Thermodynamics

SUPER HEATED STEAM

Materials:

- ✓ Copper Coil Tubing
- ✓ Black Rubber Stopper, 1-hole, Size #6
- ✓ A Meker Burner
- ✓ 250 mL Erlenmeyer Flask
- ✓ Hot Plate
- ✓ Ring Stand
- ✓ Ring or Clamp
- ✓ Sheets of Paper 2" x 2"
- ✓ Match
- ✓ Thermometer
- ✓ Crucible tongs

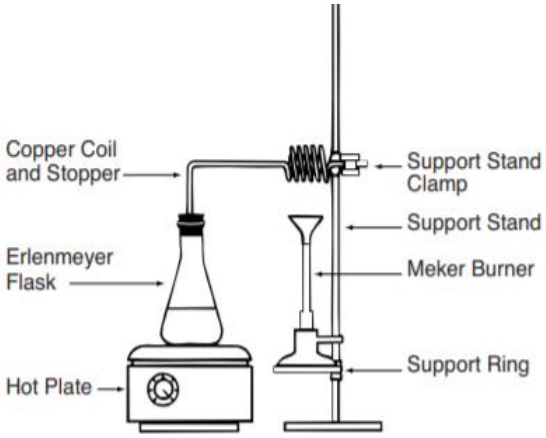

Figure 1.

Fire, the copper coil, & SUPER HEATED STEAM are VERY HOT!!!!!!

Do NOT get in the "line of fire" It will severely burn you. Make sure you follow proper safety procedures. An open flame is also extremely dangerous.

- ❖ Eye Protection
- ❖ Hair Up
- ❖ Sleeves Secures
- ❖ PPE for handling hot objects.
- ❖ Knowledge of location and uses of safety equipment.

Background Research:

1. Define the following terms:
   a. Kinetic Molecular Theory'
   b. States of Matter
   c. Boiling point of water
   d. Thermal Energy
   e. Gas Visibility
   f. Heat of Vaporization. Abbreviated H_v

2. Compare the amount of ENERGY between phases of a substance, such as water (solid, liquid, gas)

3. Discuss how condensation and vaporization are results of a change in system energy.

Scientific Investigation:

- ➔ Carefully insert the bent end of the copper tubing into the hole of the #6 rubber stopper so that the end of the tubing is flush with the bottom of the stopper.

- ➔ Fill a 250-mL Erlenmeyer flask with approximately 150 mL of tap water. Add 2 or 3 boiling chips.

- ➔ Place the Erlenmeyer flask on a hot plate.

- ➔ Obtain a support stand and clamp. Insert the rubber stopper (with inserted copper tubing) into the mouth of the Erlenmeyer flask so that it fits snugly. Secure the copper coil tubing to the support stand with the clamp so that the coil is held horizontally to the tabletop (do not use plastic-coated clamps). Make sure that the open end of the copper tubing is not pointing at anyone.

- ➔ Place a Meker burner beneath the copper coil on a support ring or adjustable support block so that the Meker burner flame will effectively heat the copper coil.

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- ➔ Place a few towels (paper or cloth) on the tabletop a foot or two in front of and beneath the exhaust end of the copper tubing to collect any water that will spurt out the end as the water and steam are heated. (Some of the steam condenses in the tubing and forms liquid water that is eventually pushed out by the flowing steam.)
- ➔ Turn on the hot plate. Adjust the temperature control to the highest setting.
- ➔ Once the water is boiling steadily and visible exhaust steam is seen flowing out of the copper tubing, follow the procedure below. If necessary, adjust the temperature control on the hot plate to maintain a rapid boil.
- ➔ Record temperature of the steam coming from the end of the copper tubing.
- ➔ Grip the end of a small sheet of paper with crucible tongs and place the paper into the stream of steam. Use the infrared thermometer to measure the temperature of the steam/paper interface.
- ➔ Use crucible tongs to insert the head of a match (flammable tip part) into the steam. Observe.
- ➔ Ignite the Meker burner and adjust the flame so that it is effectively heating the copper coil. The steam will disappear within a few seconds as it turns into superheated steam.
- ➔ Carefully grasp a cool beaker with crucible tongs and place the side of the beaker in the superheated steam.
- ➔ After coil is red hot, repeat the experiments with the 2" x 2" sheets of paper and match head.

Prompt	*Observations/Data*
Initial Temp. of water	
Boiling Temp. of water	
Temp of Steam	
What state of matter is the steam	
Temp of Steam/Paper Interface	
Does the Match light in steam?	
What state of matter is the superheated steam?	
Discuss observations with beaker of cool water	
Temp of Steam/Paper Interface	
Notable observations of superheated steam & paper?	
Does the match light in superheated steam?	

Reflection/Conclusion:

4. Discuss the state of matter of Steam compared to Superheated steam. Do they represent the same state? Elaborate on this using vocabulary terms defined in background research.
5. Why does the paper char when exposed to superheated steam?
6. Why does the match ignite when exposed to superheated steam?
7. Will steam or boiling water cause more severe burns on human skin? Explain your reasoning with physics.
8. Create a loom video in which you will reenact the experiment while explaining the physics of what is happening. Max video length is 5 minutes. Copy and paste your video link into the thermodynamics google form found in google classroom.