1-1-2016

16.0.C.1 Hands-on Convection and Radiation

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Station A

Inspect the materials: A tiny room (box) with two chimneys. A glass window that can be slid to the side. It also has a fire place (candle).

Procedure: Record data and observations

- Slide the window open.
- Light the candle.
- Carefully place the candle underneath one of the chimneys. Close the window.
- After about a minute, light a piece of incense. Hold the incense just inside the opening of each chimney and watch the flow of smoke.
- Using a digital thermometer, test the temperature of the air at the opening of both chimneys.
- Blow out the candle.

Immediate question: When you have a fireplace in the house, where does a lot of the heat go?

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Station B

Inspect the materials: A ring of clear tubing connected with a T joint. Note that the joint tilts out of the plane of the ring. There is also a bottle of food dye.

Procedure:

- Fill the ring completely with water: Take it over to the sink. Remove one side from the T joint. Fill the tube as much as possible, re-attach the joint (tilted), and finish filling with a plastic pipet so that the ring has unbroken water, but the open part of the T is air. There should be no large bubbles around the tube.
- Carefully so there are no spills, lay the ring flat on a bench top (this is why the T joint is out of the plane of the ring (so the water stays in the ring).
- Add several drops of food dye into the open part of the T. If necessary, add a little water to rinse the dye into the ring.
- The ring is still flat. For reference, consider the T position to be 12 o'clock. Use the heat gun to warm the tubing at 3 o'clock. Observe what, if anything, happens to the location of the dye.
- Pick the tubing up at the T joint and hang it between two clamp/ring stands with the T at the top. Use the heat gun to warm the tubing at 3 o'clock. Observer what, if anything, happens to the location of the dye.
- Take the tubing to the sink, tilt or detach one side of the T to let the water run out, attach the hose to the water faucet. SLOWLY turn on the water to rinse the dye out of the tubing.

Immediate question: You should see dye movement only when the tubing is vertical. What change in property of the water is caused by the heat gun to cause this movement?

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Station C

Inspect the materials: Taped to a piece of paper are pieces of thermochromic paper with different temperature zones; black, green, red, and white paper, overlapping each other. Red laser pointers

CAUTION: Laser light is disorienting and potentially harmful if it is directed or reflected into the eye.

Procedure:

- Predict how bright the red laser spot will look on each surface: white, black, red, green.
- Shine the laser onto the white surface. With the spot still on, slide the spot onto the black surface. What happens to the brightness of the spot? Slide spot back and forth to confirm. Is the change in brightness what you predicted?
- Repeat this process comparing the white surface and red surface.
- Repeat this process comparing the white surface and green surface.
- Repeat this process comparing the black surface and green surface.
- Hypothesis: If laser light carries energy, and if a surface absorbs the light, the energy must be deposited there. Use the thermochromic papers to test this hypothesis. The three pieces of thermochromic paper have change regions of 15-20 ^{o}C, 20-25^{o}C, and 25-30^{o}C. Be patient. Only one of the papers might respond.

Immediate question: Complete these sentences: When an object has a red color, it (absorbs/reflects) red light well. When an object has a green color, it (absorbs/reflects) red light well. When an object absorbs light, the energy in the light may be converted to ……..

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Station D

Inspect the materials: A handheld infrared light detector.   A heat lamp. A regular light bulb. The glass door of a fume hood.

Procedure:

- Test the IR “thermometer” by pointing it at various surfaces and seeing what temperature it shows (can use C or F scale):   test someone’s hand, inside someone’s mouth, a surface inside the room, the surface of one of the outside windows.   Any object emits radiation dependent on its temperature because of the vibrations of the atoms and molecules. This device detects infrared, which is a major part of the radiation from objects in the range of 0 ^{o}C to several hundred ^{o}C.
- Aim the sensor at anything that is not at room temperature. Then hold a notebook in the line of sight. Note how fast the reading changes.
- Turn on the IR lamp. Aim the IR sensor directly at the IR lamp. Slowly sweep the aiming point across the lamp to see where the highest temperature can be found. Record that temperature. Do the same for the regular light bulb.
- Position the heat lamp or light bulb next to the glass door of a fume hood. Point the heat lamp horizontally and parallel to the glass door. You should be able to position yourself so you can see a reflection of the light off the glass door.   Aim the IR sensor at the lamp until you can see the maximum temperature. Record that. Point the sensor toward the reflection of the lamp in the glass door. Move the sensor back and forth. Can you detect that the heat from the lamp is bouncing off the glass door?   [If the glass door doesn’t work, dry a sheet of aluminum foil.]

