Name: ______________________________________

Lab 9. Humidity

Record all data and answer all questions asked in this lab sheet in your lab notebook. Answer in complete sentences, so that I do not need to refer to these instructions to follow your answers. At the end of the lab, turn in your lab notebooks for me to grade.

1. Sensing Latent Heats

Purpose

You will feel, rather than just measure, the latent heat of vaporization of water.

Materials

Water, lidded bucket with hole in lid, cloths, two thermometers

Procedure

Evaporation

Wet your hand. Allow it to air-dry. What do you feel as your hand dries?

Condensation

1. The bucket has two thermometers: one taped to the outside, and one placed through a hole in the lid so that its bulb is inside the bucket. Read the temperature of the two thermometers (you may briefly need to raise the thermometer in the lid so that you can read it) and record the temperatures.
2. When your hands are dry, hold the outside of the bucket. Does the bucket feel warmer, cooler, or about the same temperature as the room air? Record.
3. Now, with one hand, reach inside the bucket through the hole in the lid. Does the bucket feel warmer, cooler, or about the same temperature as the room air?
4. Explain the temperature sensations and actual temperatures outside and inside the bucket.

2. Adiabatic Compression and Expansion

Purpose

You will observe how changing the pressure of a gas affects its temperature.

Materials

basketball pump, hose, rubber stopper, 2-L bottle with LC thermometer strip inside

Overview

Gases change temperature when they do work or when work is done on them. **Work** occurs when a force is applied to a moving object: it is the change wrought by the force. Static forces do not do work. It takes energy to do work. In fact, one of the more useful definitions of **energy** is the ability to do work.

When a sample of gas expands, such as blowing up a balloon, it does work on its surroundings. Conversely, when the surroundings push on a sample of gas, causing it to contract, the surroundings do work on the gas.

In this activity you will add air to a 2-L bottle already full of air. The added air takes up space in the bottle, compressing the air that already was there. When the bottle is vented, air escaping from it does work on the air outside the bottle.

Procedure

Because this activity involves gases under pressure and small objects that may fly through the air, *all members* of a group working on this activity MUST WEAR SAFETY GOGGLES. True, goggles are neither comfortable nor stylish. However, neither is a black eye or worse. So, put on a pair of safety goggles.

1. Predict: If air is pumped into a bottle, how does its temperature respond? What if compressed air is released from a bottle?

2. Read the temperature of the thermometer inside the bottle. Record it.

3. If it is not already assembled, connect the hose to both the pump and the rubber stopper so that air expelled from the pump comes out through the narrow end of the stopper. Place the stopper securely in the mouth of the bottle. It is best if one person holds the stopper in the mouth of the bottle and another operates the pump.

4. Pump a few strokes of air into the bottle until you feel resistance. Wait 20 seconds for the thermometer to equilibrate and read its temperature. Record it.

5. Pump more air into the bottle until it is noticeably pressurized. Wait 20 seconds for the thermometer to equilibrate and read its temperature. Record it.

6. Pump still more air into the bottle, until it feels about as pressurized as a soda bottle on the grocery store shelf. Wait 20 seconds for the thermometer to equilibrate and read its temperature. Record it.

7. Now *gradually* vent the air from the bottle by *gently* releasing the stopper. Wait 20 seconds for the thermometer to equilibrate and read its temperature. Record it.

Questions to ponder

Write down your answers to these questions. I may ask these questions on a homework or quiz, so satisfy yourself that you understand how it works.

1. What happens to the temperature of a gas as its pressure is increased?

2. What happens to the temperature of a gas as its pressure is decreased?

3. How does the temperature of a gas change when the gas *does* work?

4. How does the temperature of a gas change when work is *done on* the gas?

5. Doing work *on* a gas *raises* its energy. When a gas *does* work, its energy is *depleted*. How is the gas's temperature related to its energy?

3. Cloud in a Bottle

Purpose

You will explore the conditions needed to condense water vapor to the liquid.

Materials

Equipment for activity 2, plus 2-L PETE bottle without a temperature strip, warm water, matches

Background

In the vapor phase, water molecules are apart from each other. In the liquid, the molecules are all in close contact. There is a big difference between how the molecules behave and interact in the two phases. How do they make the change? Are there certain conditions that make it easier than others?

Procedure

As with Activity 2, safety glasses or goggles are again mandatory

1. Pour some warm water into the 2-L bottle. Cover the mouth of the bottle. Shake and swirl the bottle for a few seconds. Pour out the water.

2. If it is not already assembled, connect the pump to the rubber stopper so that air expelled from the pump comes out through the narrow end of the stopper. Place the stopper securely in the mouth of the bottle. It may be easiest if one person holds the stopper in the mouth of the bottle and another operates the pump.

