Your Name _____ Score _____

Group Members _____

_____ Minutes _____

Standard 4
Key Idea 2

Performance Indicator 2.2

Explain how incoming solar radiation, ocean currents, and land masses affect weather and climate.

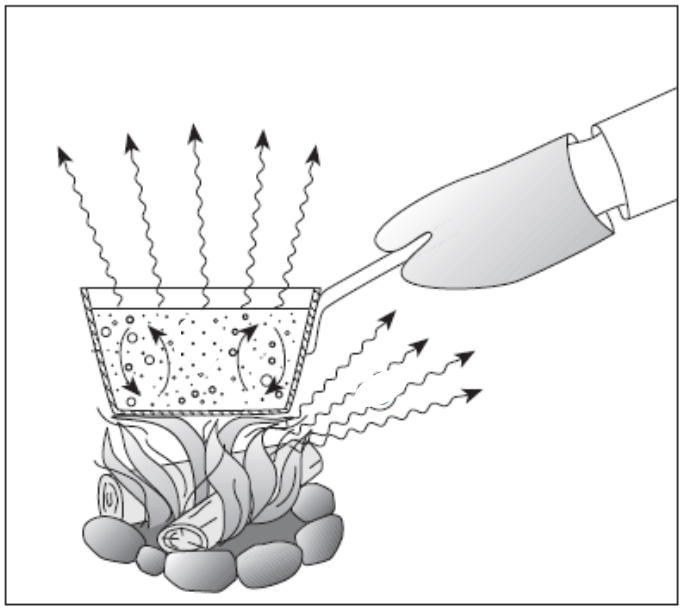
Major Understanding:

2.2a Insolation (solar radiation) heats Earth's surface and atmosphere unequally due to variations in:

- the intensity caused by differences in atmospheric transparency and angle of incidence which vary with time of day, latitude, and season
- characteristics of the materials absorbing the energy such as color, texture, transparency, state of matter, and specific heat
- duration, which varies with seasons and latitude.

2.2b The transfer of heat energy within the atmosphere, the hydrosphere, and Earth's surface occurs as the result of radiation, convection, and conduction.

- Heating of Earth's surface and atmosphere by the Sun drives convection within the atmosphere and oceans, producing winds and ocean currents.



Mini Lesson 1: Energy Transfer – Radiation

There are three main types of energy transfer: conduction, convection and radiation. Each type of energy transfer is a part of our weather system. Radiation from the Sun heats of the surface of Earth. This heat is then reradiated into the atmosphere and helps to heat the air. Heat radiated from Earth is called terrestrial radiation. The air that is touching the ground is heated in part by conduction. Once the air at Earth's surface is heated it rises (because it is less dense). This causes convection currents to form that heat our air and affects our weather everywhere. Internal energy refers to heat coming from Earth's interior. Radioactive decay along with the heat left over from Earth's formation contribute to Earth's internal energy. External energy is primarily solar energy, *energy from the Sun*.

Radiation is energy transfer in the form of electromagnetic waves. It can travel through empty space (vacuum), air (gas), water (liquid) and depending on the type of radiation even solids. The electromagnet spectrum is the classification of radiation based on wavelength, frequency and amplitude. **In**coming **Sol**ar Radi**ation** is commonly called insolation. In simple terms it means radiation from the sun. Many factors contribute to the amount and intensity of insolation that actually reaches Earth's surface. Atmospheric transparency (cloud cover), Angle of insolation (how high the sun is) and Duration of insolation (how long the sun is above the horizon).

Need to know:

1) Name the three types of energy transfer. _____ , _____ and _____

2) What type of energy transfer heats Earth's surface? _____

3) What type of energy transfer heats the air that is touching the ground? _____

4) Why does warm air rise? _____

5) What forms due to rising air in the atmosphere? _____

6) What is reradiated heat from Earth called? _____

7) What does internal energy refer to? _____

8) What two factors contribute to Earth's internal energy? _____

_____

9) What is the major source for external energy?

10) What is radiation? _____

11) What different types of mediums can radiation travel through? _____

_____ , _____ and _____

12) What is the classification of radiation based on? _____

_____ and _____

13) What does the word "insolation" refer to? _____

14) List and describe three factors that contribute to the <u>amount</u> and <u>intensity</u> of insolation that reaches Earth's surface.

(a) _____

(b) _____

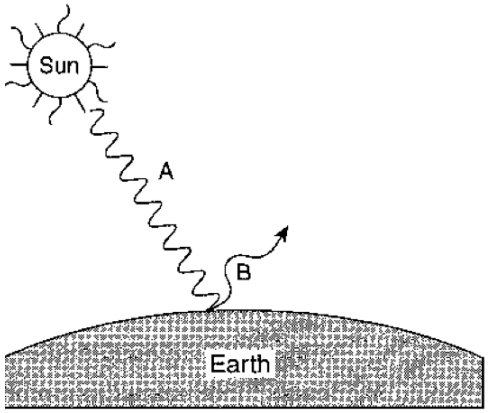
(c) _____

(d) _____

15) The diagram to the right represents Solar Radiation from the Sun and Terrestrial Radiation given off by Earth.

Label the diagram next to each letter:

- A – Insolation (solar radiation)
- B – Terrestrial radiation



"Electromagnetic Spectrum" Earth Science Reference Tables page 14

1. When referring to "rays" from the Sun, what is "rays" short for? _____
2. Name the type of radiation that comes from the Sun that can cause skin cancer?

   _____
3. Name the type of radiation that comes from the Sun that you can "SEE" ?

   _____

4. If I were a spy and needed to see things at night I would need special lenses (goggles).

   Which type of radiation allows you to see heat coming off of people and places?

   _____
5. Lead protects you from this type of radiation at the dentist. _____
6. Music is sent along these waves. _____
7. Which type of radiation has the shortest wavelength? _____

8. Which type of radiation has the longest wavelength? _____

9. The type of radiation used to cook your food. _____

10. Which color (visible light) has the shortest wavelength? _____

11. Which color (visible light) has the longest wavelength? _____

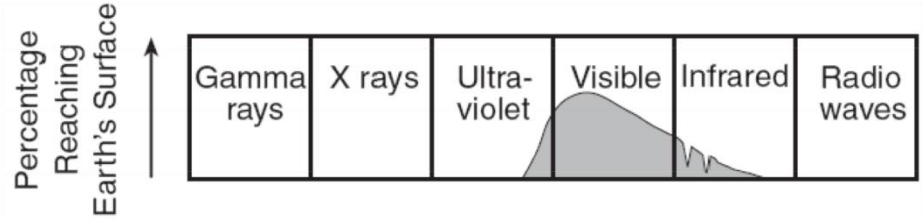
12. Which type of radiation that overlaps radio waves and infrared? _____

13. Which type of radiation that overlaps gamma rays and ultraviolet? _____

Regents Questions:

____ 1. Scientists are concerned about the decrease in ozone in the upper atmosphere primarily because ozone protects life on Earth by absorbing certain wavelengths of
(1) x-ray radiation (3) ultraviolet radiation
(2) infrared radiation (4) microwave radiation

____ 2. The diagram below shows the types of electromagnetic energy given off by the Sun. The shaded part of the diagram shows the approximate amount of each type actually reaching Earth's surface. Which conclusion is best supported by the diagram?



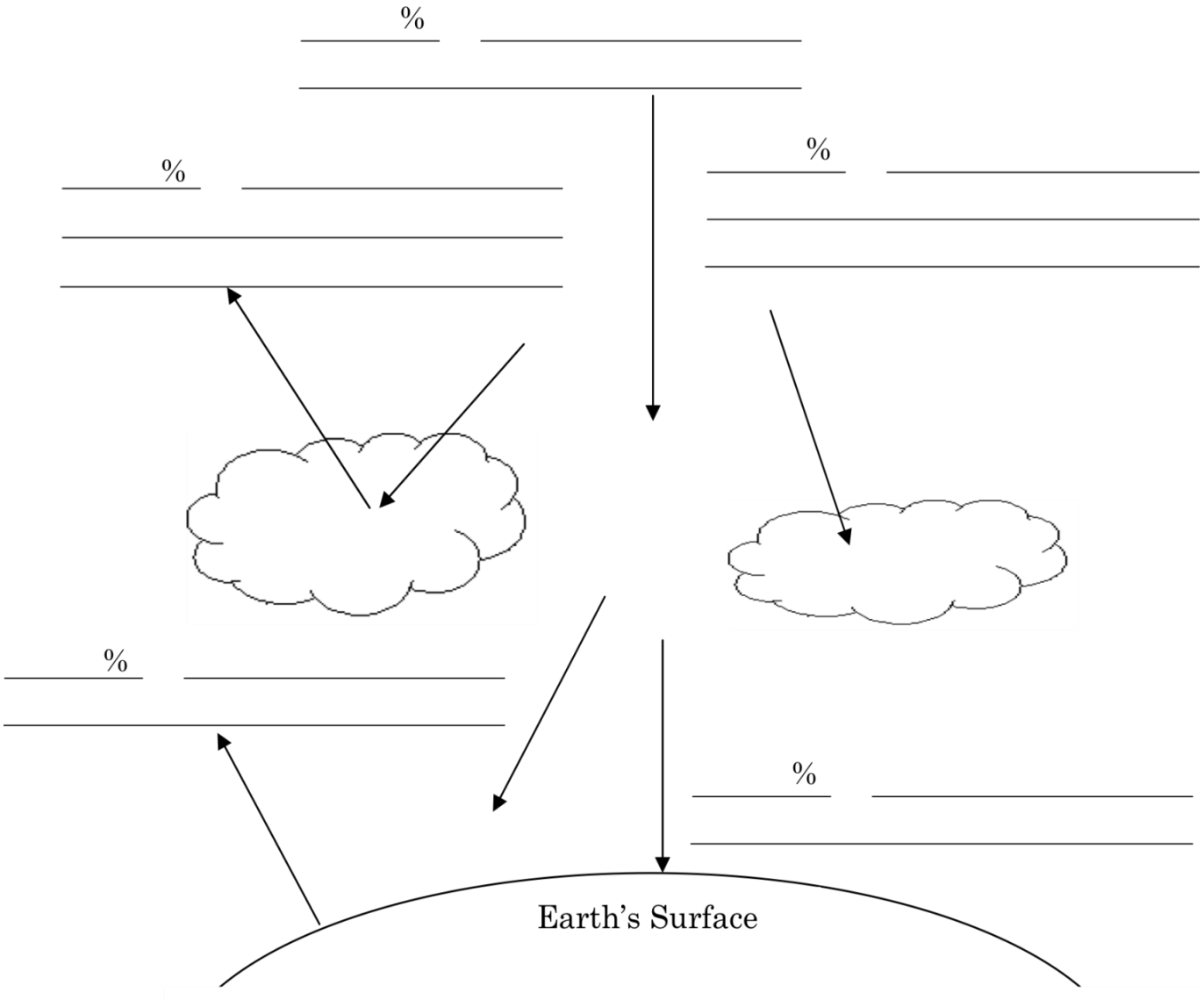
(1) All types of electromagnetic energy reach Earth's surface.
(2) Gamma rays and x rays make up the greatest amount of electromagnetic energy reaching Earth's surface.
(3) Visible light makes up the greatest amount of electromagnetic energy reaching Earth's surface.
(4) Ultraviolet and infrared radiation make up the greatest amount of electromagnetic energy reaching Earth's surface.

