IHAD Summer Camp Activities

Abbreviated Outline—Day 2

Day 2 : How does temperature affect matter?

Wednesday, July 12

1. **Pre-activity preparation**
2. **Recap properties of solids, liquids and gasses (10 minutes)**
   - Have the students recall the activities from Day 1
3. **PhET Simulation (___ minutes)**
   - Students use their understanding of states of matter to form a microscopic picture of temperature with respect to gases.
     - PhET simulations explicitly model the particle nature of matter
     - Additionally use this activity to gauge the student's comfort level with technology
4. **Imploding Pop Can Demo (10 minutes)**
   - This activity will introduce the idea of pressure.
5. **Relationship between the temperature and volume of gasses (30 min)**
6. **Class Discussion (10 minutes)**
   - Share group explanations of how temperature affects matter

*** OR ***

5. **Heavy Air: Air has mass (30 min)**
6. **Class Discussion (10 minutes)**
7. **Break (10 minutes)**
8. **Phase change with Liquid Nitrogen Demo (10 minutes)**
   - This demo is a good transition from the balloon activity into introducing phase change
9. **Introduction to SAM (___ minutes)**
   - Demonstrate SAM by reenacting part of the "Student Molecules" activity using a "story board"
   - The students will then brainstorm the big ideas from the two days from which they will pick the topic of their group's movie. Narrow to 5 topics to choose from.

Detailed Daily Activities—Day 2

Day 2: How does temperature affect matter?

Objectives: Students will be able to…

- predict how temperature affects the volume of gases.
- illustrate what happens to particles when matter goes through temperature changes.
- communicate what happens when the temperature of matter changes enough for it to change state (beyond its boiling point or melting point).
- create a particulate model of gases using discussion and diagrams
- become familiar with the SAM program.

Materials:

- Pop can demo
  - A few empty pop cans
  - Hot plate
  - Ice water
  - Oven mitt
  - Rubber coated tongs
- Volume of balloon
  - Balloons
  - Ice
  - Hot plate
  - 2 Buckets per group, one filled with ice water and one with hot water
  - Access to a refrigerator and freezer (or cooler filled with ice)
- Liquid nitrogen demo
  - Liquid nitrogen
  - Gloves
  - A balloon filled with air
- PhET Sim
- SAM
  - Computers with program and cameras up and ready to go
  - Art supplies

Instructors:

- As the students are working, the instructors should move from group to group
    - The instructors should:
        - Keep students on task
        - Ask questions to check for understanding
        - Help guide the students to recognize and correct their own mistakes

Background:

Heat causes molecules to move faster (increases energy) and molecules spread apart, while the cold slows them down (decreased energy) and molecules get closer together. Emphasize that when the balloon contracted in the ice water, even though the volume changed, there were the *same* number of molecules in the balloon. EXAMPLE: You can make an analogy to a jar full of a 100 fruit flies. If you release the flies from the jar they will fly all over the room. There are still 100 fruit flies, they will now just occupy a larger space. What makes solids, liquids and gases different is the *movement* of the molecules:

Solids: In solids, molecules have a tightly packed structure held together by electrical attraction. **Crystals** are very strong because they have a regular and rigid shape. The molecules, however, are not motionless. They may vibrate or rotate in place but they CANNOT move out of place. Thus the solids kept their shape and retained the same volume in the freezer.

Liquids: In liquids, the molecules are still as close together as they are in solids, but they can slip over each other and change places. This would be a liquid—they are just as close together and still cannot go off on their own, but they can move and change places.

Gases: The molecules of a gas move even faster. They have too much energy (movement) to remain attached to each other. The molecules now bounce off of each other (particle collisions increase) and the walls of their container. A gas thus will spread out and take the shape of its container. Gases have NO fixed volume (as demonstrated by the balloons); the pressure exerted on it will determine the volume.

Note that **Absolute Zero** is the theoretical temperature where all motion of molecules would stop.

Activity:

1. Pre-activity preparation

- Set up SAM on enough computers for each group to have one to use.

- Display all Post-its from the day before. These vocabulary words will be referred to throughout the activity. Leave enough room to write properties and examples for each during recap.
- Do the same with the new vocabulary for the day (see vocab sheet)
- Place desks or table/chairs into groups of four.

2. Recap properties of solids, liquids and gasses (10 minutes)

- Have the students recall the activities from Day 1
- As a class, recall the properties of solids, liquids and gases on the Post-its at the front of the room.
    - Solid- has a fixed shape and volume
    - Liquid- has a definite volume, but takes the shape of the part of the container which it occupies
    - Gas- does not have a fixed shape or volume and will take the volume and shape of the container that holds it
- Do not bring up the fourth state of matter, plasma, unless prompted by the students. Note that plasma is not found naturally on earth (or our neighboring planets) because it requires extremely high temperatures. For plasma to form, the atoms must become ionized (lose electrons). Plasma consists of these ionized atoms and their loose electrons.