Immediate question: What evidence did you see in this activity that tells you that this type of heat is a type of light?

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Station E

Inspect the materials: a microwave oven and small beakers of water. This oven uses an electronic component to create radiation that is farther away from visible light than infrared.

Procedure:

- Using a digital thermometer, test the temperatures of each small beakers of water. They should be the same within a degree and close to room temperature.
- Check the temperature of the air inside the oven.
- Put one small beaker into the center of the microwave oven, set the time to 10 sec, and start. Measure the temperature of the water and the air inside the oven afterwards.
- Put a different beaker of water into the oven, set the time to 20 sec, and start. Measure temperature.
- Repeat for 30 sec, 40 sec, 60 sec. Use a fresh beaker each time.

Immediate question: What evidence do you have that the water is not being heated by conduction of heat? What evidence do you have that microwave radiation carries energy?

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Station F

Inspect materials: Computer station with PhET "Black body spectrum". This station investigates the radiation given off by solid or liquid objects simply because of their temperature and the amount of atomic/molecular vibration that causes. You will explore the characteristics of this phenomenon.

Procedure:

- Note the variables on the two axes.
- Adjust the horizontal axis scale so you can see clearly where visible light and colors are. Identify the shortes and longest wavelengths that humans can see. Infrared is to longer wavelengths, and microwave is to even longer wavelengths. What region is to shorter wavelength?
- Set the object temperature to that of the sun. What T is that in K (in ^oC?) Adjust the horizontal and vertical axes until you can see most of the red curve. This shows the intensity of light emitted because of the Sun's surface temperature. Is the emission at a single wavelength or a range? At what wavelength (color) is the maximum intensity? Why does the sun look "white" to us (or even slightly yellow-green?)
- Note that the little dots on the display [B G R star] change color according to how bright we would see each color or how the total color would look to us.
- For a stars hotter than our sun, what color coud they be? Betelgeuse is a red giant star. About what temp would that star be?
- Set the horizontal axis to a range of about 1.5 micrometers. Pretend you turn on a heating element on top of a stove. The temperature starts at room temp but increases to about 900 K. If you watch the burner element, you will see no color, then red, then yellow, and then if you crank it, whitish. Explain that.
- The average temperature of Earth is about 300K. What wavelength range is Earth's blackbody emission range. What would happen to the planet's temperatu is more visible light arrived? If less IR light escaped.

Immediate question: What would happen to the temperature of Earth is more visible light arrived at the surface? What would happen to the temperature of Earth is less infrared light escaped out into space?

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Station G

Inspect materials: A bell jar attached to a water aspirator; the jar contains a small inflated balloon.

Procedure:

- The bell jar is attached to a water aspirator. When you turn on the water, it draws air from the jar (the balloon will inflate, indicating the drop in pressure outside the balloon).
- Shine a laser through the bell jar onto a piece of white paper. Note its brightness.
- Turn on the water, until the balloon indicates that the inside of the bell jar has a lower pressure. Then shine the laser through the jar again. Is the intensity any different?
- If you're not sure, keep the laser light on and have someone release the pressure in the jar.

Immediate question: Does light need matter present in order to "travel"?

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The experiments we did before break and the ones you did today demonstrate the fundamental ways in which heat can move. There is convection, conduction, and radiation. Conduction is what you explored before break and what you wrote about recently.

Activities A and B are about conduction. Develop a concise description of what conduction is that encompasses what you saw, and how this process “moves heat”.

The other activities are about radiation. Develop a concise description of what radiation is and how this process “moves heat”. Identify the fundamental ways in which movement of heat by radiation is different from the other mechanisms by which heat moves.

Write these things down and bring with you to class on Thursday.

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RECORDER REPORT, Chem 444A "Fire & Ice"

Group Member Name | Role | Date: March 24, 2015

Kaleigh Z

Taylor W.