____ 3. What is the basic difference between ultraviolet, visible, and infrared radiation?
(1) half-life (2) wavelength (3) temperature (4) wave velocity

____ 4. Radiation with the wavelength between blue and yellow is usually visible as what color?
(1) violet (2) green (3) blue (4) yellow

Write the following percentages and information on the corresponding lines in the diagram below, based on their descriptions.

100% - incoming solar radiation
8 % - reflected by Earth's Surface
43% absorbed by Earth's surface
24 % - reflected by clouds and dust particles
25% - absorbed by clouds and dust particles



Introduction:

Did you ever wonder why in the summer light colored clothes are more popular and in the winter dark clothes are more popular. Well, you may find out that it is more than a fashion statement. Different surfaces absorb and radiate heat differently. Can you figure out which color absorbs and radiates heat more?

Materials
- ✓ Black can
- ✓ Shiny can
- ✓ Insolated lids
- ✓ 2 thermometers
- ✓ Heat lamp

Objective:

- Determine how the color of a material affects energy transfer by radiation

Procedure:

1. Arrange the black and white (shiny) cans as shown in the diagram.
2. Center both cans 8 inches in front of the lamp.
3. Record the temperature of each thermometer at Time 0 in the data table provided.
4. Turn on the lamp and read the thermometers at one minute intervals for 10 minutes. Record these temperature readings in the data table provided.
5. Without disturbing the positions of the cans, turn off the lamp and turn it away from the area of the cans. CONTINUE TO TAKE READINGS
6. Continue taking temperature readings every minute for another 10 minutes recording them on the data table provided.
7. Create a line graph using your data. Plot both curves on the same set of axes. Remember to label the graph and use a key.

Data Table

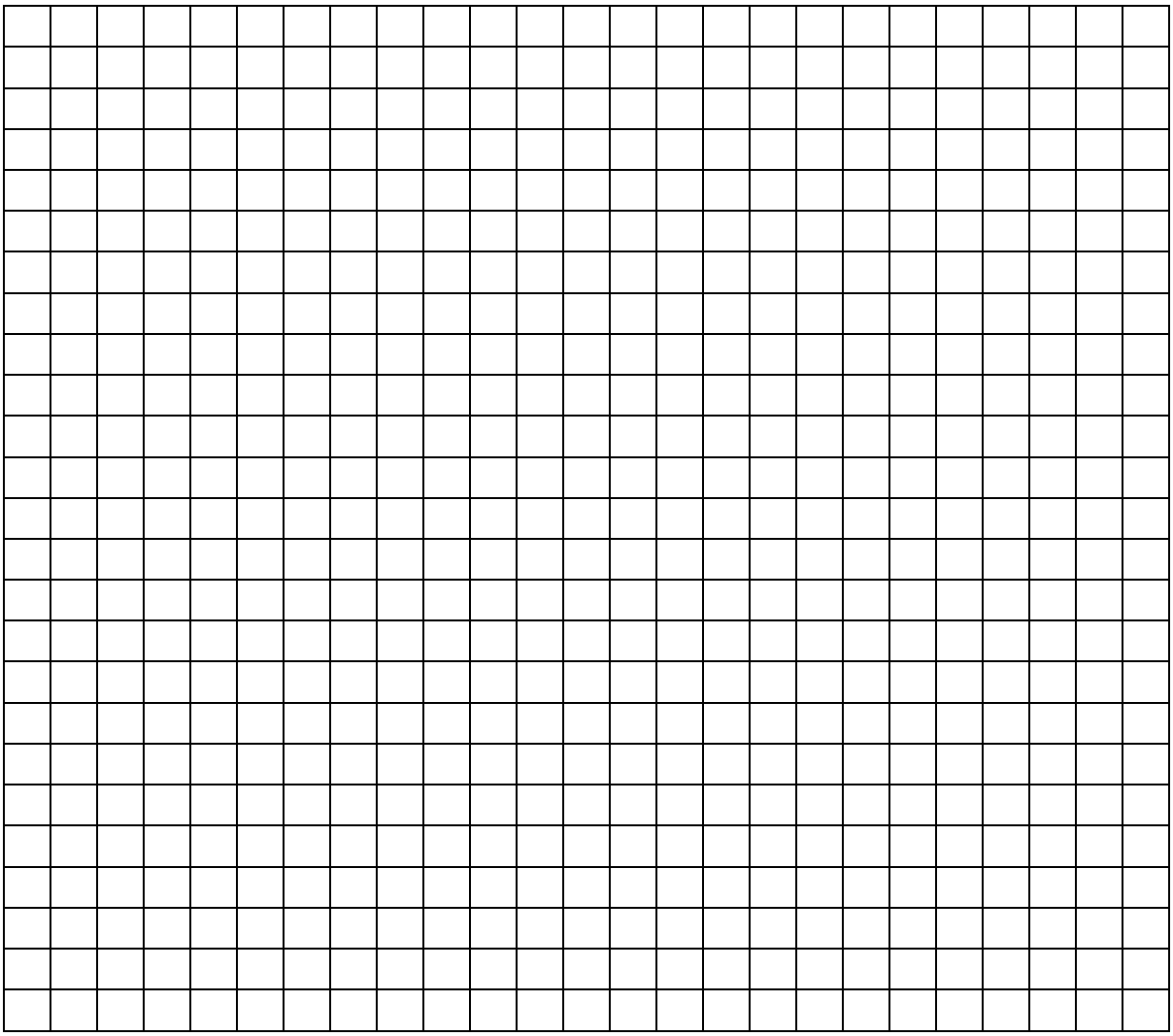
Time (min)		0	1	2	3	4	5	6	7	8	9	10
Temp (°C)	Black											
	Shiny											

Time (min)		11	12	13	14	15	16	17	18	19	20
Temp (°C)	Black										
	Shiny										

Line Graph for Black and Shiny Can

KEY

☐ Black ☐ Shiny



✓ **Check Point**

1. Why was it important to place each can an equal distance from the lamp? _____

   _____

2. Which can received the most energy? _____

3. After 10 minutes why was it necessary to turn the lamps away from the area of the cans?

   _____

4. (a) Which can absorbed energy more quickly? _____

   (b) How does your graph illustrate this? _____

5. (a) Which can radiated energy more quickly? _____

   (b) How does your graph illustrate this? _____

6. Which can had the greatest rate of change throughout this experiment? _____

7. What evidence can you find from your graph that indicates neither cup heated up nor cooled off at a constant rate? _____

8. If you know that the surface is a good absorber of energy, what can you infer about its ability to radiate energy? _____

9. What characteristic of the surface was tested in this lab to determine the rates of heating and cooling? _____

A good <u>absorber</u> of electromagnetic energy is a good <u>radiator</u> of electromagnetic energy.

10. Write the statement above on the lines below.

_____

_____

If a material heats up fast, it also cools down fast.

11. Write the statement above on the lines below.

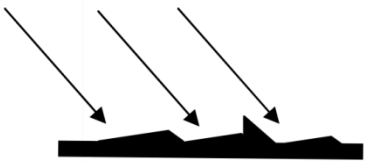
_____

_____

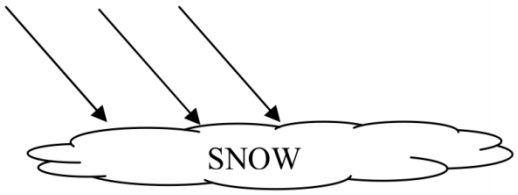
Absorption of radiation: Dark vs. Light

Write the following information on the corresponding lines in the diagram below.

- Absorbs greatest amount of heat	*- Radiates the greatest amount of heat*
- Reflects the greatest amount heat	*- Radiates the least amount of heat*



Dark surfaces



Light surfaces

_____ _____

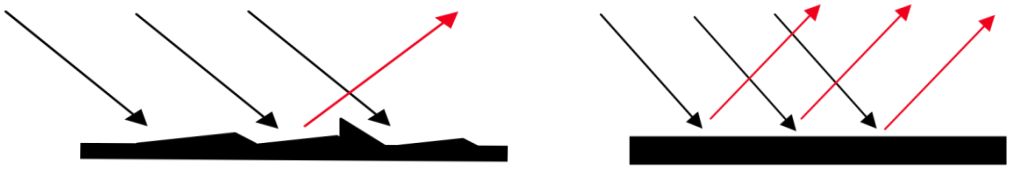
_____ _____

_____ _____

***Absorption of radiation*: Smooth vs. Rough**

Write the following information on the corresponding lines in the diagram below.

- more surface are to absorb heat	*- more reflection less absorption*
- less surface area – does not absorb as much	*- less reflection more absorption*



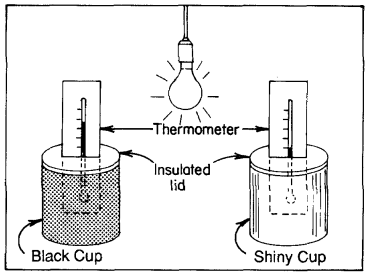
Regents Questions:

____ 1. A person in New York State worked outdoors in sunlight for several hours on a day in July. Which type of clothing should the person have worn to absorb the *least* electromagnetic radiation?

(1) dark colored with a rough surface
(2) light colored with a rough surface
(3) dark colored with a smooth surface
(4) light colored with a smooth surface

____ 2. The diagram to the right shows a light source that has been heating two metal containers of air for 10 minutes. Both cups are made of the same material and are equal distances from the light source. Compared to the amount of energy reflected by the shiny cup during the 10 minutes of heating, the amount of energy reflected by the black cup is

(1) less (2) greater (3) the same



____ 3. Which type of land surface would probably reflect the most incoming solar radiation?

(1) light colored and smooth
(2) dark colored and smooth
(3) light colored and rough
(4) dark colored and rough

____ 4. Which of the following Earth surfaces usually reflects the most incoming solar radiation?

(1) snow cover (2) dark soil (3) green grass (4) lake water

Information

Color is not the only thing that determines how fast or slow an object heats up. An additional factor in heat transfer is what the object is made of. In the summer months, when it is hot during the day and cools off at night, does the water in a pool cool down as fast as the air?

