LAB 17. WORK AND HEAT

Purpose

- To examine experimentally the relationship between temperature, pressure, and volume of a gas.
- To understand the physics behind how engines and refrigerators work.

Measurement

1. Temperature

Materials

Two glass jars, hot water, cold water dropper bottle of liquid food coloring

Procedure

1. Fill one glass jar most of the way with cold water. Fill the other most of the way with hot water. Allow both jars to stand undisturbed long enough for any water currents to settle.

2. Gently drop one drop of food coloring onto the center of the hot water. Gently drop one drop of food coloring onto the center of the cold water. Observe both drops for a few minutes. How do they behave? Are there any differences between the two?

2. Mechanical Equivalent of Heat

How much work does it take to raise the temperature of a substance?

Materials

Bottle partly filled with sand; thermometer

Procedure

1. Open the bottle. Place the thermometer in the sand. Allow it a minute to equilibrate. Measure and record the temperature. _____

2. Remove the thermometer and re-seal the bottle. Have everyone in the group shake the bottle vigorously many times. Give it at least a hundred hard shakes.

3. Measure and record the temperature of the sand again. _____

3. Latent Heat of Vaporization, part 1: Evaporation

Materials

Water

Procedure

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

_____

_____

4. Latent Heat of Vaporization, part 2: Condensation

Materials

Lidded bucket with hole in lid, damp cloths, two thermometers

Procedure

One thermometer should be outside the bucket, measuring the temperature of the ambient air. The other should be inserted in the lid of the bucket, measuring the temperature inside.

1. Record the temperature readings of the two thermometers.

Ambient air: _____ Inside bucket: _____

2. When your hands are dry, feel the outside of the bucket. Does the bucket feel warmer, cooler, or about the same temperature as the room air?

_____

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?

_____

5. Volume at Constant Pressure

In this activity you will observe how a gas behaves when its temperature changes.

Materials

Hot water, ice water, balloon, large glass flask, string, length measuring device (ruler, meter stick, tape measure), thermometer

Procedure

1. If there is a partially filled rubber balloon on the end of the glass flask, great! You can use it. If not, blow up a balloon, not too full. Pinch its neck to keep the air in and stretch the mouth of the balloon around the mouth of the flask.

2. Measure the circumference of the balloon somehow. Record the temperature and the balloon's circumference.

Temperature: _____ Circumference: _____

3. Place the flask and the thermometer in hot water. Hold the jug as completely submerged as possible. After it has been there for at least one minute, measure the circumference of the balloon. Record the temperature and the balloon's circumference.

Temperature: _____ Circumference: _____

4. Place the flask and the thermometer in cold water. Hold the jug as completely submerged as possible. After it has been there for at least one minute, measure the circumference of the balloon. Record the temperature and the balloon's circumference.

Temperature: _____ Circumference: _____

5. Clean up any water or other mess from the table.

6. Pressure at Constant Volume

Materials

Hot water, ice water, balloon, constant volume apparatus (hollow metal sphere connected to an absolute pressure gauge and release valve), thermometer

Procedure

1. Measure and record the temperature and pressure.

Temperature: _____ Pressure: _____

2. Place the metal sphere in a water bath at a different temperature. Measure and record the temperature and pressure.

Temperature: _____ Pressure: _____

3. Place the metal sphere in a water bath at yet a different temperature. Measure and record the temperature and pressure.

Temperature: _____ Pressure: _____

7. Adiabatic Compression and Expansion

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

Materials

basketball pump equipped with rubber stopper, silicone grease, 2-L PETE bottle with LC thermometer strip inside

Safety

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.

Procedure

1. Read and record the temperature of the LC thermometer inside the bottle. _____

2. If it is not already assembled, pierce the rubber stopper with the inflation needle 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.

3. Pump a few strokes of air into the bottle until you feel resistance. Wait 15 seconds for the thermometer to equilibrate. Record the temperature. _____

4. Pump more air into the bottle until it is noticeably pressurized. Wait 15 seconds for the thermometer to equilibrate. Record the temperature. _____

5. Pump still more air into the bottle, until it feels about as pressurized as a soda bottle on the grocery store shelf. Wait 15 seconds for the thermometer to equilibrate.
Record the temperature. _____

6. Now *gradually* vent the air from the bottle by *gently* releasing the stopper. (This is the difficult part, where an accident is most likely.) Wait 30 seconds for the thermometer to equilibrate. Record the temperature. _____

Analysis

Activity 5, Volume at constant pressure

You have measured three (temperature, circumference) points. Approximating the shape of the balloon as a sphere, calculate the balloon volume for each temperature. Record in the table.

Temperature	Circumference	Volume

Make a temperature (vertical axis) vs. volume (horizontal axis) scatter graph of the points and fit a straight trend line to them. Record the equation of the trend line. _____

If the trend line is projected to a volume of zero, what would the temperature be at that volume?

_____

Activity 6, Pressure at constant volume

You have measured three (temperature, pressure) points. Make a temperature (vertical axis) vs. pressure (horizontal axis) scatter graph of the points and fit a straight trend line to them. Record the equation of the trend line. _____

If the trend line is projected to a pressure of zero, what would the temperature be at that pressure?

_____

Lab Report

All that is needed beyond the observations and answers to the questions in this packet is to show me the graphs requested in the Analysis section.