

Interactive Notes-“Heat Transfer”

Student Materials (per group of 4 students):

Demo 1	1-beaker (any size)- half full of ice
Demo 2	1-desk lamp
Demo 3	1-candle on its own stand
	1-ring stand
	1-ring
	1-wire pad
	1-beaker (any medium size- 250mL, 400, or 600) half full of tap water
	1-baggie with potassium permanganate (KMnO₄) granules
	1-plastic spoon
Demo 4	<i>(desk lamp again)</i>
...and	4-note sheets (see last page)

Additional Teacher Materials:

PowerPoint (see last page)

1-lighter- the kind with the clicker


1-cooler of ice

Beaker of water and food coloring- optional with demo #2

Beforehand:

- Insert page and paragraph numbers from relevant pages in your textbook at the bottom of slides 1 and 2 if you choose to have the class read from it together. This is a good way to connect with your textbook as well as transition into the next demo. You can also delete these page inserts, or Copy and Paste them onto later slides if needed.
- Set out extension cords for the lamps, if needed.
- Pour a few KMnO₄ granules into zipper-seal plastic bags. Use black marker to write “potassium permanganate (KMnO₄)” on the outside of each.
- In preparation for demo #3: turn on exhaust fans if you have them. The candles will create smoke when blown out. Remind yourself what to do in case of an emergency.
- As with any other demonstration, try these out ahead of time for yourself so you know how they work best and so you know what to expect.
- Print extra copies of the notes pages on paper for yourself, students that are slow writers or can't see well, and for absentees. Click “File” → “Print” → then where it says “Print what:" select “Handouts” → and then “OK”.
- Keep an extra lamp up front for yourself so you can refer to it as you're talking about demo #4. It wouldn't be a bad idea to have an entire set of materials for all demos either. *Showing* students what to do is about 100x easier than telling them.
- If your candles are brand new you might want to light them and let them burn a little so they're easier to light during class (when time is more valuable).

Interactive Notes: Heat Transfer



Do: Held an ice cube.

See: The ice melted & made my hand cold.

What's Happening: Cold things are cold because the atoms move slowly and don't collide as hard.

Atoms in hot things move faster and collide harder, producing more heat (**friction**). **Temperature** is the measure of how much heat these collisions produce.

Read p. 1 together

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1.

*Before student #1 begins, student #3 needs to get their demo started now so convection currents are occurring in the beaker when their turn comes. Go around and light the candles, or light them all up front and have students come get them. Tell students that anyone who plays with the flame will have theirs put out (and be ready to do so!). Tell each student #3 to set up the ring stand with the ring and wire pad so it's 2-3 inches above the flame. Set the beaker on the wire pad and the candle below on the ring stand base.

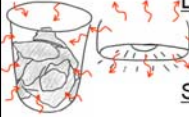
Now back to demo #1. Ask student #1 to take an ice cube or two from the beaker, put it in their hand, and just notice the coldness. As they do, start leading them through a series of questions meant to give them a whole new understanding of temperature- "Would you all agree that ice is H₂O? And what about when it melts- still H₂O? If both are the same molecule, what makes the atoms in ice feel cold? Have you ever thought about that? Another clue is that we could take melted and re-freeze it and make it cold again, right? If the atoms themselves aren't changing, I wonder if their behavior is what's changing."

What you're trying to do is put the thought in students' minds that temperature is really a measure of how active the atoms are. If we had the ability to see the atoms that make up air, we would see hot air moving much faster than cold air. And the faster they move, the harder they collide. Since those collisions generate heat due to friction, the harder they collide the more heat they give off.

Another example- "Imagine our class is at an amusement park and we're on the bumper cars. To make it more interesting we're all blindfolded! At first, before the switch is thrown, no one is moving, and with no collisions there's no heat generated (we're cold). Then the switch is thrown and the cars can move slowly. Every time they bump (*randomly.... consider mentioning Brownian Motion*), a little bit of heat is generated. When the switch is pushed all the way up the cars can go even faster, hit harder, and generate more heat." Students now see the connection between how fast atoms move and heat generated.