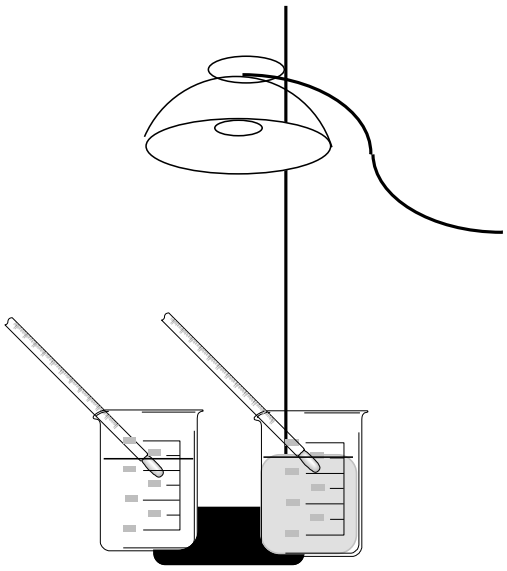
Materials
- ✓ 2- 400 ml beakers
- ✓ Water
- ✓ Sand
- ✓ 2 thermometers
- ✓ Heat lamp

Objective:

- Determine the rate of heating based on the type of material
- Compare the specific heat of land and water

Procedure

1. Place the two containers under the heat lamp as shown in the diagram
2. Place a thermometer in each cup making sure that the bulb is just below the surface of the cup's contents.
3. Read and record (on the data table – time 0) the temperature for each material.
4. Turn on the heat lamp and take readings at one minute intervals for 10 minutes.
5. Record these temperatures on the data table provided.
6. At the end of 10 minutes, turn off the lamp and move it away from the cups.
7. Continue reading and recording the temperatures of both cups each minute for the next 10 minutes.
8. Plot the points for the land temperatures on the graph provided. Using a colored pencil, connect the points with a smooth
9. Plot the points for the water temperatures on the graph provided. Using a different colored pencil, connect the points with a smooth curved line.



Data Table

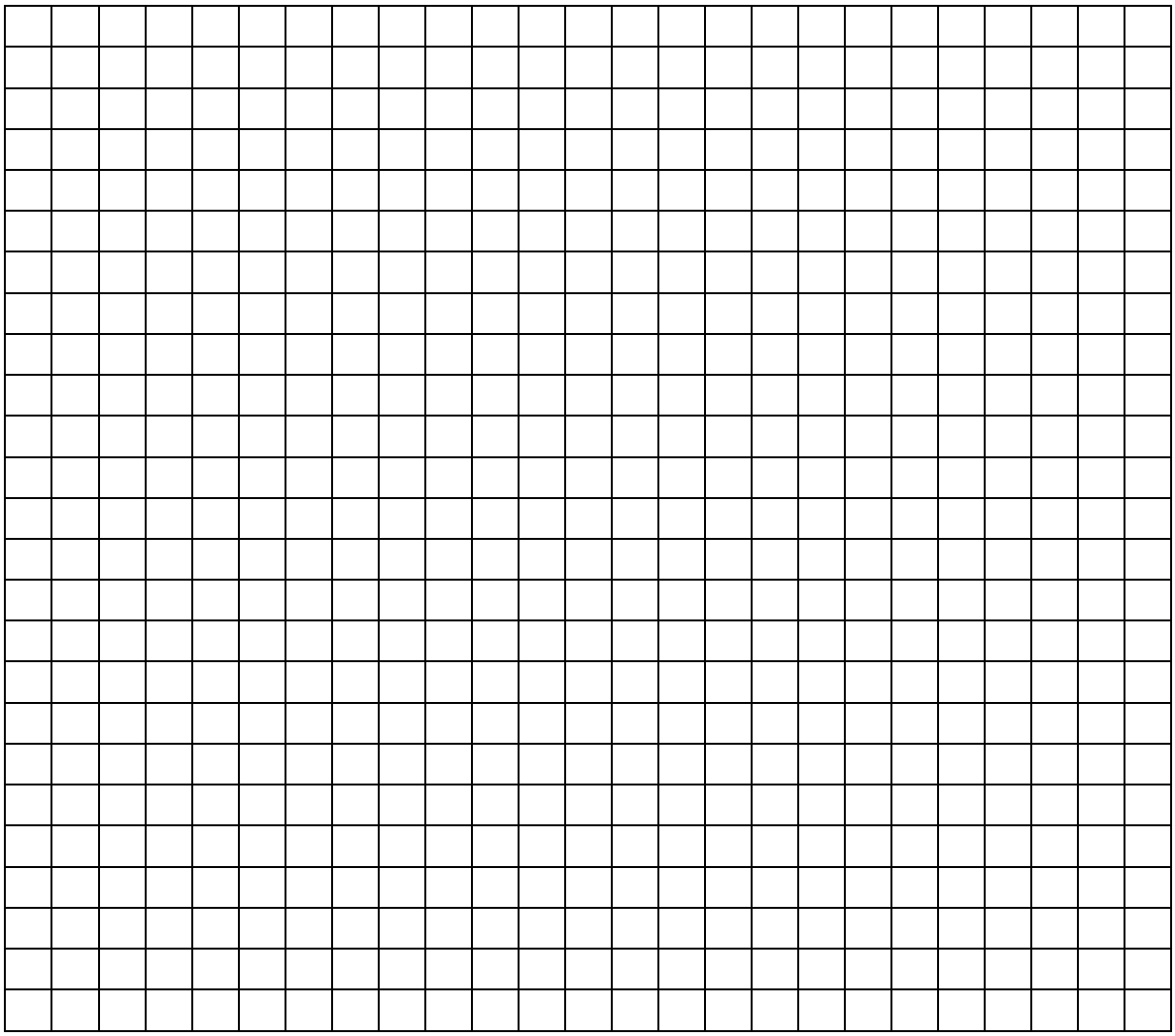
Time (min)		0	1	2	3	4	5	6	7	8	9	10
Temp (°C)	Soil											
	Water											

Time (min)		11	12	13	14	15	16	17	18	19	20
Temp (°C)	Soil										
	Water										

Line Graph for Soil and Water

KEY

Soil Water



✓ **Check Point**

1. How did the heat energy received by the cup of soil compare to the heat energy received by the cup of water? _____
2. Which cup (sand or water) heated more rapidly (absorbed energy)? _____
3. Which cup (sand or water) cooled more rapidly (radiated energy)? _____
4. Which is a better **absorber and radiator** of heat energy (soil or water)? _____
5. What the specific heat of liquid water? _____ Joules/gram·°C

Show what you know: **Specific Heat**

Absorption of radiation: ***Specific Heat***

- ✓ Specific heat is the amount of heat needed to raise the temperature of a material one degree Celsius.
- ✓ Different materials absorb electromagnetic energy at different rates

Circle the correct answers below.

- If you are heating water on a stove, which heats up faster *(the metal pan* ***or*** *the water)?*
- On a hot July afternoon it is 95°F. The pool water is about 85°F. At night the temperature drops quickly to 75°F. Does the pool water also drop 20°F? *(yes* ***or*** *no)*
- Which cools down faster *(air* ***or*** *water)* ?
- If you are looking for something to poke a fire with, would you pick a long stick made of *wood* or a *metal* rod? _____ Why? _____

"Specific Heats of Common Materials" **Earth Science Reference Tables front cover**

1. Look at the chart labeled located on the front cover of the Earth Science Reference Tables.
   a. What heats up faster, liquid water or copper (metal)? _____
   b. What is the specific heat of water? _____ Joules/gram • °C
   c. What is the specific heat of copper? _____ Joules/gram • °C
2. Circle the choice that best completes the sentences:
   - The higher the specific heat, the *(faster or slower)* the material heats up.
   - The lower the specific heat, the *(faster or slower)* the material heats up.
3. Answer the following questions.
   Which material on the specific heat chart heats up the fastest? _____
   Which material on the specific heat chart heats up the slowest? _____
   Which material needs the most amount of energy to raise its temperature? _____

4. In each set below, circle the material that would heat up the fastest:

Water	Iron	Copper
Ice	Basalt	Granite
Lead	Water	Iron

Dry air	Lead	Granite
Iron	Basalt	Water vapor
Ice	Copper	Dry air

6. What is the specific heat of land? (use the value for granite)? _____ Joules/gram•°C

7. State the relationship between specific heat and rate of heating. _____

_____

Regents questions

____ 1. Liquid water can store more heat energy than an equal amount of any other naturally occurring substance because liquid water
(1) covers 71% of Earth's surface
(2) has its greatest density at 4°C
(3) has the higher specific heat
(4) can be changed into a solid or a gas

____ 2. On a clear summer day, the surface of land is usually warmer than the surface of a nearby body of water because the water
(1) receives less insolation
(2) reflects less insolation
(3) has a higher density
(4) has a higher specific heat

____ 3. Land surfaces of Earth heat more rapidly than water surfaces because
(1) more energy from the Sun falls on land than on water
(2) land has a lower specific heat than water
(3) sunlight penetrates to greater depths in land than in water
(4) less of Earth's surface is covered by land than by water

____ 4. During some winters in the Finger Lakes region of New York State, the lake water remains unfrozen even though the land around the lakes is frozen and covered with snow. The primary cause of this difference is that water
(1) gains heat during evaporation
(2) is at a lower elevation
(3) has a higher specific heat
(4) reflects more radiation

Introduction:

Angle of insolation refers to how high the sun is over the horizon. In this activity you will describe the relationship between temperature and the angle of insolation and how it relates to time of day, latitude and the seasons.

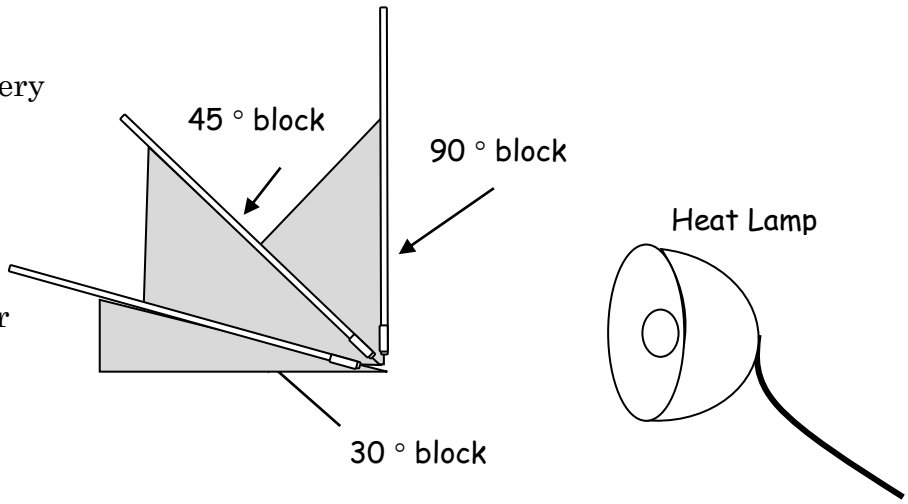
Materials
- ✓ Heat lamp
- ✓ 3 blocks of wood
- ✓ 3 thermometers
- ✓ Color pencils

Objective:

- Determine how the angle of the Sun affects the rate of heating

Procedure:

1) Attach one thermometer to each block of wood.
2) Place the three blocks of wood next to each other with the thermometers equidistant from the heat source as shown to below.
3) Record the angle of the blocks and the corresponding temperature on the data table provided.
4) Turn on the light and record the temperature readings every minute for 15 minutes.
5) Plot the points for the first set of data. Using a colored pencil, connect the points and create a line graph. Repeat this step for the other two angles.



