy and energy transfer

A-1 Electromagnetic energy

What Are the Properties of Electromagnetic Energy?

		A-1a	A-2a	B-1a	B-1b	C-1a	LTI - #5	FE - #5
A-1.1 Properties	A-1.11	■						
	A-1.12	■						
	A-1.13	■			■			
	A-1.14				■			
A-1.2 Solar energy	A-1.21							
	A-1.22	■						
A-1.3 Earth energy	A-1.31							

A-2 Energy transfer

How Can Energy Be Transferred?

		A-1a	A-2a	B-1a	B-1b	C-1a	LTI - #5	FE - #5
A-2.1 Conduction	A-2.11		■					
A-2.2 Convection	A-2.21							
	A-2.22						■	
A-2.3 Radiation	A-2.31							

B. Energy transformation

B-1 Transformation in earth processes

What Are Some Energy Transformations That Can Be Observed in Earth Processes?

		A-1a	A-2a	B-1a	B-1b	C-1a	LTI - #5	FE - #5
B-1.1 Latent heat	B-1.11			■				
	B-1.12			■				
	B-1.13							
B-1.2 Movement of water	B-1.21							
B-1.3 Wavelength absorption and radiation	B-1.31				■			
	B-1.32				■			
B-1.4 Friction	B-1.41							

C. Energy relationships in earth processes

C-1 Conservation of energy

What Inferences Can Be Drawn About the Total Energy Within a Closed System?

		A-1a	A-2a	B-1a	B-1b	C-1a	LTI - #5	FE - #5
C-1.1 Closed system	C-1.11		■	■		■		
	C-1.12		■	■		■		
	C-1.13					■		■
	C-1.14					■		
	C-1.15							
	C-1.16							

PROCESS OF INQUIRY OBJECTIVES

		A-1a	A-2a	B-1a	B-1b	C-1a	LTI - #5	FE - #5
Mathematical Skill	PIO-1					■		
Measurement Skill	PIO-2		■	■	■	■	■	■
Creating Models	PIO-3							
Analysis of Error	PIO-4		■	■	■	■		
Data Analysis	PIO-5	■	■	■	■	■	■	■

TITLES

Multimedia: Check Multimedia Section of Supplement for reference to this topic.

A-1a	A-2a	B-1a	B-1b	C-1a	LTI - #5	FE - #5
Electromagnetic Spectrum	Heat Transfer	Changes in State	Energy Absorption	Specific Heat	Stream, Pond, or Lake Temperature	Beach

Easy (2)

V-A-1a: ELECTROMAGNETIC SPECTRUM

QUESTION:

What are the properties of electromagnetic energy?

MATERIALS:

Spectrum kit or piece of diffraction grating, pieces of red and blue glass or cellophane, NaCl, (optional: other salts such as $SrCl_2$, LiCl, $BaCl_2$, $CuSO_4$, KCl) heat source, gas discharge tubes (if available), colored pencils.

SUGGESTED APPROACH:

1. Have the students use a spectroscope to study the visible energy from the sun.
2. Aim the slit toward the bright sky and look through the diffraction grating end.
3. Hold pieces of red and blue glass or cellophane over the slit, one at a time, and then both at once, while pointing the spectroscope at the sky.
4. Have the students compare light from various sources. For example, a light bulb, NaCl, or other salts heated in an open flame, or gas discharge tubes.
5. In each case, have the students sketch what they see using colored pencils.

PRECAUTIONS:

1. DO NOT AIM THE SLIT DIRECTLY AT THE SUN because eye damage could occur.
2. Try to make sure each student is actually observing a spectrum; this might be accomplished by checking their colored pencil drawings of what they see.
3. The lab itself will serve only to stimulate the students' interest; topic understanding must be accomplished during the postlab session.

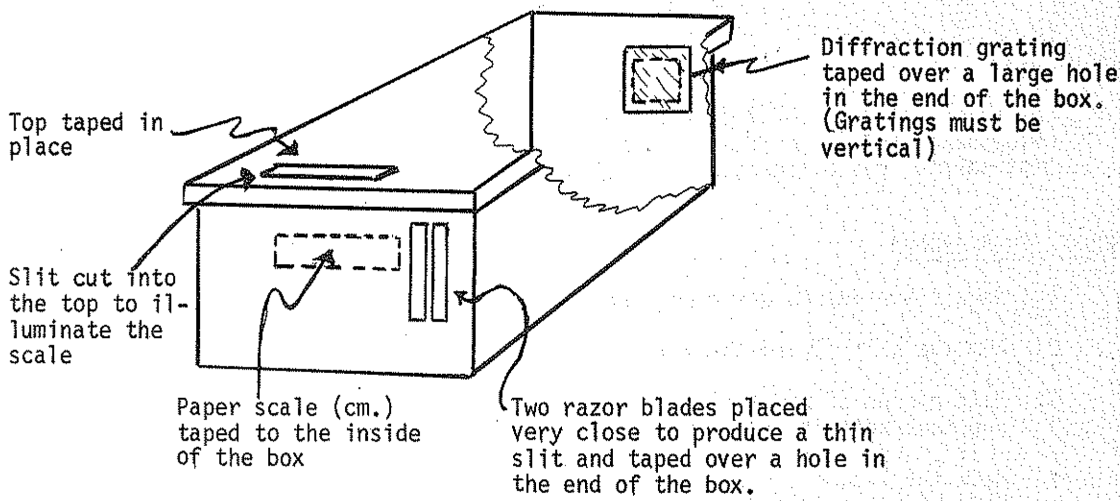
TYPICAL RESULTS:

1. Student drawings of the sun's continuous spectrum should represent a generalized rainbow of colors.
2. Drawings of sun's spectrum filtered by the cellophane should show darkened areas near the blue end when red cellophane is used and near red end when blue cellophane is used.
3. Drawings of heated NaCl or discharge tubes should demonstrate individually spaced bright lines which are characteristic of that element or substance. The location of the lines should correspond to the relative position in the spectrum for that color.

MODIFICATIONS:

Construct shoebox spectroscopes for improved viewing of the spectra. (See labeled diagram.)

SHOEBOX SPECTROSCOPE (cutaway view)



REFERENCES:

Investigating the Earth, pp. 142-149, Teacher's Guide, pp. 183-186.

V-A-1a: ELECTROMAGNETIC SPECTRUM

QUESTION:

What are the properties of electromagnetic energy?

INTRODUCTION:

You have seen and felt the effects of solar energy all of your life. In order to find out more about the properties of this energy, we can use an instrument called a spectroscope. In this investigation you will use this instrument to investigate light from various sources including the sun.

OBJECTIVES:

When you finish this investigation you should be able to:

1. list the colors of the visible spectrum in correct order.
2. describe the effect of a filter on the solar spectrum.

METHOD:

1. Carefully observe a portion of the bright sky through the slit in your spectroscope. DO NOT LOOK DIRECTLY AT THE SUN. Using colored pencils, sketch what you see in the box below.

   Bright sky.

2. Hold pieces of red and blue glass or cellophane over the slit, one at a time, and both at once, while pointing the spectroscope at the sky. Sketch what you see.

   Bright sky with blue filter.

   Bright sky with red filter.

   Bright sky with both filters.

3. Carefully observe the spectrum of various other energy sources provided by your teacher. Sketch what you see below. Label each.

QUESTIONS:

1. How many color zones did you see in the solar spectrum?

2. How do the zones compare in size?

(A-1.13) 3. What effect does the blue filter have on the observed solar spectrum? The red filter?

4. What is the effect, in general, upon the observed spectrum of a color filter corresponding to one of the spectrum colors?

5. What are the similarities and differences among the spectra produced by the different sources?

6. What do you think causes the differences in spectra?

7. What do you think is meant by the statement "the spectrum of a source is like a fingerprint"?

(A-1.11) 8. Under what conditions does a potential source appear to produce a spectrum? Why?

(A-1.12) 9. Which color in the visible spectrum has the longest wave length? the shortest? the greatest frequency? the smallest?

10. Where is the visible spectrum located with respect to the total electromagnetic spectrum?

(A-1.22) 11. How is the sun's energy distributed among the various portions of the electromagnetic spectrum?

Easy (1.5)

V-A-2a: HEAT TRANSFER

QUESTION:

How can energy be transferred?

MATERIALS:

Heat transfer kit, or two polystyrene coffee cups, and a 12-inch aluminum bar bent to a U shape, two high temperature thermometers (-10° to 110°C).

SUGGESTED APPROACH:

1. Ask students how they think energy can be transferred. The discussion should lead to the three basic ways: conduction, convection, and radiation. In this lab they will investigate conduction.

2. Have students carry out the investigation and graph their results.

3. In the postlab discussion, help them develop a molecular model that will explain the observed results. The high kinetic energy molecules on the hot end transfer their kinetic energy from one molecule to another until kinetic energy equilibrium is reached throughout the system.

PRECAUTIONS:

1. The energy gained by the cool cup will not equal the energy lost by the hot cup. This may trouble some of the students who are aware enough to recognize it. Ask them to suggest reasons for this. Eventually they should suggest that the aluminum bar may radiate heat into the air around it. This is not the only reason and the students may come up with many more.

2 Caution should be taken to make sure both thermometers read the same at room temperature before the investigation is begun.

