SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Heat Transfer Part 2 **Grade 7 – Heat in the Environment**

Lesson Plan

Assessment	AFL, experiment, worksheet
Cross-curricular	

Big Ideas

- Heat is a form of energy that can be transformed and transferred. These processes can be explained using the particle theory of matter.
- There are many sources of heat.

Learning Goals

- Hot gas expands, compared to cold gas.
- Understand how heat creates convection currents.
- Understand convection from the local to global scale on Earth

Specific Expectations:

2.2 investigate the effects of heating and cooling on the volume of a solid, a liquid, and a gas
2.4 use scientific inquiry/experimentation skills to investigate heat transfer through conduction, convection, and radiation
2.5 use appropriate science and technology vocabulary
3.2 identify ways in which heat is produced
3.5 explain how heat is transmitted through convection, and describe natural processes that depend on convection
3.7 describe the role of radiation in heating and cooling the earth

Description:

This is the **second** lesson in a five-lesson unit on heat. The framework for the unit is to look at the heat transfer from solar energy on Earth. In this lesson we will look at the effect of heat on gas.

Materials/Resources:

Heat Transfer Part 2 Visuals, Reference Images, Experiment Worksheet
Several balloons
Place to freeze/cool a balloon
Plastic wrap or other clear plastic, Tape
1 box per group, two clear pop bottles
Scissors and X-Acto knives
1 tea light group (or "hot packs" for safety)
Lighters, matches
Incense sticks (or something that will smoke and not set off the fire alarm)
Optional: Thin black garbage bags
- String, Packing tape
- Short broom handle (to wind string)

Safety Notes

Caution working open flames and cutting blades

Introduction

Recap from lesson 1

- Yesterday students observed how heat can be transferred by radiation.
- This is how the Earth is heated by the Sun.
- We also saw that heat can be seen as the faster motion of particles in a hot material.

Heat and Gas

Discussion questions:

- **Once solar energy reaches Earth, what does it interact with first?** (The atmosphere)
- **What is the atmosphere made of?** (Different gases)
- In this lesson students will do some experiments to learn about the effects of heat on a gas in order to help us to understand our atmosphere.

Action

Frozen balloon experiment

- In lesson 1, students observed how heat increases the particle motion in a liquid (water).
- **Does the same happen in a gas? What happens to the volume of a gas if the particle motions increase?**
- Let's blow up balloons and put some of them in a cold place to see what happens to them.
- Perform experiment:
    - Get everyone to blow up one small balloon.
    - Either blow it up JUST until it is pressurized or tape masking tape around it as a ring. This will allow you to easily see if it shrunk. Unless you cool it with dry ice it won't totally deflate if you have it highly inflated to start with.
    - Place half of the balloons in the freezer or large cooler with ice in it.
    - Leave the other half out as a comparison.
- Since this requires a bit of time, students will perform another experiment in the meantime.

Optional: Heating Gas with the Sun

If it is a nice sunny day this is a great demo that fits in really nicely. It will demonstrate both that hot gas expands and that it rises. If weather or other conditions do not permit you to do this demo, just move on to the convection box activity. If you do this demo you should plan on taking an extra day to then build the convection box.

Prep ahead of time:

- Cut the bottom off of about 5 or 6 garbage bags
- Now tape all the garbage bags together into a long tube. Put a bag WITH a bottom at the end. You should end up with a long tube that is open on one end.
- Cut a long piece of strong and light string (e.g. 50 lbs. fishing line will work great) and wrap it around something like a broom handle piece or a dowel (so you can let out string like when you fly a kite)

Demo:

- Take your bag tube outside on a sunny day.
- Fill it with air by holding it open on one end and run with it until is fairly full. You may want to seal the end with your hands a couple of times and then "push down" the air that you have (so you end up with a "sausage" that you gradually fill up).
- Make sure that at the end you still have SOME room in the bags for air. Tie the string around the open end.
    - So now you should have a sealed sausage that is NOT totally inflated (maybe about 80% full)
- **Lay the tube out in the Sun.**
    - Observe how it fills out as it lies there. The hot air is expanding!
    - Notice that eventually it is starting to lift off (do NOT let go of the end of the string). This is because hot air has lower density than cold air.
        - This makes sense when you think about the fact that you sealed the bag with a certain amount of air in it. You noticed that it "filled out", but you didn't add any air to it. So the air inside the tube MUST be lower pressure – it takes up more space now and particles are further apart.

Convection Box

Convection is the second way (after radiation, discussed in lesson 1) of how heat can be transferred. It is also a very important mechanism in the Earth's atmosphere. For this reason we decided to focus the lesson on heat in the atmosphere. This is a nice activity to really give the students something they'll remember. If you are tight for time you could also just do this as a demo.

- Let us do an experiment to find out more about how heat affects the flow of a gas – in this case.
- Do we already know something about what happens to a gas that is heated? (Students may know that the gas rises).
- Let's build our device now:
    - NOTE: See reference images (See Materials/Resource section). Get each student group to complete each step, and then move to the next step as a class.
    - If necessary remove lids of box on one side – you want a box with ONE side open.
    - Place the box so that the open side is facing you, and the longest side lies on the table.
    - Cut two holes into the top of the box (one on each end) that will fit your bottle snugly.
    - Cut off the bottom of your bottles (so you end up with a tube of plastic)
    - Place the bottles into the holes and apply tape around the seam so that the air cannot escape anywhere except THROUGH the bottle.
    - Cover the front of the box with plastic. Make sure to tape it on so that there are NO air gaps. Leave one bottom corner open for now.
    - Place a candle under one bottle (by sliding it under the open corner of the plastic) and light it.
    - Finish closing the plastic.

- Wait a minute or two and then light the incense stick; hold it just inside the bottle that does NOT have a flame under it.
- Observe what happens:
  - Some of the smoke will be pulled down, and soon come up the other bottle again.
  - There is airflow present. Air is flowing up over the flame, and air is flowing down on the other side.
  - What you see is CONVECTION. The heated air rises up. This draws in cold air on the other side (to equalize the pressure in the box). Discuss that hot air rises because it has LOWER DENSITY than cold air.
  - Show Visuals on convection (See Link) and discuss further convection around a candle, in the box, and how it works on Earth (locally and globally).
  - Students complete the Convection Box Experiment worksheet. (See Link)

Consolidation/Extension

Return to frozen balloons

- Students have just learned that hot air has lower density than cold air. This means that hot air takes up more room!
- So what do you think might have happened to the balloons when we cooled them? (Take guesses). Let's see!
- Open the freezer/cooler and pull out the balloons.
  - They should look quite deflated.
  - Wait and see what happens – as they heat up they will inflate again.
  - Students complete the Frozen Balloon Experiment Worksheet. (See Link)
- **Discussion:**
  - As we learned, heat makes particles in a gas move more. This pushes them further apart and so the gas has a lower density.
  - It also has a higher pressure – allowing it to push back against the pressure of the balloon.
    - What is pressure?
- It is really the gas particles pushing against the balloon.
- This means that a warmer gas has HIGHER particle motion.
- When the gas gets cold its density increases and it now has less pressure to push back against the balloon because the particles move at a lower rate. So it deflates.
- We see the same result in lesson 1 when we looked at a liquid: heat increases particle motion.