3. PhET Simulation (___ minutes)

- Assign pairs or let people chose a partner
    - One person will control the mouse and the other will be the recorder.
- Begin with a class discussion:
    - What phase (solid, liquid, or gas) is the air around us?
        - The hope is that they will say gas, but if not it may be a good idea to talk about that at this point. This would make a nice practical transition from the review beforehand.
    - Next, talk about how you can't see air and ask the students how (if you can't see it) they know its there.
    - Do you feel anything when you wave your hands around? *(wave hands around)* If so, what?
        - Use this to let them know that air like any other gas is made up of something. (Note: this may be review for them).
    - How is a gas different from a solid or a liquid?
        - If we fill a balloon up with air, what is in the balloon?
        - How is it different from an empty balloon?
            - Also review some of the things learned from the Oobleck and the Mystery matter activity from the previous day.
- Instructor Demo of the PhET Simulation on the computer
    - Have student pairs following along on their laptop computers
    - This is to show the students basically how to get the PhET simulation up and running.

- Students engage with the PhET Simulation working in pairs following a worksheet (WORKSHEET 5, one for each pair)
    - *Draw a picture of what a gas looks like in a container.*
        - The goal here is to get an idea of how closely students' initial perception of what a gas looks like matches with what the students perceive at the end. At this point any instructors should be walking around the class making sure that all the groups are on task and that they are not completely lost.
    - *Use the pump to put a few gas particles in the box.* (The students only need to pump once)
    - *Look at the gas particles' motion. Talk with your partner about how you think the gas molecules move and interact with each other based on your observations. Write down a few of these observations.*
    - *Raise the temperature of the box to 300K by turning on the burner. Then raise it to 1000K. What happens to the motion of the blue gas particles as you raise the temperature?*
        - Hopefully the students will see that the gas particles speed up when they heat up the container.
    - *Look at the right hand side of the Phet window at the number by the blue word Heavy Species. Did the number of blue particles ever change while you were heating the box?*
        - The students should <u>not</u> see a change in number of particles. However, if they get the temperature way above 1000K they will see a couple of particles disappear so if this problem occurs then this is most likely the cause.
    - *Lower the temperature to 500K by bringing the ice near the box. Next lower it to 100K. What happens to the motion of the gas particles as the temperature gets lower?*
    - *Now bring the ice near the box until you get the temperature as low as you can. Could you get the balls to stop moving? If so, at what temperature did they stop moving at?*
        - This would be a nice point to begin talking about the Kelvin scale when going over this question. Tell the students the temperature at which all matter supposedly stops.
    - *Draw a picture of what the motion of air in a container looks like when it is cold. Now when it is hot?*
- At the end of the activity, ask the students to share their ideas about pressure based on the activity and their background knowledge.
    - Refer to when the blue gas particles hit the walls and each other. Also may be a good idea to refer to the blowing up balloon example.
    - Talk about pushing.
    - Optional: Have two people demonstrate pushing back on each other's hands. Ask what would happen if one of them was not there. (The one pushing would fall into where the other was standing). This is like pressure.

4. Imploding Pop Can Demo (10 minutes)

- Fill two empty pop cans with ~two tablespoons of room temperature water.
- Ask the class what happens to water when you heat it.
    - Begin heating the 1st can on hotplate. Bring to a boil. (It takes 5 minutes for the water to boil)
- Ask the class what will happen if you turn the pop can over into ice water.
    - Using the tongs, flip the pop can upside down into a glass bowl full of ice water. Submerge the opening of the can in the ice water. Make sure that you set the can straight into the ice water to seal the opening of the pop can.
    - The can will implode.
- Have another can ready to repeat the demo for students to see it again.
    - Encourage them to think about why the can implodes.
- Discuss what happened in the demonstration as a class. Address the common misconception of sucking vs. pressure.
- **Discussion Questions:**

    1. What was in the can besides the water at the begining?
    2. What happens when water is boiled?
    3. What do you think will happen if the can is inverted in the bowl of water?
    4. What happens to the air in the can as water vapor is formed?
    5. What force is working on the outside of the can?

- EXPLANATION: Before heating, the can was filled with water and air. By boiling the water, it changed states, from liquid to gaseous state (water vapor). The water vapor (steam) pushed the air that was inside, out of the can. By inverting the can in water, we are cooling the vapor very quickly and constraining the potential for rapid flow of air back into the can by submerging the top in water. The cooling condenses the water vapor back to water. All of the vapor which took up the interior space of the can before is now turned into a few drops of water, which takes up much less space. This causes the pressure to drop and the atmospheric pressure is therefore pushing on the can and crushing it.