Angle of Block: 90°

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp (°C)																

Angle of Block: 45°

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp (°C)																

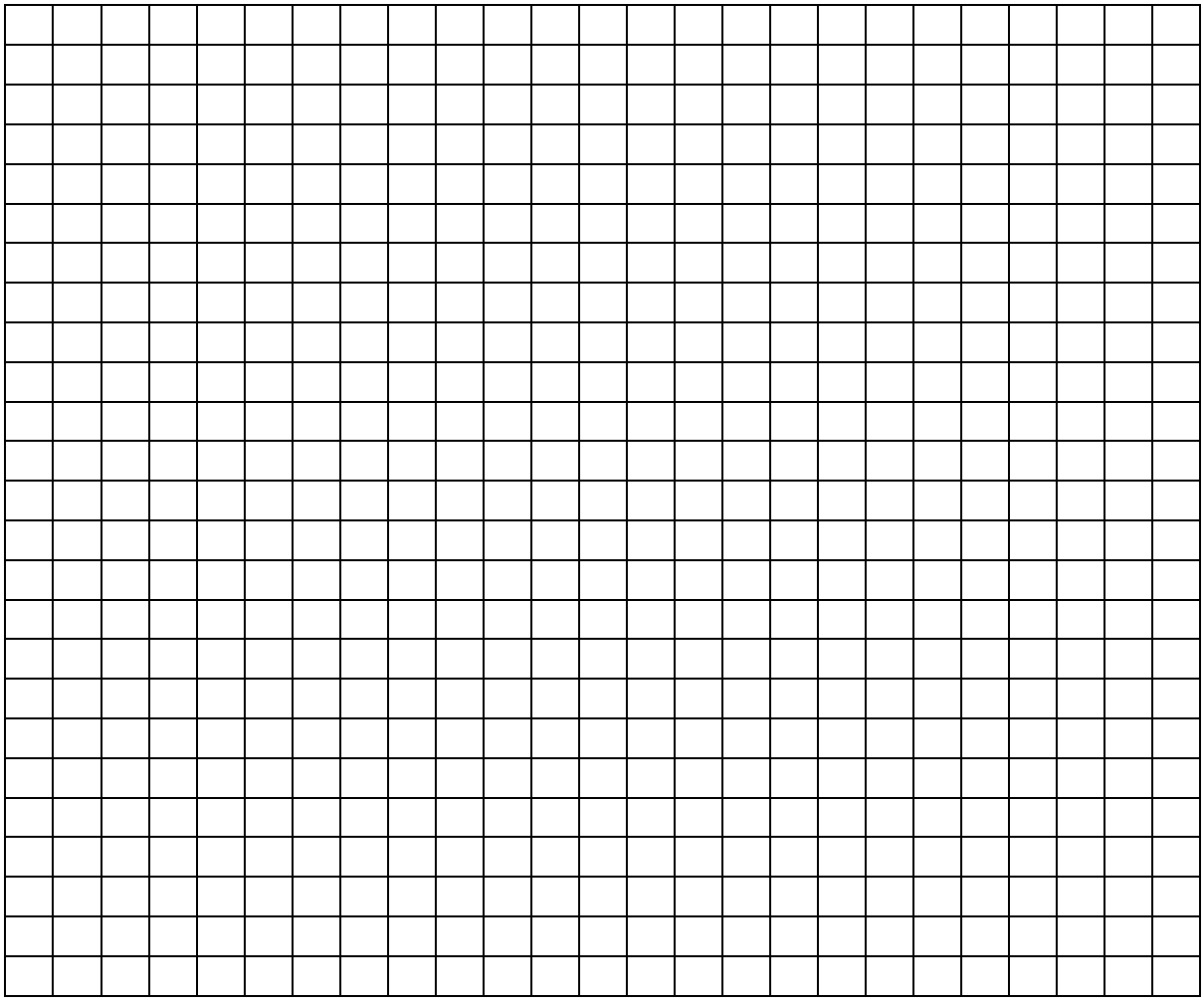
Angle of Block: 30°

Time (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp (°C)																

Line Graph for Angle of Insolation

Key

☐ 90° ☐ 45° ☐ 30°



✓ **Check Point**

1. What was the angle of the block that the thermometer heated up the fastest? _____ °
2. What was the angle of the block that the thermometer heated up the slowest? _____ °
3. Write the relationship between angle of insolation and the rate of heating. _____

_____

4. Draw the relationship between angle of insolation and the rate of heating on the graph to the right. Remember to label the axis.

✓ Angle of insolation changes depending on three things:

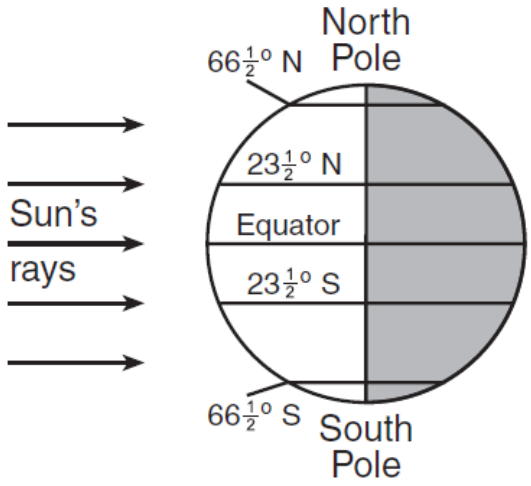
1) **Time of day**

Sunrise - Sun is [low / high] in the sky and temperatures are [warmer / cooler].

Solar noon – Sun is [highest / lowest] the sky and temperatures are [warmer / cooler].

Sunset - Sun is [low / high] in the sky and temperatures are [warmer / cooler].

2) Latitude – refer to the diagram to the right



a. Which location (name and degree latitude) is the sun's rays directly overhead (highest angle of insolation)

_____ , _____ °

b. Which location would have the highest temperatures? _____

c. Which two locations (name and degree latitude) are the sun's rays at the lowest angle of insolation.

_____ , _____ °

_____ , _____ °

d. What is true about the temperatures at the two locations in question "c"? (warm / cold)

e. Write the relationship between angle of insolation and the rate of heating.

_____

_____

f. Draw the relationship between latitude and the angle of insolation on the graph to the right. Remember to label the axis.

3) Season

a. Label the seasons (summer and spring) next to the dates given in the diagram to the right.

b. Determine the <u>month</u> for the sun labeled "A" on the diagram.

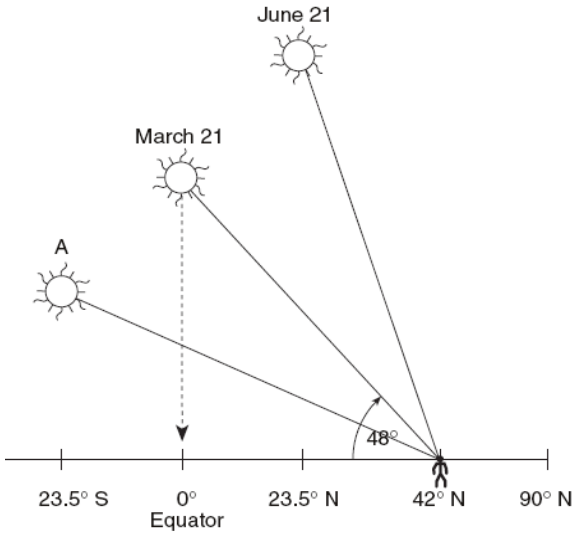
c. What season is "A"? _____

d. Which season is the sun highest in the sky? _____

e. Which season has the warmest temperatures? _____

f. Which season is the sun lowest in the sky? _____

g. Which season has the coldest temperatures? _____



Duration of Insolation is the <u>length of time</u> the sun is over the horizon.

- ✓ The longer the sun is over the horizon the greater the duration of insolation. This depends on two main factors.

Latitude

a. What locations on Earth is there 24 hours of darkness or sunlight for approximately 6 months of the year? _____ , _____ °N
_____ , _____ °S

b. Does location in question "a" have a high or low angle of insolation? _____

c. What are the temperatures like at the locations listed above? _____

d. Name the location where 12 hours of daylight every day? _____ , _____ °

e. Does location in question "d" have a high or low angle of insolation? _____

f. What are the temperatures like at the location listed above? _____

Time of Year

a. In New York State, what season has the longest hours of daylight? _____

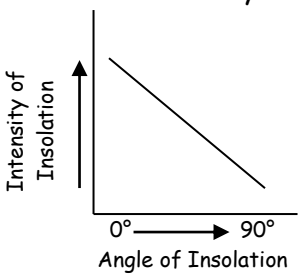
b. What season has the warmest temperatures in New York State? _____

c. In New York State, what seasons has the shortest hours of daylight? _____

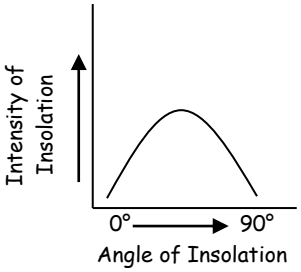
d. What season has the coldest temperatures in New York State? _____

Regents Questions

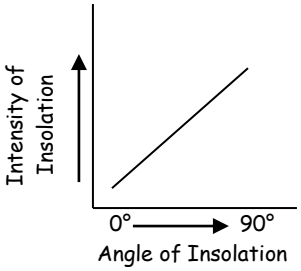
____ 1. Which graph best represents the relationship between the angle of insolation and the intensity of insolation?