TYPICAL RESULTS:

The results should graphically show a reduction in heat in the hot cup, and a heat gain in the cool cup. As a result of the heat lost through the aluminum bar, the heat lost by the hot water will be greater than the heat gained by the cool water. Students should be led to realize that the difference between the heat lost and the heat gained is a result of other variables and NOT a result of experimental error.

MODIFICATIONS:

The readings of temperatures can be extended for several hours. The results may eventually indicate that both cups become sources while the bar is the sink.

REFERENCES:

Investigating the Earth, pp. 130-131, Teacher's guide, pp. 175-176.

Do Not Print

V-A-2a: HEAT TRANSFER

QUESTION:

How can energy be transferred?

INTRODUCTION:

Heat energy transferred from a high heat "source" to a low heat "sink" is the basic principle behind most of our engines that do work for us. A tremendous amount of heat energy is stored in the ocean. If an appropriate heat sink could be found, the resulting heat transfer could do a great deal of work for us. In this investigation, you will observe and analyze the flow of heat energy.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. indicate the direction in which energy would be transferred between two objects, given their temperatures.

2. identify conditions in which heat is lost or gained, and determine the amounts and relative rates of heat exchange, given a graph of temperature vs. time of two equal masses of water that are exchanging energy.

METHOD:

1. Put boiling water (100°C) in one calorimeter, and water at room temperature (approximately 25°C) in the other. Place the two cups in such a position that one end of the U-shaped aluminum bar can be inserted into the water in one cup, and the other end of the bar inserted into the water in the other cup. Place a thermometer in each cup.

2. Record the temperature reading of each thermometer at 4-minute intervals for 20 minutes.

3. Graph your results for both cups.

QUESTIONS:

(C-1.11) 1. In what direction does the energy flow? What is your evidence?

(C-1.12) 2. How does the energy lost compare with the energy gained? Why?

(A-2.11) 3. How is the energy transferred from the water in one calorimeter to the water in the other?

4. What could you do to make the final temperature readings higher?

5. How do the rates of energy exchange in each cup compare?

Challenging (1.5)

V-B-1a: CHANGES IN STATE

QUESTION:

What are some energy transformations that can be observed in earth processes?

MATERIALS:

Each group should be provided with a beaker (at least 100 ml.), high temperature thermometer (-10°C to 110°C), ring stand with ring clamp and wire gauze, crushed ice, heat source.

SUGGESTED APPROACH:

1. Ask the students what kind of a relationship exists between heat and temperature. Can the relationship be demonstrated and measured? How? Many possibilities exist and original thinking by the students should be encouraged.

2. Have the students set up apparatus, make appropriate measurements, and graph their results.

3. Class discussion of results should lead to the conclusion that a direct and constant relationship between heat and temperature does not always exist.

PRECAUTIONS:

1. Caution should be exercised since the students will be working with boiling water.

2. Constant stirring of the mixture is very important for accurate temperature determinations.

3. The heat source should not be altered after temperature readings have begun. The basic assumption is that heat is being added at a constant rate and is proportional to time. Students should be made to realize this.

4. Adequate time must be allowed for temperature readings to be taken as the temperature rises from zero or below to approximately 100°C. This time will vary depending on heat source, however; 15 to 20 minutes should be allowed.

5. Many of the students will not be expecting the results obtained, and may have a tendency to try to connect the points on the graph with a straight line.

TYPICAL RESULTS:

It is unlikely that all groups will produce graphs which show heat of fusion as well as vaporization. It may be desirable to have a member of each group sketch the group's graph on the chalkboard or on an overhead projector so that the graphs may be considered together. In this way you should be able to show a tendency for the curves to flatten out at 0°C. and at 100°C.

MODIFICATIONS:

If adequate equipment is not available, the heat of fusion portion only may be done by allowing ice to melt at room temperature.

Students can investigate the change in state of mothball crystals. This involves melting mothball crystals in a test tube using a water bath. A thermometer should be inserted into the melted material and readings taken every 30 seconds until crystallization is complete. Additional information can be found in many physics laboratory manuals.

REFERENCES:

Investigating the Earth, pp. 138-140, Teacher's Guide, pp. 180-182.

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V-B-1a: CHANGES IN STATE

QUESTION:

What are some energy transformations that can be observed in earth processes?

INTRODUCTION:

In this investigation you will be adding energy to a common earth material. As you do so, you will be measuring the effects of this addition of energy. Try to determine where the energy is coming from, and where it is going.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. identify conditions of energy change (e.g., kinetic energy increase or decrease, potential energy increase or decrease) when given a graph showing temperature change as a function of time for water which is heated from a temperature below 0°C. to steam.

2. describe how the heating abilities of two samples of a substance compare at the same temperature, but in different phases.

METHOD:

1. Set up ring stand with ring clamp and wire gauze at the appropriate height above the heat source. Turn on and adjust heat source.

