SC1 INVESTIGATION:
MUM'S MUG OF TEA

HOW DO CONDUCTION, CONVECTION AND RADIATION AFFECT THE AMOUNT OF HEAT LOST FROM HOT WATER?

Plan

Variables:

- Temperature of water
- Amount of water
- Size of beaker
- Type of insulation

I have chosen to investigate how the type of insulation affects the heat lost through conduction, convection and radiation.

Preliminary

Originally I was going to use the following method:

1. Collect apparatus
2. Set up beakers of boiled water, 1 covered with silver foil, 1 insulated with a nappy, 1 with a lid on, and 1 as a control.
3. When the temperatures all reach 86°C start recording the temperatures every 2 minutes for 20 minutes
4. Record results.

There were several problems with this method when I tried it in my preliminary work. Firstly, it took a long time for all of the temperatures to reach 86°C. By the time they had, it wasted time that could have been used for recording results. Not all of the beakers of water reached the temperature at the same time. I improved this in my proper experiment by increasing the starting temperature to 92°. This was the temperature the water which had just been boiled was when it reached the beakers. Next, I found that measuring the temperature only every 2 minutes provided inaccurate results. It also meant that I didn't have enough results for them to be considered reliable. In my next experiment, I improved this by measuring and recording the temperature every minute. Finally, in my preliminary experiment I found that 20 minutes was too long. It took up a long time, and provided only a few results. As I had already halved the stage at which I measured the temperature, I would have 20 results in my experiment. I decided that reducing the time to 15 minutes would make more sense, as I would get more results than if I had stuck to my preliminary experiment, and it left me more time to repeat my experiments.

METHOD

Apparatus:

- Beakers
- Kettle
- Thermometer
- Stop clock
- Silver foil
- Nappy
- Lid

Method:

1. Gather all apparatus
2. Boil some water in the kettle.
3. Cover one beaker in silver foil, to prevent radiation, one in a nappy, to prevent conduction, and put a lid on another to prevent convection. Leave one beaker as a control.
4. When the water boils, pour 200ml into each beaker. Immediately measure the temperature.
5. When all beakers contain water at 92°C, start the stop clock. Record temperature 0 as 92°C for all beakers.
6. Every minute, record the temperature of the water in each beaker.
7. Continue this for 15 minutes.
8. After 15 minutes, clear away apparatus safely.

Fair Test:

To ensure a fair test I will keep all of the variables the same, except for the variable I am testing. I will keep the temperature of the room the same by conducting the experiments in the same room at the same time. Measuring all temperatures at the same time, with the help of members of my group, will ensure that the recorded evidence is fair. I will start the experiments at the same time to ensure that they are in the same conditions. Use the same amount of water in the experiment to ensure fairness, as a beaker containing a larger amount of water would take a lot longer to cool down. I will also use the same size of beaker when conducting the experiment, to prevent a larger surface area on top of the water for heat to be lost from.

Safety:

To ensure my experiment is successful and causes no damage or danger to either myself, or others, I will follow some simple safety guidelines:

- Wear goggles to prevent hot water from getting in my eyes.
- Tie hair back so it won't get in the way.

- Put all beakers on the side because if they spill it won't be on the table.
- Tie shoes up to prevent tripping whilst carrying breakable equipment or boiling water
- Keep the experiment in one place. This reduces the risk of accident through movement
- Stay near the apparatus, as accident risk is minimised if the experiment is watched at all times.
- Stand up whilst conducting the experiment. If standing it is easier to get away from spilt water, and it wont scald your lap.

Prediction:

I predict that the best insulator against heat loss will be the lid. This is because I think the most heat is lost through convection. Convection is when currents of hot water rise to the top of their container. This is because they are lighter than the other water particles. When they reach the surface, they are cooled down by contact with the air. They then become colder, and therefore heavier than the other water particles, and sink back to the bottom. This continues until all of the liquid is the same temperature. This is a very rapid process, and the heat escapes as steam through the opening of the beaker. By putting a lid over the beaker, the steam will be trapped inside, and will condense back to water and remain in the beaker. Heat lost through radiation is lost at a steady heat throughout the water, more slowly than radiation. The foil protecting against heat loss through radiation will reflect back the heat, and help keep the water warm. Coming into contact with something cooler loses heat lost through conduction. Again, heat lost this way is continuous, and slower than heat lost by convection. Using an insulator, like the nappy that is filled with air can slow it down. It takes longer for heat to be lost through air.

I think the beaker with no form of insulation will loose the most heat, as it is not protected against any of the ways of heat loss. It will probably get very cool very quick, as conduction, convection and radiation are all occurring. I don't know what sort of results I will get, but I think that there will be a significant difference between the control beaker and the beaker with a lid.

Results

I repeated my experiment three times for accuracy, and the figures below are mean averages. I measured the results to within 0.5°C using an accurate thermometer. This means my results are as accurate as possible. My results are on a separate page.

Analysis

The line graph I have drawn shows that a lid is the best way to stop heat loss. This means that the most heat is lost through convection. The control is the beaker that lost the most heat in the quickest time. This was to be expected, as it had no form of insulation at all. I can see that the temperatures start off the same, and stay close together for the first two minutes before separating. By the end of my experiment, the temperatures are very varied, spanning over 9°C.

My prediction is supported by my results. I predicted that the best insulator against heat loss would be the lid. This is because the most heat is lost through convection. Convection is when currents of hot water rise to the top of their container. This is because they are lighter than the other water particles. When they reach the surface, they are cooled down by contact with the air. They then become colder, and therefore heavier than the other water particles, and sink back to the bottom. This continues until all of the liquid is the same temperature. This is a very rapid process, and the heat escapes as steam through the opening of the beaker. By putting a lid over the beaker, the steam will be trapped inside, and will condense back to water and remain in the beaker. I said that heat lost through radiation is lost at a steady heat throughout the water, more slowly than radiation; therefore the foil was not as effective. Also, I think using silver foil is not a very good idea, as it will get crumpled and not reflect as much heat as possible. Coming into contact with something cooler loses heat lost through conduction. Again, heat lost this way is continuous, and slower than heat lost by convection. The nappy slowed it down.

Evaluation

I think that, in general, my experiment was successful. I think the method worked well. If I could repeat this experiment, I would have tried to make it more of a fair test. I wouldn't wait for the water to cool down, as the type of insulation on a beaker would make this unfair. For example, if the temperature of the water starts nearly the same, then I wait for it to cool down, the control could potentially loose more heat, whereas the beaker with a lid might loose less. If possible, I would have made my results more accurate. I used a normal mercury thermometer, which left the experiment open to human error. I may have misread some of the results. If I repeated this experiment, I would use an electronic thermometer.

I believe that this type of human error may have caused the few anomalies in my graph. None of the results seemed unusual when recorded, but on the graph there are several places where the curves flick up. I may have measured the temperature just out of time, or may have read the temperature wrongly.

My results clearly show that there is a link between the type of insulator and amount of heat lost. I think this shows my experiment was quite successful. I think repeating my experiment three times is enough to provide adequate support for my predictio n, but I would have liked to have spent more time gathering my results.