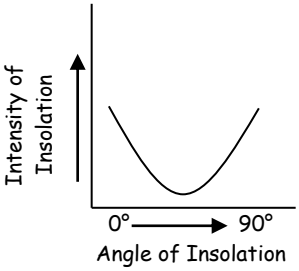
(1)



(2)



(3)



(4)

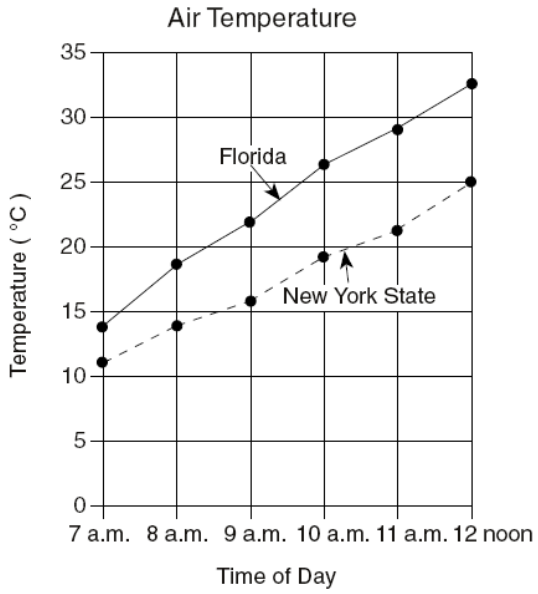
____ 2. The average temperature at Earth's North Pole is colder than the average temperature at the Equator because the Equator

(1) receives less ultraviolet radiation
(2) has more cloud cover
(3) receives more intense insolation
(4) has a thicker atmosphere

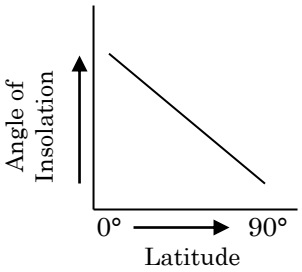
____ 3. The graph to the right shows air temperatures on a clear summer day from 7 a.m. to 12 noon at two locations, one in Florida and one in New York State.

Air temperature rose slightly faster in Florida than in New York State because Florida

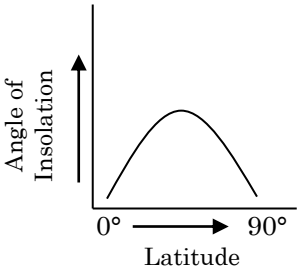
(1) has a lower angle of insolation
(2) has a higher angle of insolation
(3) is closer to the Prime Meridian
(4) is farther from the Prime Meridian



____ 4. Which graph best represents the relationship between the latitude and the angle of insolation?



(1)



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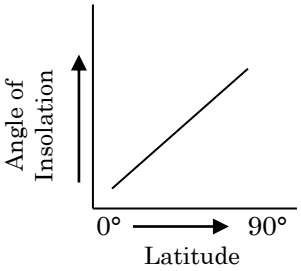
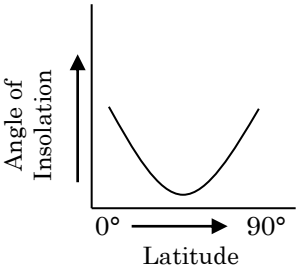


(3)

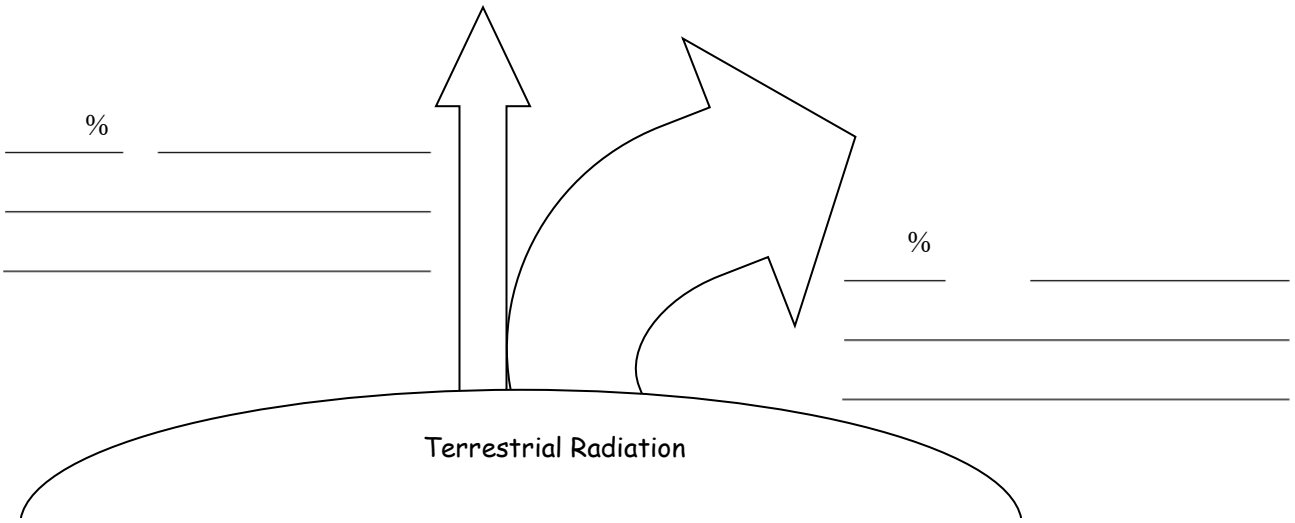


(4)

Terrestrial Radiation Insolation from the sun is primarily in the visible light range. This short wave radiation is able to enter Earth's atmosphere and heats Earth's surface. This heat energy is then re-radiated from Earth's surface and is called terrestrial radiation. Infrared radiation (long wave radiation) is emitted from Earth and other terrestrial objects. **Greenhouse gasses,** such as **carbon dioxide** and **water vapor** absorb and trap in the long wave radiation. This causes Earth the continually warm.

1. Write the following information on the corresponding lines in the diagram below.

9% lost outside Earth's atmosphere
91% absorbed by gasses within the atmosphere



Greenhouse effect:

a. In the diagram to the right, label visible light and infrared radiation.

b. What are the two main greenhouse gasses?

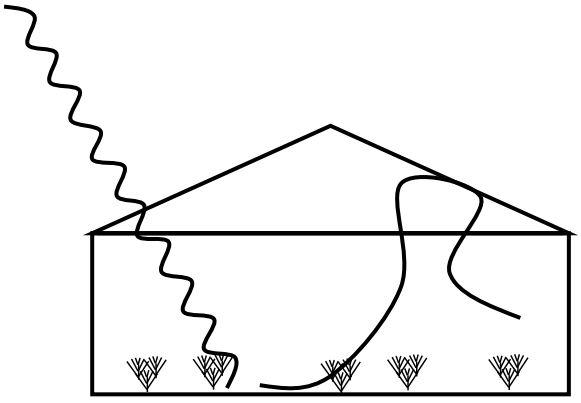
_____ & _____

c. Describe how the greenhouse effect occurs.

_____

_____

_____



Regents Questions

____1. Short waves of electromagnetic energy are absorbed by Earth's surface during the day. They are later reradiated into space as
(1) visible light rays (2) infrared rays (3) X-rays (4) ultraviolet rays

____2. What is the most likely reason for a decrease in air temperature observed between 12 midnight and 6 a.m. in New York State?
(1) Air pressure was decreasing (3) Cloud cover was increasing
(2) Earth was radiating heat. (4) Plants were giving off water vapor

____3. In which region of the electromagnetic spectrum is most of the outgoing radiation from Earth?
(1) infrared (2) ultraviolet (3) visible (4) (4) X-ray

____4. Which component of Earth's atmosphere is classified as a greenhouse gas?
(1) oxygen (2) carbon dioxide (3) helium (4) hydrogen

____5. Which two gases in Earth's atmosphere are believed by scientists to be greenhouse gases that are major contributors to global warming?
(1) carbon dioxide and methane (3) oxygen and nitrogen
(2) hydrogen and helium (4) ozone and chlorine

____6. An increase in which gas would cause the most greenhouse warming of Earth's atmosphere?
(1) nitrogen (2) carbon dioxide (3) oxygen (4) hydrogen

____7. A gradual increase in atmospheric carbon dioxide would warm Earth's atmosphere because carbon dioxide is a
(1) poor reflector of ultraviolet radiation (3) good reflector of ultraviolet radiation
(2) poor absorber of infrared radiation (4) good absorber of infrared radiation

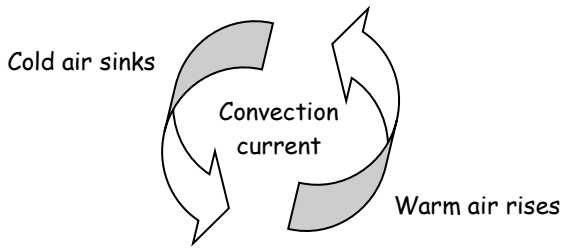
____8. Which method of energy transfer is primarily responsible for energy being lost from Earth into space?
(1) conduction (2) solidification (3) convection (4) radiation

____9. Earth's atmosphere is warmed when
(1) ultraviolet radiation emitted by Earth is absorbed by nitrogen and carbon dioxide in the atmosphere
(2) x-ray radiation emitted by Earth is absorbed by nitrogen and carbon dioxide in the atmosphere
(3) infrared radiation emitted by Earth is absorbed by carbon dioxide and water vapor in the atmosphere
(4) gamma radiation emitted by Earth is absorbed by carbon dioxide and water vapor in the atmosphere

Mini Lesson 2: Energy Transfer – Conduction & Convection

Heat transfer by conduction occurs when heat is transferred from molecule to molecule. The closer the molecules are to each other the faster the transfer. It is also dependent on the type of material, for example heat travels faster through metal than through water.

Heat transfer by convection occurs due to differences in density. Heat is transferred through a fluid (gas or liquid). As the fluid is heated it becomes less dense and rises. Cold air (or water) is more dense, sinks and pushes the warm air (or water) up. This creates a convection current.



Need to know:

1. What heat transfer is from molecule to molecule (touching)? _____
2. Give two examples of heat transfer by conduction.
   a) _____
   b) _____
3. What does heat transfer by conduction depend on? _____
4. What causes heat transfer by convection? _____
5. What two states of matter does heat transfer by convection occur? _____
6. Why does warm air rise?
7. Describe how a convection current forms. _____

   _____
8. Give two examples of heat transfer by convection.
   a) _____
   b) _____
9. Which layer of Earth's interior has convection currents? _____
10. What do the convection currents in Earth's interiors cause to happen? _____

Introduction.

Conduction is heat transfer by touching, from molecule to molecule. The rate at which heat is transferred depends on the material the object is made of and the heat loss due to medium in which the heat needs to transfer through.