3

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tation C:

When an object has a red color, it reflects red light well. When an object has a green color, it absorbs red light well. When an object absorbs light, the energy in the light may be converted into heat because it leaves a residual gray mark on the black thermochromic paper.

ation D:

Light bulb: 270.1°F

IR Lamp: 287.2°F

IR Lamp after placed next to glass door: 382.8°F

The evidence we saw in this activity was that the temperature of the glass where the light was reflecting was around 110°F, while the temperature of the glass where the light was not present read around 87°F. This proves that the type of heat is a type of light.

tation E:

a) Initial H_2O: 19.8°C

H_2O after 10 sec in microwave: 40.5°C

Air in microwave:

b) Initial H_2O: 19.9°C

H_2O after 20 sec: 48

Air in oven After: 20.5

c) H_2O after 30 sec: 70.2°C

Air in oven After: 35.6

he evidence that proves the water is not being heated by onduction is that the air in the microwave was remaining relatively he same, while the temperature of the water increased. We know hat it is being heated by microwave radiation. The evidence to upport this is that the water is heating up, thus gaining energy from the microwave

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Station G:

Light does not need matter present in order to "travel" because when we pointed the laser through the vaccuum we could still see the light when all of the matter was sucked out of the vaccuum. When there was nothing inside, the light still traveled to the other side of the vaccuum device.

Station A:

Observations -

We observed that the smoke from the incents flowed downward into the room, when placed above the chimney without a candle. The smoke traveled upward, away from the room, when placed above the chimney with the candle underneath.

Temperatures -

Chimney (without candle) = 21.6°C

Chimney (with candle) = 46.3°C

When you have a fireplace in your home, most of the heat goes outside of the home and travels back up the chimney, to the outdoors.

Station B:

The heat gun is giving heat energy to the water in the tubing. The increased heat is causing the water molecules to speed up and spread out, making room for the green dye to move through the tube.

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Group Member Name | Role | Date: 3/24

Group Member Name	Role
Samantha	recorder
Eliza	
Jake	

3

(F) If more visible light arrived at the surface some of it would bounce off and the Earth would heat up, like global warming. If less infared light escaped it would also heat up.

(G) ~~[scribbled out]~~
matter is not required for light to travel, because when the air was removed the light was still there, so air particles do not affect the traveling of the light. Light travels with or without particles and it did not change intensity.

(A) When you have a fireplace in the house, the heat rises, and that "vacuum" flow pulls on the air in the surrounding area up as well, which is why the spot with no chimney, when ~~[crossed out]~~ incense placed above, had the smoke pulled toward the heat source (candle) and it all rose up the "chimney". This proves that heat is a force.

(B) The property of water that is changed by the heat of the heat gun was that when we put heat on one portion, the water from there went "down and clockwise, while the other water was pushed around to make the dye move down to the heat, we think.

(C) When an object has a red color it <u>reflects</u> red light well.
When an object has a green color it <u>absorbs</u> red light well.
When an object absorbs light, the energy in the light may be converted to <u>heat</u>.

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(D) 248.2°F - IR
163.1°F - regular
In this activity, the IR light is a type heat because it reflected off of the glass like light would

(E) water (I): 63.6°F
air (I): 74.9°F
microwave (I)

10	20	30	40	60	time
88.5°F	119.4°F	142°F	203°F	207°F	temp of water
67°F	72.2°F	76.5°F	77°F	81°F	temp of air

It is not conduction of heat because the air is not really changing, it is radiation because the longer the water is exposed to radiation, the hotter it gets at a much faster rate than the air.

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Group Member Name | Role | Date: March 24

Emily Koester

Kyle

Calé

3

D| Highest temp IR = ~~119°C~~ 192°C (pointing @ middle of bulb)

Highest Py = 195°C at center

on glass = 40°C

Question: The heat was reflected ~~onto~~ the glass just like light is reflected and the hottest part of the bulb was the brightest part.

oven temp ~~initial~~ = 30.6°C . All beakers = ~23°C

E| micro = 25°F

① 10 sec 56°C H_2O

② 79.7°C

③ 30 sec 85°C

Question 1) The microwave itself is not not
2) water was evaporating, which requires energy

F| 700 nm = ~~longest~~ wavelength 400 nm = shortest
visible light = shorter wavelengths

Sun = 5520 K
max intensity = green
Sun emits all colors, so ~~[illegible]~~ appears white
Hotter stars = more blue/purple. Cooler = more red
As stove gets hotter, emits broader spectrum of wavelengths and looks white

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Question 840 K
- It would get hotter than 840 K
- would also be hotter if less infrared escaped

(5) (1) Matter is not required for light to travel.