2. Add crushed ice to the beaker and quickly insert thermometer into it, place beaker on wire gauze over the heat source.

3. Begin temperature readings immediately and continue taking readings at 1-minute intervals, continuing for at least 3 minutes after the water begins to boil.

4. Include in your data times when ice begins to melt, when it is entirely melted, and when the water begins to boil.

5. Throughout the time readings are being taken, you should stir the solution gently with the thermometer.

6. Graph your results.

QUESTIONS:

1. What is the relationship between energy input (heat) and temperature change?

2. When was the temperature changing at the fastest rate?

(B-1.11) 3. When was the temperature changing at the slowest rate?

(B-1.12) 4. What is the cause of the major variations in the rate of temperature change?

5. How does water at 100°C. compare to steam at 100°C. in its ability to heat other materials?

6. How does ice at 0°C. compare to water at 0°C. in its ability to cool other materials?

(C-1.11) 7. In what direction does energy flow?

(C-1.12) 8. If the system used in the investigation is closed (no energy entering or leaving), what is the relationship between heat lost and heat gained?

V-C-1a: SPECIFIC HEAT

QUESTION:

What inferences can be drawn about the total energy within a closed system?

INTRODUCTION:

During colonial days, stones were sometimes heated in the fire and then dumped into special containers and placed at the foot of the bed to keep the occupant's feet warm. Would it matter what kind of stones were used? Would equal masses of different materials give off the same amount of heat? This investigation will help you answer this question.

OBJECTIVES:

When you finish this investigation you should be able to:

1. identify the material with the greatest specific heat, given the amount of temperature change equal masses of various materials undergo when placed in the same mass of water.

2. indicate which would produce the greatest temperature change when equal masses of the materials are added to the same mass of water, given the specific heat of various materials.

METHOD:

1. Suspend equal masses of aluminum, copper, and granite in a container of boiling water. Keep the water over the heat source so that it continues to boil even after these objects are placed in it.

2. Fill the calorimeter about 2/3 full with a known mass of room temperature water. Use this same amount of water for all future steps.

3. Remove the aluminum from the boiling water, and place it in the calorimeter. Record the time and temperature. Measure and record the temperature at 1-minute intervals until no change in temperature is noted.

4. Repeat the previous step using first the copper and then the the granite. Be sure to use fresh water at room temperature with each new piece of material.

5. As a final step, pour boiling water with a mass equal to that of one of the solids into the calorimeter cup. Make the same measurements as in the previous steps.

QUESTIONS:

1. Which sample caused the greatest temperature change?

2. Which sample caused the least temperature change?

(C-1.12) 3. How does the amount of energy lost by one substance compare with the amount gained by the other?

(C-1.13) 4. How does the amount of temperature change for the various materials compare with the amount of energy transferred?

5. Which sample required the greatest time to effect the temperature change? Which the least?

6. List the samples in order of temperature change...greatest first. List the samples in order of time required to cause the change...greatest first. How do the lists compare?

(C-1.14) 7. Which of the substances has the greatest specific heat? the least?

(C-1.15) 8. How can the amount of heat lost and gained be determined?

(C-1.11) 9. For each case, in which direction did the energy flow?

V-B-1b: ENERGY ABSORPTION

QUESTION:

What are some energy transformations that can be observed in earth processes?

INTRODUCTION:

People living in tropical climates often wear light-colored clothing, while people in higher latitudes dress in darker colors. Is this coincidence or is there a reason? Have you ever observed any similar reaction to earth materials? How does the temperature of an asphalt surface compare to that of light-colored sand? This investigation may help you answer some of these questions.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. state verbally which of two given materials of different color is likely to absorb the most heat energy most quickly.

2. interpret graphs representing the temperature changes of two objects which are being heated, and identify the one of greater heating rate.

METHOD:

1. Place the heat lamp at equal distances form the dark and light colored cans. Push the thermometers through the slot in the top of the cans. MAKE CERTAIN THERMOMETER DOES NOT TOUCH SIDES OR BOTTOM OF CAN.

2. Turn the light on and record the temperatures each minute for 10 minutes, or until the temperature reaches 45°C. Turn the light off, remove it without disturbing the cans, and record the temperatures each minute for 10 more minutes.

3. Draw a graph for the temperature change in each can.

QUESTIONS:

1. Which can heats faster?

2. Which can cools faster?

3. Which can absorbs energy faster? What is your evidence?

(A-1.14) 4. Which can radiates energy faster? How do you know?

(B-1.31) 5. What determines the rate at which energy is absorbed?

(A-1.13) 6. What can happen to the incoming energy that reaches the surface of the cans?

7. What process was responsible for the energy transfer in this investigation?

8. What forms of energy did you observe?

(B-1.32) 9. How do you think the wavelength of the energy absorbed by the cans compares with the wavelength radiated back? Explain.