Caution concerning the fire in demo #3: Locate all fire safety equipment and be familiar with their operating procedure BEFORE doing this; keep the lighter for the candles in your pocket the whole time and blow out candles as soon as possible (right after demo #4); warn students to keep clothing, hair, hands, and any other flammables away from the flame; comply with the fire codes in your building.

2.



Do: Touched a cold beaker and a hot light bulb.

See: The beaker was colder than my hand, and the bulb hotter.

What's Happening: Heat can move 3 ways. This method, through direct contact, is called **Conduction**. Heat is carried through collisions of neighboring particles, always from areas of more heat to less.

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Tell student #2 to switch on the lamp and briefly touch the hot light bulb and then wrap their other hand around the beaker of ice. What they just did was touch the coldest and hottest things in the room. Ask if they know which direction the heat was moving in each case.

Get them thinking about the transfer of heat occurring between their hands and the hot and cold objects- “When you touched the cold beaker, heat left your hand and went into the beaker. Feel your hand- it’s cold now isn’t it? The heat that used to be there went into the beaker. And what about the light bulb? Which was hotter- your hand or the bulb? (bulb). So in this case it went from the bulb to your hand. Notice how heat spreads from areas of higher concentration to those of lower (see optional demo below).”

Optional demo- hold up a beaker of water and ask the class what will happen when you put a drop of food coloring into it. It will spread (diffuse) out evenly into the entire beaker, due to the movement of the water atoms. That’s also what heat does. It’s always moving, or spreading, from areas of higher concentration to lower. The same thing happens with the transfer of heat- it naturally moves from warmer to less-warmer objects. That’s why your hand is colder after touching the ice beaker and warmer after touching the light bulb.

Have student #2 turn the lamp off when done so the bulb is cool for demo #4.

3.



Do: Put KMnO_4 granules into water being heated.

See: Water continuously rose on the hot side and fell on the other.

What's Happening: Heat moves by **Convection**. Since warmer atoms are more active and need more space, they spread apart, making them lighter than the rest, so they rise. This is why heat rises.

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(At least 10 minutes should have passed since student #3 first set this up.)

Have student #3 first look into the water and try to detect any movement. It looks like there isn't any. Advance the slide to show the picture of the spoon with a few granules in it (shown to the right)- that's all the potassium permanganate they need. Instruct them to drop the granules on the "hot" side of the beaker (just above the candle), and then watch the beautiful streams of purple show how the water is actually moving. Ask if anyone knows the name of this movement (convection).




The reason this demo was put 3rd was so there would be 10 more minutes to watch the convection currents swirl.

If KMnO_4 is unavailable or just too risky for you, another way to show the currents is to add a spoonful of liquid hand soap or shampoo that contains either *glycol stearate*, *glycol distearate*, or *glycerol stearate* in it. It's what gives them their pearly, metallic look, and will form little "strings" when added to water, allowing you to see the convection currents. This method doesn't show the currents as effectively as the KMnO_4 and is harder to clean up with all the suds. If you'd rather do the shampoo version, substitute in that drawing and change the wording, if needed.

About the easiest kind of candle to use are the "votives". They're short and fat kind, so they stand on their own and will burn a good while. You might want to put a little square of wax paper or aluminum foil under it to catch the hot wax.

Caution: Potassium Permanganate is slightly toxic and reactive. Familiarize yourself with the [MSDS sheet](#). This demo was set up so that students would never come in direct contact with it. All bags should be sealed up to when the KMnO_4 is spooned and then resealed immediately after. Potassium permanganate is also a strong oxidizing agent. Students must remain a safe distance from the candle flame, as should anything else that's flammable-like hair, loose clothing, and paper.

4.



Do: Switched on a light.