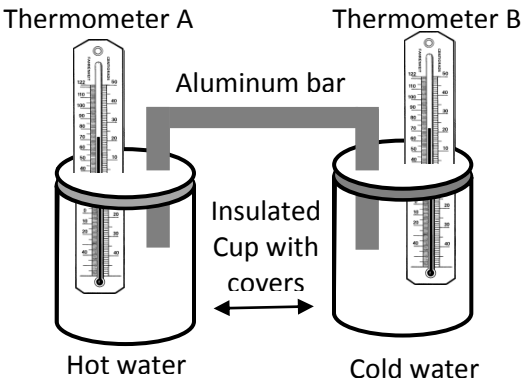
Materials
- ✓ Aluminum bar
- ✓ 2 insulated cups
- ✓ 2 lids
- ✓ 2 thermometers
- ✓ Water

Objective:

- To measure the amount of heat being transferred by conduction

Procedure:

1. Assemble the equipment as illustrated by the diagram below
2. Place the aluminum bar in both of the lids for the two containers.
3. Fill one insulated cup with cold water and the other with boiling water
4. Quickly place the lids (with the aluminum bar) on the containers with the water. DO NOT TOUCH the aluminum bar after this point.
5. When the thermometer in the hot cup reaches its highest point, record this temperature under Time 0 for the "HOT cup" in the data table provided. At exactly the same time record the cold temperature under Time 0 for the "COLD cup".
6. Continue taking temperature readings for both cups at one minute intervals for a total of 20 minutes. Record all data in the data table provided.



Data Table

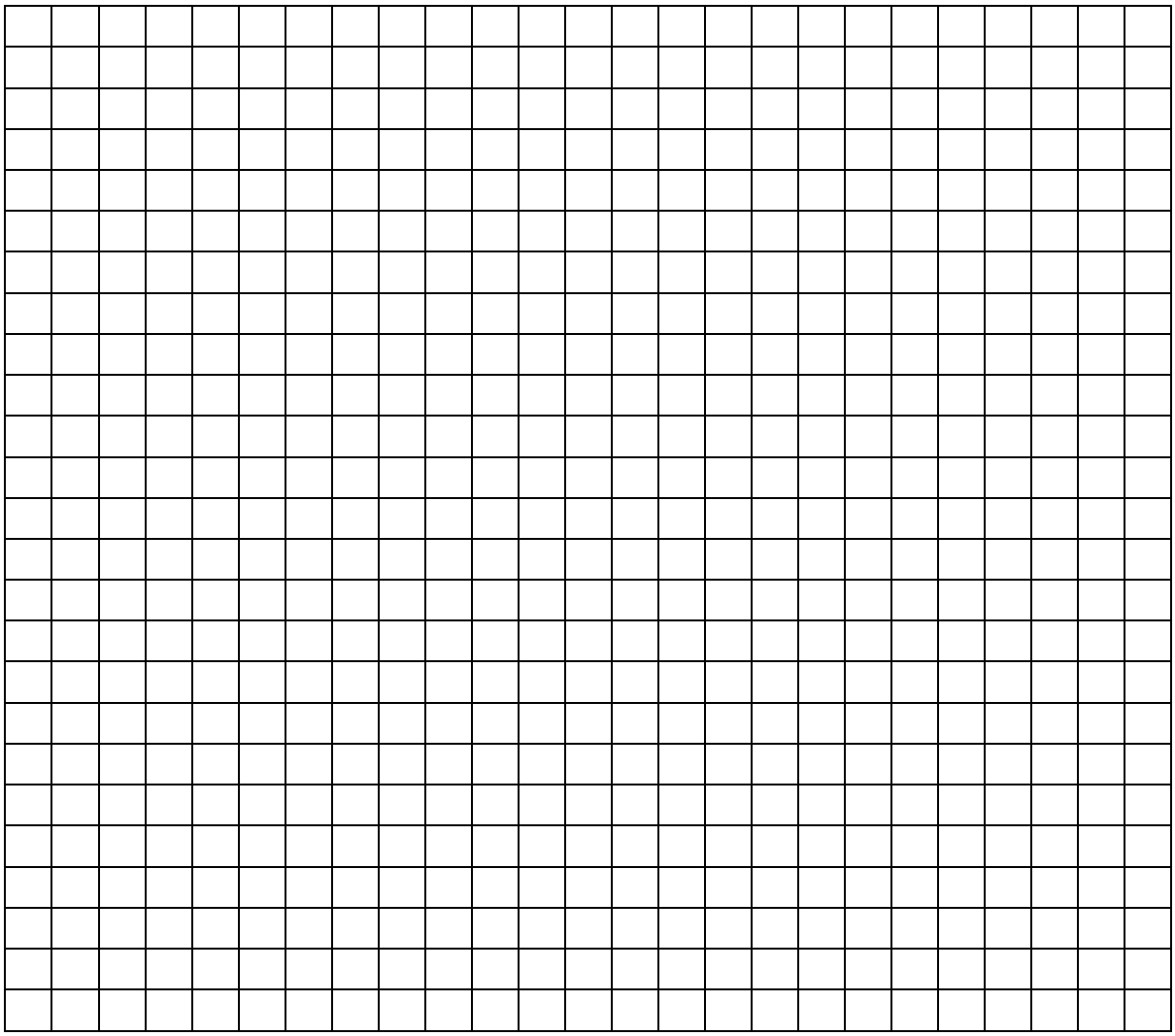
Time (min)		0	1	2	3	4	5	6	7	8	9	10
Temp (°C)	Hot cup											
	Cold cup											

Time (min)		11	12	13	14	15	16	17	18	19	20
Temp (°C)	Hot cup										
	Cold cup										

Line Graph for Hot and Cold

KEY

Hot cup Cold cup



✓ **Check Point**

1. Which cup was the heat source? (hot or cold) _____
2. Which cup lost heat energy? (hot or cold) _____
3. Which cup gained energy? (hot or cold) _____
4. How many degrees did the hot cup drop? _____ °C
5. How many degrees did the cold cup increase? _____ °C

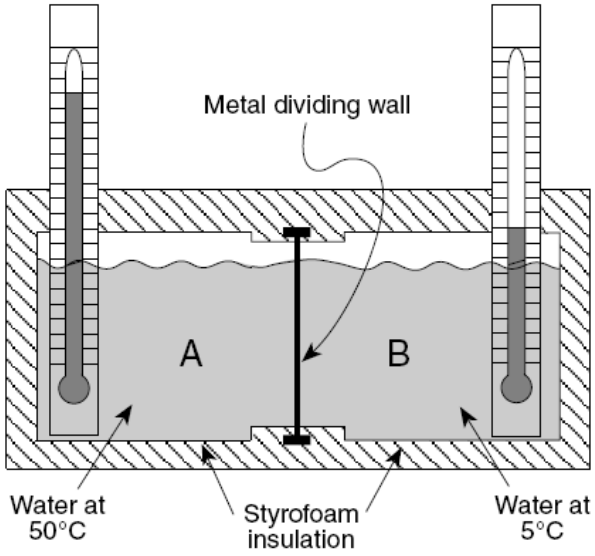
6. Explain why there is a difference between the amount of energy lost by one cup and the amount of energy gained by the other. Where did the lost energy go?

7. Explain why the hot cup changed temperature almost immediately and the cold cup took longer to warm up.

8. How could you modify the experiment to increase the rate and amount of heat transfer so?

9. What would happen to the temperature of the water in the hot and cold cup if you left it standing overnight?

10. Explain why the set up below would allow more efficient heating and less heat loss.



Introduction

Heat transfer by convection occurs due to differences in density. It doesn't matter if it is in a liquid or a gas, the properties are the same. Warm air and warm water both rise because they are less dense than cold water or air.

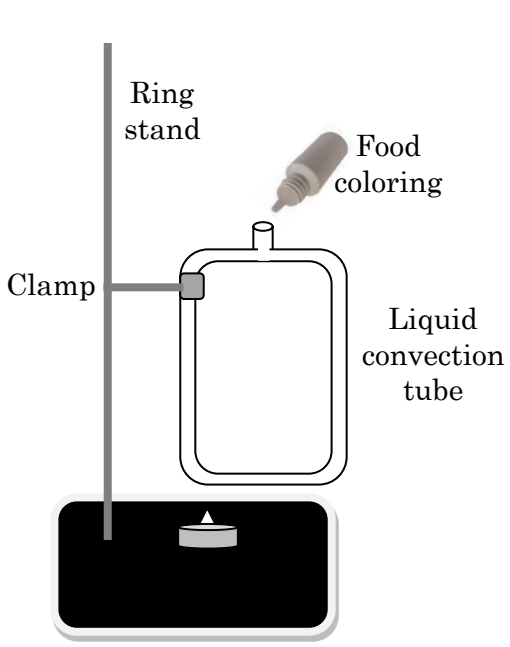
Materials
- ✓ Liquid convection tube
- ✓ Candle
- ✓ Ring stand
- ✓ Clamp
- ✓ Water
- ✓ Food coloring
- ✓ Gas Convection tubes
- ✓ Smoke paper
- ✓ Color pencils

Objective

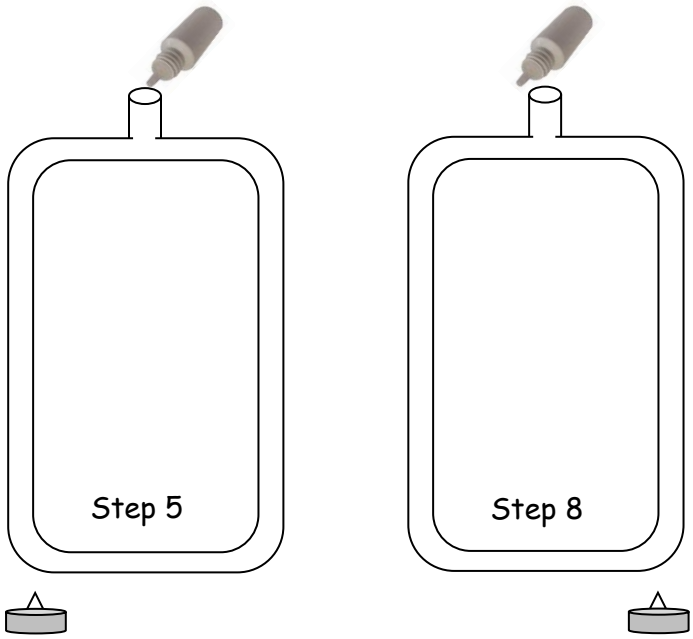
- Observe movement of air and water due to differences in density

Procedure A: Convection in a Liquid

1. Fill the convection tube with water.
2. Assemble the equipment as illustrated by the diagram below.
3. Light the candle under the tube filled with water.
4. Place four or five drops of food coloring in the top of the tube.
5. Draw your observations in the space provided below labeled "Step 5" to the right of the diagram (use a color pencil and arrows to show movement of food coloring).