[A] candle chimney = 34°C
smoke goes up

empty ~~chimney~~ chimney = 21.5°C
smoke down

Question:
A lot of the heat goes out the chimney

(3) As the water heats at the point of heat sun, the molecules ~~[illegible]~~ become less densely packed. This pushes the dye down the other side away from the heat source.

[C] Question
Red objects reflect red light well.
Red absorbs red light well.
Green absorbs red light well.
When an object absorbs light, the energy may be converted into thermal energy.

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Group Member Name	Role	Date: 3/24
Tim		3
Emily D.		
Amanda J.		

G) No because even when we took matter out of the container by creating a vaccum seal, the light still traveled but it just had a duller presence.

A) observations:
long w/ incense = 41.8°c
short chimney = 31°c
Based on our data most of the heat goes up the chimney and follows the known fact that heat rises. To prove the concept of convection we believe that the cold air is being pulled in through the small chimney and pushes the hot air out the long chimney which can be seen by observing the smoke.

B) When using the heat gun we are warming up the water causing the molecules to move faster. Due to the increase in energy it allows the dye to move through it and it must be vertical due to gravity

C) Predictions: red - Least noticeable (4)
white - (2)
black - darkest/most vibrant (1)
green - (3)
ranked in most visible/brightest

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- White is brighter than black, not what we predicted
- Green & black are equal and white & red are equal.

when an object has a red color, it reflects red light well. [When] an object has a green color, it absorbs red light well. When an object absorbs light, the energy in the light may be converted to thermal energy.

D) IR lamp = 413 °F } seperate
Reg light bulb = 160 °F

IR lamp = 413 °F } there is a minimal heat transfer between
glass door = 138 °F } the light and the glass.

You have a reflection so you can tell there is light, but you are also able to measure a slight heat change showing that the surface gains heat.

E) water temp beginning: 62.5 °F
Air temp: 74 °F
Microwave temp: 77.2 °F

Seconds	10	20	30	40	60
Microwave	75.3 °F	78.2	78.3 °F	78 °F	
water	102.5 °F	145.4 °F	190 °F	198 °F	

Not Finished

We know that the water is not being heated by conduction of heat because there is a drastic temperature difference in the microwave and water. Our proof of microwave radiation carrying energy is that the waters temperature increases while the microwave air temperature does not.

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(Ran out of time on some questions)

RECORDER REPORT, Chem 444A "Fire & Ice"

Group Member Name	Role
Nick Bouchard	Recorder
Emma	
Charles	

Date: 3/24/15

3

E.

water ~~temp~~: 22.1

microwave: 220°C

1.) water 63°C

micro: 23

Time(s)	Water °C	Microwave °C
0	22.1	22
10	63	23
20	80	23.4
30	93	25.3
40	94	28.1
60	99	29.5

Q: Our proof that heat isn't being conducted is that there is a difference between the water temp and the microwave air temp. The evidence we have that radiation carries energy is the water temperature increased. Therefore the heat (energy) is being transferred to the water causing its molecules to speed up.

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F:
y-axis: intensity (MW/m²/um) x-axis: wavelength (um)

Q. The temperature of Earth would be higher if more visible light arrived at the surface. If less infrared light escaped Earth would be hotter also.

G. Light doesn't require matter to travel. We come to this conclusion after doing the "balloon vacuum experiment". Even when there was no matter in the vacuum the laser still traveled.

A. Most of the heat escapes through the chimney. Our proof is that the escaping rising heat pushed the smoke from the incense straight up, illustrating the heat escaping

B. The moleculer of water began to move quicker when heated. Then stop the diffusion of the dye. The diffusion of the dye of the non-heated side. continued on the

C. (on) (out of time).

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Group Member Name | Role | Date: 3/24/15

Nick Bouchard

Emma

Charles

C. Red - brighter
Green - dull
white - brighest
black - dullest

Green → Black
duller →

- Brightness decreases.
- Red → White
Brighter →

When an object has red color, it absorbs red light well.

When an object has a green color it reflects red light well.

When an object absorbs light, the energy in the light may be converted to heat energy. We assume this because light "heats" up objects in contact with it.

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D. Ir lamp: 393 °F top center
regular bulb 373 °F top left

Ir lamp 414 °F
Glass - 104 not in light, 134 in light

We know that it was atleast absorbing it since the glass temperature increased.

Q: The evidence we have is the light causes the glass to heat up. Therefore the heat transferred to the glass is a type of light.

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