3. Pump a few strokes of air into the bottle until the bottle becomes hard. Wait 30 seconds for the temperature to equilibrate. *Gently* release the pressure by releasing the stopper. What do you see inside the bottle?

4. Light a match. When its phosphor has burned down, shake to extinguish it. Drop the smoldering match into the bottle.

5. Connect the pump to the bottle as before. Pump a few strokes of air into the bottle until the bottle becomes hard. Wait ten seconds for the temperature to equilibrate. Gently release the pressure by releasing the stopper. What do you see inside the bottle?

6. Connect the pump to the bottle once again. Pump a few strokes of air into the bottle until the bottle becomes hard. What do you see inside the bottle now?

7. Release the pressure. What do you see inside the bottle?

8. Repeat a few more times until you think you understand what is happening.

9. Remove the burnt matches from the bottle and clean up any water or other debris from your table.

4. Sling Psychrometer

Purpose

You will determine the humidity of the air.

Background

A sling psychrometer contains two side-by-side thermometers. One is an ordinary thermometer for measuring air temperature. The other is a "wet-bulb" thermometer kept wet by a thin wick of wet cloth on its bulb. Since water will evaporate if the relative humidity is below 100%, evaporating water cools the wet bulb thermometer by an amount depending on the humidity. The lower the humidity, the greater the difference between the wet- and dry-bulb temperatures.

My psychrometer appears to contains mercury thermometers, despite the label on its box. Of course, be careful when handling it to prevent the thermometers from breaking. But more importantly, notify me immediately if a thermometer breaks. Do not attempt to clean up any spilled mercury. That is my problem.

Materials

Wet-dry bulb psychrometer, wick for wet bulb, water for wick, psychrometer chart

Procedure

Make sure the wick on the wet bulb is wet.

1. Pull the thermometer assembly out of the psychrometer sleeve until the hinge is locked into place at the end of the sleeve. Turn the thermometer assembly at the hinge so that it is perpendicular to the sleeve.
2. Hold the psychrometer by the sleeve, in a space clear of any objects or people. Spin it rapidly (several rotations per second) for 30–60 seconds. The objective is to get a good breeze over the wet bulb, so that the water evaporates as fast as the humidity will allow.
3. Read the wet and dry bulb thermometers. Record the readings.
4. Calculate the relative humidity and the dew point from the two readings. Record it as well.
5. Repeat the above steps outdoors if the weather permits.

5. Heat of fusion

Purpose

You will observe the cooling capability of melting ice.

Background

Ice is cold, and we use it to lower the temperature of things that are hotter. But ice is not just a cold version of water. Its cooling power comes from the additional energy needed to melt the solid.

Materials

Cooler of ice, thermometer, hot water, cold water, stirrer, beakers, balance

Procedure

Hot water + cold water

1. In a beaker large enough to hold 1000 mL, measure out about 500 g of hot water on the balance. Record its mass in your lab notebook. It is not critical that you have exactly 500 g of water, but it is critical that you know the mass that you have.

2. In another beaker, measure out about 500 g of cold water. Again, you need to know exactly how much water you have, but it is not critical that it be exactly 500 g. Record the mass in your notebook.

3. Take the temperatures of the two beakers of water. Record in your notebook.

4. Add the cold water to the beaker of hot water. Stir to mix. Take the temperature. Record in your notebook.

Hot water + ice

1. In a beaker large enough to hold 1000 mL, measure out about 500 g of hot water on the balance. Record its mass in your lab notebook. It is not critical that you have exactly 500 g of water, but it is critical that you know the mass that you have.

2. In another beaker, measure out about 500 g of ice. Again, you need to know exactly how much ice you have, but it is not critical that it be exactly 500 g. Record the mass in your notebook.

3. Take the temperatures of the hot water and the ice. Record in your notebook.

4. Add the ice to the beaker of hot water. Stir to mix. Take the temperature. Record in your notebook.

Data Processing

1. Calculate the average temperature of the hot water and cold water that you combined. Since the masses are probably not exactly the same, we need to figure something proportional to the average thermal energy, accounting for mass. Use the formula

$$T_{\text{avg}} = \frac{T_H m_H + T_C m_C}{m_H + m_C}$$

Where *T* is a temperature, *m* is a mass, and the subscripts *H* and *C* denote the hot and cold water, respectively. Record the calculated average in your notebook.

2. Compare this average to the observed temperature of the mixture after combining the two. Are they close?

3. Calculate the average temperature of the hot water and ice using the same formula from above, using the values for the ice in place of the values for the cold water. Record the calculated average in your notebook.

4. Compare this average to the observed temperature of the mixture after combining the two. Are they close?