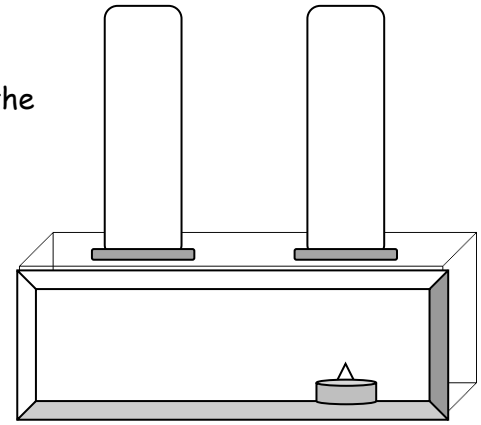
Draw observations below.



6. Empty the tube and refill it with water and reattach it to the apparatus.
7. Move the candle to the other side and repeat step 3 and 4.
8. Draw your observations in the space provided below labeled "Step 8" to the right of the diagram (use a color pencil and arrows to show movement of food coloring).

9. Describe in detail what is happening in the convection tube. Start with the candle, mention the water, density, the movement of water and the food coloring.

Procedure B: Convection in a Gas



1. Use the gas convection set up as illustrated in the diagram to the right.
2. Carefully remove the glass plate in the front of the apparatus.
3. Use a match and light the candle and place it under the tube on the right.
4. Replace the glass plate.
5. With a new match light the smoke paper.
6. Hold the smoke paper over the tube above the candle.
7. Write your observations below.

8. Move the smoke paper over the left tube without the candle.
9. Draw your observations in the diagram above. Use a grey color pencil to illustrate the smoke and remember to use arrows.
10. Write your observations below.

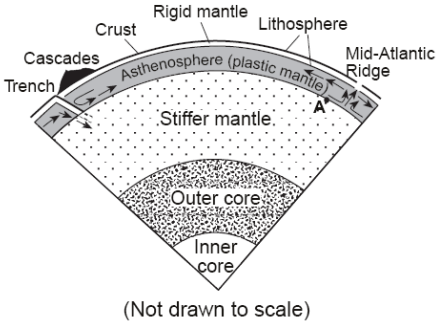
11. Describe in detail what is happening to the smoke in the convection tube when it was held over the left tube without the candle. Start with the candle, mention the air, density, the movement of smoke.

Regents questions

____ 1. During which process does heat transfer occur because of density differences?
(1) conduction (2) radiation (3) convection (4) reflection

____ 2. What is the primary method of heat transfer through solid rock during contact metamorphism?
(1) advection (2) absorption (3) convection (4) conduction

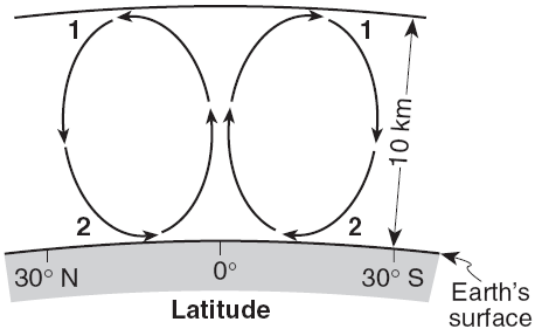
____ 3. The diagram to the right shows a portion of Earth's interior. Point *A* is a location on the interface between layers. The arrows shown in the asthenosphere represent the inferred slow circulation of the plastic mantle by a process called
(1) insolation (3) conduction
(2) convection (4) radiation



(Not drawn to scale)

Base your answers to questions 4 through 6 on the cross section below and on your knowledge of Earth science. The cross section shows the general movement of air within a portion of Earth's atmosphere located between 30° N and 30° S latitude. Numbers 1 and 2 represent different locations in the atmosphere.

____ 4. Which temperature zone layer of Earth's atmosphere is shown in the cross section?
(1) troposphere (3) mesosphere
(2) stratosphere (4) thermosphere



(Not drawn to scale)

____ 5. The air movement shown in the cross section is due to the process of
(1) condensation (2) conduction (3) evaporation (4) convection

____ 6. What is the approximate percentage by volume of oxygen present in Earth's atmosphere at location 2?
(1) 10% (2) 33% (3) 21% (4) 46%

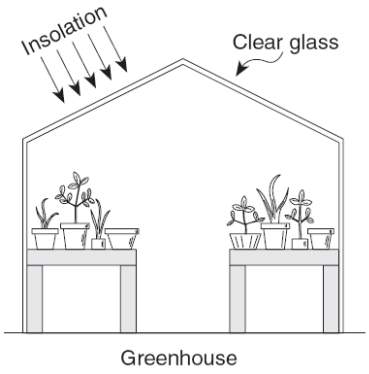
____ 7. Which type of surface absorbs the greatest amount of electromagnetic energy from the Sun?
(1) smooth, shiny, and dark in color (3) rough, dull, and dark in color
(2) smooth, shiny, and light in color (4) rough, dull, and light in color

____ 8. One reason Massena, New York, has a colder climate than Binghamton, New York, is that Massena

(1) absorbs more rays of incoming solar radiation
(2) is usually closer to the source of solar radiation
(3) receives shorter wavelengths from the source of solar radiation
(4) receives lower angle rays of incoming solar radiation

____ 9. The diagram to the right shows a greenhouse. What is the primary function of the clear glass of the greenhouse?

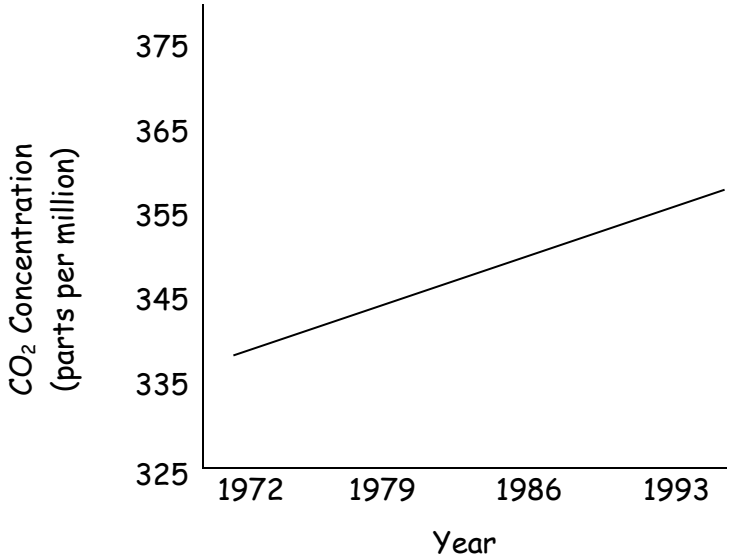
(1) The glass reduces the amount of insolation entering the greenhouse.
(2) The glass allows all wavelengths of radiation to enter and all wavelengths of radiation to escape.
(3) The glass allows short wavelengths of radiation to enter, but reduces the amount of long wavelength radiation that escapes.
(4) The glass allows long wavelengths of radiation to enter, but reduces the amount of short wavelength radiation that escapes.



____ 10. Electromagnetic energy that is being given off by the surface of Earth is called

(1) convection (2) specific heat (3) insolation (4) terrestrial radiation

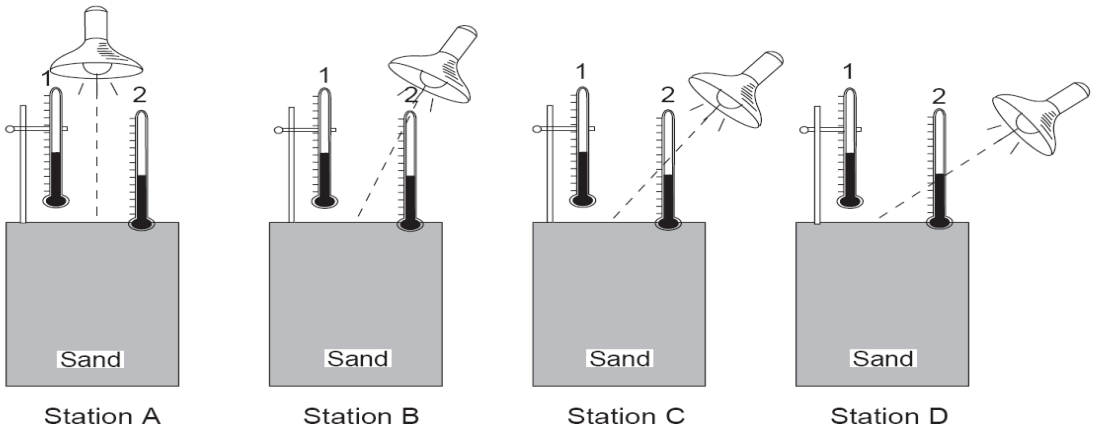
____ 11. The graph below represents the average yearly concentration of carbon dioxide (CO_2) in Earth's atmosphere from 1972 to 1993.



This change in CO_2 concentration most likely caused

(1) a decrease in the average wavelength of solar radiation
(2) a decrease in the thickness of Earth's atmosphere
(3) an increase in the absorption of long-wave heat radiation by Earth's atmosphere
(4) an increase in the thickness of Earth's glaciers

Base your answers to questions 12 through 16 on the diagram below and on your knowledge of Earth science. The diagram represents four stations, *A, B, C,* and *D,* in a laboratory investigation in which equal volumes of sand at the same starting temperature were heated by identical light sources. The light sources were the same distance from each station, but at different angles to the surfaces. Two thermometers were used at each station, one just above the surface and the other just below the surface. The lights were turned on for 30 minutes and then removed for the next 30 minutes. Temperatures were recorded each minute for the 60 minutes.