See: Heat produced by the filament traveled through empty space but didn't become heat until it hit something and was absorbed.

What's Happening: Heat moves by **Radiation**. Electromagnetic waves carrying heat and other kinds of energy can pass through empty space. This is how sunlight heats the earth.

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Tell student #4 that you have a riddle for them to solve. Have them hold their hand right over front of the light bulb that's off and ask what they will feel when it is switched on (heat). And how quickly? (after a couple of seconds?... *which gives you a chance to remind them of the speed of light, about 300,000 meters per second*). "Ok, so you'll feel the heat through the air almost instantly, but then I want you to then touch the bulb as soon as you feel the heat over the bulb. Your brain will be telling you not to, but you're in for a big surprise when you touch it. Go ahead and do that now." (*they'll feel the heat through the air, but the light bulb will feel cool*).

"And the most puzzling thing of all (*advance to show the drawing of the bulb*) is what's happening inside the bulb. The tungsten filament is held in place by two contact wires, which carries the current to and from the filament. And what else is there inside? Nothing. It's a vacuum. The fact that you can see the filament glow is proof that light travels through empty space. And so can heat apparently."

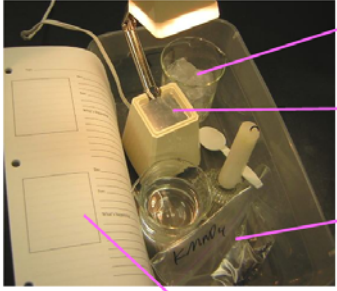
Try this yourself ahead of time so you know how close you need to hold your hand over the bulb for this to work as intended.

Keep an extra lamp up front so you can show students how to do this demo.

This is a nice demo to finish with because all three forms of heat transfer occur in it. Heat moves from the filament to the glass (and continues on) by radiation. When the glass bulb heats, air molecules on the outside of the bulb that touch it will heat (conduction). That air expands and rises (convection).

Instead of using light bulbs, radiometers (item #WW6280000 at sciencekit.com) are another good way to teach radiation. All you have to do is point a flashlight at the little fins inside of it and watch them spin. If you'd rather do this as a demo, substitute in that drawing and change the wording of the notes.

Clean Up- this is what your box needs to look like in 3 minutes.



Person 1
 •Pour off melted water
 •Fill beaker halfway with ice

Person 2
 •Turn lamp off and leave it plugged in.

Person 3
 •Seal KMnO_4 bag shut
 •Empty, rinse, and fill beaker halfway with water
 •Rinse hands

Person 4
 •Count 4 note sheets

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Leave refills of the note sheets in the back of your room: cooler with ice and note sheets.

If you don't want this slide to show, right-click on the slide and select "Hide Slide".


To help you with clean up, have your last science class take everything out of the boxes and put them in like piles in the back of your room.

Remind student #3 to wash/rinse hands to remove any residual potassium permanganate.

There is a little quiz in the folder with this lesson you can give at a later time. It would be a helpful way to review the 3 methods of heat transfer.

Come back and visit InteractiveScienceTeacher.com to upgrade this lesson with:

PowerPoint- lead your students through the lesson click-by-click




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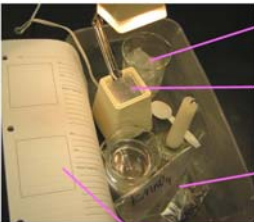
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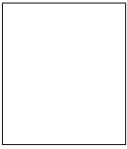
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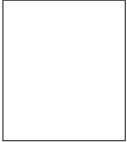
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Student Handout

Topic _____ Date ____/____/____



Do: _____
See: _____
What's happening _____



Do: _____
See: _____
What's happening _____

10 Question Quiz

1. During the summer it's cooler in the basement of your home than the upstairs.

Conduction
Convection
Radiation

To print this as a student handout: click "Print" or "Print", where it says "Print what" select "Handout", in the top right corner of the window.