5. Relationship between the temperature and volume of gasses (30 min)

- **For the Temperature/Volume activity (written on large Post-it):**

    1. **Skeptic** – questions the group's reasoning and writes the group's observations and conclusions on the worksheet.
    2. **Measurer** – makes the measurements, collects data and performs tests
    3. **Equipment Manager** – gathers materials needed
    4. **Reporter** – shares the group's results and reasoning with the class

- Hand out worksheets (WORKSHEET 6, one for each group)
    - The groups will follow the worksheet
- Remind the groups to discuss as a group before making a decision
- The students will start tying a weight (rock) to the barrel of the syringe
- Then the will record the volume of air inside their syringe using the tick marks on the syringe.
    - Predict what will happen to the volume of air inside the syringe if the temperature is lowered.
- The students should next place the syringe in the ice water for three minutes. (10 min)
    - They should record the volume of the air in the syringe after being in the ice water and discuss in their groups what they think has happened and why.
    - Did their results match their predictions?
- Based on their observations, they should make a prediction about what will happen to the volume of air in the syringe if they raise the temperature instead.
- Then, they carefully place the syringe under hot water for 3 minutes and record the volume of air in the syringe. (10 min)
    - They should then record their results and in groups discuss what happened and why.
    - Did their results match their predictions?
- Repeat with dry ice bath.
- Have the students draw a picture of the gas inside the syringe at each stage.

6. Class Discussion (10 minutes)

- As a class, have the Reporters share their group's conclusions about the relationship between temperature and volume for a gas. (7 min)
    - Did the volume change? How?
    - Why do you think this happened?
    - Did the mass of the gas inside the syringe change?
        - Make sure that they understand that the mass does *not* change.
    - What happened to the number of molecules? (refer back to student molecules activity)
- Explanation: In gasses, as temperature increases, so does volume, and as temperature decreases, so does volume.

OR

5. Heavy Air: Air has mass (30 min)

- **For the Temperature/Volume activity (written on large Post-it):**

1. **Skeptic** – questions the group's reasoning and writes the group's observations and conclusions on the worksheet.
2. **Measurer** – makes the measurements, collects data and performs tests

3. **Equipment Manager** – gathers materials needed
4. **Reporter** – shares the group's results and reasoning with the class

- Hand out worksheets (WORKSHEET 6, one for each group)
  - The groups will follow the worksheet
- Materials for each group:

1. Two drinking straws.
2. Three pins or needles and two pieces of thread
3. Two identical un-inflated balloons.

- First, the students tie a piece of thread to each of the two balloons and tie the threads to the two ends of one of the straws.
- Then, balance this straw on your finger, push a pin through the straw where it is balancing and attach it to the other straw held vertically.
- Make sure that the straws are moving freely around the needle; balance the horizontal straw, then push a pin through at the spot where the threads are attached (to prevent them from sliding).
- Make sure that the two un-inflated balloons are in perfect balance; then blow air in one of them and tie a knot at the end. The balance will tip down at the end of the inflated balloon.

6. Class discussion (10 minutes):

1. What is inside the un-inflated balloons?
2. What kind of air was blown in one of the balloons?
3. What could happen if no pins were placed on the ends of the horizontal straw where the threads were attached?
4. What does the balance indicate after inflating one balloon?
5. What would you expect the balance would do if the other balloon was also inflated?
6. How else could we show that air has weight?

- Explanation: The straw balance may be adjusted by moving the threads further or closer to the end of the straw. In order to keep these attached threads from sliding, we need the pins. The air that was blown in the balloon was exhaled air, which is containing some water vapor but, for our purposes, may be neglected. By inflating the other balloon, the balance should be in equilibrium again. The air in the balloon is compressed by the balloon; therefore it is more dense and heavier than an equal volume of air at regular atmospheric pressure.

7. Break (10 minutes)

8. Phase change with Liquid Nitrogen Demo (10 minutes)

- This demo is a good transition from the syringe activity into introducing phase transitions.

- Demo putting a balloon filled with air and one with helium into liquid nitrogen.
    - Discuss what happens and why as a class.
    - Relate to syringe activity and volume
    - Introduce change of state. HOW?

9. Introduction to SAM (___ minutes)

- The instructor will introduce SAM by demonstrating how to make a movie using SAM and a projector (should already be set up)
    - Follow the steps outlined in the student worksheet
    - Start with a topic
        - Student Molecules
    - What part do we want to demonstrate?
        - Student Matter changing from a gas to a liquid, and then from a liquid to a solid
    - Create a story board
        - Using the Post-its, draw 4 – 5 story frames:

            1. Students running around classroom
            2. Students slowing down and condensing into a container (chairs)
            3. Students in the liquid state in the container
            4. Students cooling to a solid state
            5. Students in the solid state in the container

    - Shoot the "Student Molecules" movie using SAM and the student actors
    - Make sure to indicate how you take pictures, etc using SAM
    - Show the final movie to the class
    - The groups will be doing the same thing the next day
- **Brainstorming big ideas**
    - Write down all the ideas the students come up with on large Post-it
    - Include a review of the day similar to the review for day 1
    - Narrow down to the following five (adding these to the student list if they did not come up during the brainstorming)

        1. _____
        2. _____
        3. _____
        4. _____
        5. _____