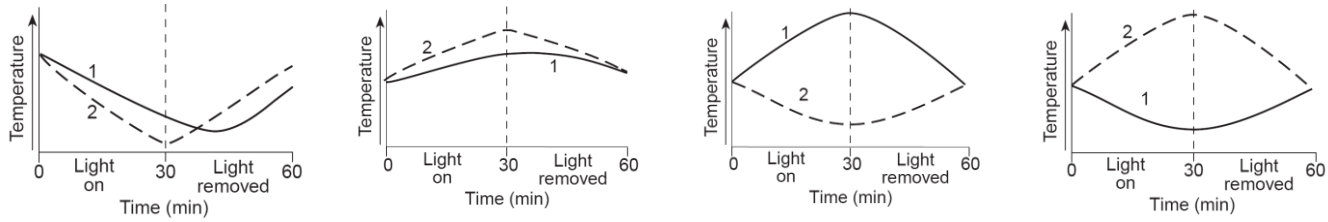
____ 12. Most of the energy from the light sources was transferred to the sand by the process of
(1) conduction (2) transpiration (3) convection (4) radiation

____ 13. Which type of sand surface would most likely absorb the most radiation?
(1) dark colored smooth surface (3) dark colored rough surface
(2) light colored smooth surface (4) light colored rough surface

____ 14. Which station received the *least* intense light energy?
(1) A (2) B (3) C (4) D

____ 15. After the light sources were removed, the electromagnetic energy radiated by the cooling sand was mostly
(1) infrared rays (2) visible light rays (3) ultraviolet rays (4) gamma rays

____ 16. Which graph best represents the temperatures that would be shown by thermometers 1 and 2 at station *A*?



(1) (2) (3) (4)

____ 17. At an altitude of 95 miles above Earth's surface, nearly 100% of the incoming energy from the Sun can be detected. At 55 miles above Earth's surface, most incoming x-ray radiation and some incoming ultraviolet radiation can no longer be detected. This missing radiation was most likely

(1) absorbed in the thermosphere
(2) reflected by the stratosphere
(3) absorbed in the mesosphere
(4) reflected by the troposphere

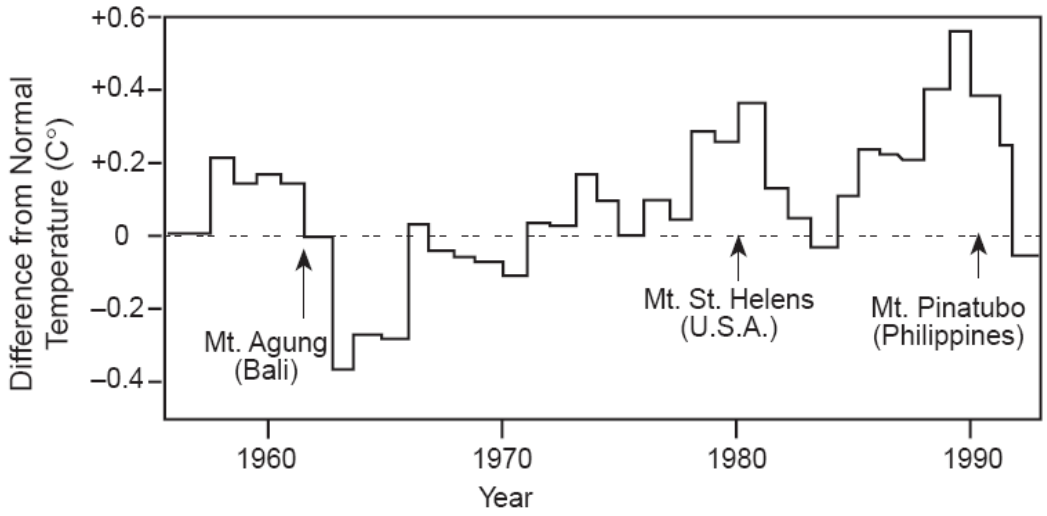
____ 18. As the ability of a substance to absorb electromagnetic energy increases, the ability of that substance to radiate electromagnetic energy will

(1) decrease (2) increase (3) remain the same

____ 19. What is the usual cause of the drop in temperature that occurs between sunset and sunrise at most New York State locations.

(1) strong winds
(2) ground radiation
(3) cloud formation
(4) heavy precipitation

____ 20. The graph below shows atmospheric temperature variations on Earth between 1956 and 1993. The dates of three major volcanic eruptions are indicated.



What is the most probable reason that Earth's atmospheric temperature decreased shortly after each major volcanic eruption?

(1) Water droplets produced by the eruptions absorbed terrestrial reradiation.
(2) Ozone produced by the eruptions absorbed ultraviolet radiation from the Sun.
(3) Volcanic dust from the eruptions blocked insolation.
(4) Carbon dioxide gas from the eruptions blocked terrestrial reradiation.

Mini Lesson 3: Properties of Water

Water is the only substance that can be found in nature as a solid, liquid or gas. Solid water (ice) has molecules that are tightly packed, liquid water molecules are still bound together but allows it to flow easily. As in any gas, the molecules of water vapor are not bound together and flow freely. In order to change from one phase to another, energy needs to be added (gained) or removed (released). The amount of energy required is dependent on which phase water is in. For example, it takes much more energy to evaporate water than it does to melt the same amount of ice. As a phase change is taking place all of the energy is being used to change phase. This is called latent heat.

Need to know:

1. What is the only substance that can be found in nature in any state of matter? _____
2. Describe how the molecules are packed in each of the following states of matter.

   Solid _____

   Liquid _____

   Gas _____
3. What does a substance need in order to change phase? _____
4. Which takes more energy, melting ice of evaporation of water? _____
5. What is it called when all of the energy added or released in being used to change the phase of water? _____

"Properties of Water" Earth Science Reference Tables - Front Cover

1. How much energy is gained during melting? _____
2. How much energy is gained during vaporization? _____
3. How much energy is released during freezing? _____
4. How much energy is released during condensation? _____
5. Which two changes in phase need to gain energy to occur?

   _____ and _____
6. Which two changes in phase need to lose energy to occur?

   _____ and _____

Regents Questions:

____1. Which process requires water to gain 334 Joules of energy per gram?
(1) vaporization (3) melting (2) condensation (4) freezing

____2. What is the latent heat of vaporization of water?
(1) 334 J/g (2) 540 J/g (3) 2260 J/g (4) 80 J/g

____3. During which phase change of water is the most energy released into the environment?
(1) water freezing (3) water evaporating
(2) ice melting (4) water vapor condensing

____4. Which phase change requires water to gain 2260 Joules per gram?
(1) solid ice melting (3) liquid water vaporizing
(2) liquid water freezing (4) water vapor condensing

____5. During which process does water gain the most heat energy?
(1) condensation (3) evaporation
(2) freezing (4) melting

____6. During which phase change will the greatest amount of energy be absorbed by 1 gram of water?
(1) melting (2) freezing (3) evaporation (4) condensation

Show all calculations for questions 7 through 10.

7. How many Joules of energy are required to melt 5 grams of ice?

---

8. How many Joules of energy are required to evaporate melt 100 grams of ice?

---

9. How many Joules of energy are released when freezing 200 grams of water?

---

10. How many Joules of energy are released when condensing 200 grams of water vapor?

Introduction:

Latent heat is the amount of heat energy that is either released or absorbed during a phase change.

Materials
- ✓ Hot plate
- ✓ 400 mL glass beaker
- ✓ Ice
- ✓ Water
- ✓ Thermometer
- ✓ Stirring rod
- ✓ Color pencil
- ✓ Stop watch

Objective:

- Determine what happens to the heat energy during a change phase

Procedure:

1. Place 100 mL of water into the beaker
2. Fill the rest of the beaker with ice.
3. Stir the ice in the beaker so that the water is as cold as the ice will allow (about 2 minutes).
4. Take the temperature and place it in the data table below under time zero (00 min 00 s).
5. Turn the hot plate on high. Continue to stir the ice water mixture the entire time of the experiment.
6. Take temperature reading every 30 second and record it in the data chart below.
7. When all of the ice has melted, color that box yellow.
8. Continue to stir the water and taking temperatures.
9. Once the water begins to boil (rolling bubbles), color that box yellow.
10. Continue to stir the water and taking temperatures for an additional 10 minutes.
11. Graph the data on page 35. Remember to label the axis with units.
12. Circle the point that represents what the temperature was when all of the ice was melted.
13. Circle the point that represents what the temperature was when all of the ice was boiling.
14. Describe what happened to the temperature of the ice while it was melting.

15. Describe what happened to the temperature of the water while it was boiling.

16. If the added heat was not raising the temperature, where did the added energy get used?

Data Table

Time		Temp (°C)
00 min	00 s	
00 min	30 s	
01 min	00 s	
01 min	30 s	
02 min	00 s	
02 min	30 s	
03 min	00 s	
03 min	30 s	
04 min	00 s	
04 min	30 s	
05 min	00 s	
05 min	30 s	
06 min	00 s	
06 min	30 s	
07 min	00 s	
07 min	30 s	
08 min	00 s	
08 min	30 s	
09 min	00 s	
09 min	30 s	
10 min	00 s	
10 min	30 s	
11 min	00 s	
11 min	30 s	
12 min	00 s	

Time		Temp (°C)
12 min	30 s	
13 min	00 s	
13 min	30 s	
14 min	00 s	
14 min	30 s	
15 min	00 s	
15 min	30 s	
16 min	00 s	
16 min	30 s	
17 min	00 s	
17 min	30 s	
18 min	00 s	
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19 min	00 s	
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21 min	00 s	
21 min	30 s	
22 min	00 s	
22 min	30 s	
23 min	00 s	
23 min	30 s	
24 min	00 s	
24 min	30 s	

Time		Temp (°C)
25 min	00 s	
25 min	30 s	
26 min	00 s	
26 min	30 s	
27 min	00 s	
27 min	30 s	
28 min	00 s	
28 min	30 s	
29 min	00 s	
29 min	30 s	
30 min	00 s	
30 min	30 s	
31 min	00 s	
31 min	30 s	
32 min	00 s	
32 min	30 s	
33 min	00 s	
33 min	30 s	
34 min	00 s	
34 min	30 s	
35 min	00 s	
35 min	30 s	
36 min	00 s	
36 min	30 s	
37 min	00 s	

Time		Temp (°C)
37 min	30 s	
38 min	00 s	
38 min	30 s	
39 min	00 s	
39 min	30 s	
40 min	00 s	
40 min	30 s	
41 min	00 s	
41 min	30 s	
42 min	00 s	
42 min	30 s	
43 min	00 s	
43 min	30 s	
44 min	00 s	
44 min	30 s	
45 min	00 s	
45 min	30 s	
46 min	00 s	
46 min	30 s	
47 min	00 s	
47 min	30 s	
48 min	00 s	
48 min	30 s	
49 min	00 s	
49 min	30 s	

✓ **Check Point**

1. According to your graph did the temperature of the water increase while the ice was melting? _____
2. According to your graph, what change occurred in the temperature of the water between the time the ice melted and the water boiled? _____
3. According to your graph, what change occurred in temperature after the water began to boil? _____
4. Refer to the slope of your graph between the time the ice melted and the water boiled. What can you tell about the **rate** of temperature change? _____
5. Describe the energy input during each minute of the experiment. _____

_____

6. Before the temperature began its steady rise, for what was the added heat energy being used?

_____

7. What changes in temperature occurred during the last ten minutes? _____
8. What was the added heat energy being used? _____

_____

9. What is another term for the potential energy that is stored during a phase change?

_____

10. Which phase change required the most added heat energy? _____

11. How much energy is required during each of the following phase changes. Do not forget units.

    Evaporation _____

    Melting _____

12. How much energy is released during each of the following phase changes. Do not forget units.

    Condensation _____

    Freezing _____