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How Does Insulation Affect the Rate of Cooling?

P PLANNING

The Problem

The problem which I intend to investigate is out if insulation affects the rate of cooling, and whether the amounts of insulation would affect the rate of cooling

Scientific Background

An insulator is any of various substances that blocks or slows down the flow of heat, they can only transfer energy slowly. Many materials make air as an insulator, because air is an excellent insulator.

Air can reduce heat lost due to conduction. The material has to trap the air to get the best result. This is to avoid warm air escaping and taking the energy with it.

Energy can be transferred in four main ways when you heat something: by conduction, convection, radiation and evaporation.

In conduction the particles are joined together by bonds, when the material is heated the particles vibrate really fast, they have kinetic energy. A fairly still part in a cold part of the material can pick up vibration from an atom in a hot part of the metal. The energy is transferred from one particle to another very quickly. Soon particles from far away have more and more kinetic energy, heating the material. A good conductor is metal.

In convection, particles in a fluid moves all the time. When you heat a fluid, energy is transferred to the particles. The particles move faster and get further apart, so the heated part of the fluid expands. This makes the heated fluid less dense than the unheated fluid. Because the fluid is less dense, the warm fluid floats above the cool fluid, taking its extra energy with it.

In radiation particles are not needed. Silver surfaces and smooth white surfaces are bad at absorbing and bad at emitting radiation. Black surfaces are good at absorbing and good at emitting radiation.

In evaporation, the particles in a liquid sticks together, but much more weakly than particles in a solid. The particles move about and constantly bump into each other, they have kinetic energy. Some particles will receive so much energy during the collisions that they escape from the liquid. These escaped particles have so much kinetic energy that they move as fast as particles in gas. During the process, the energy is transferred from the liquid to the gas because only the most energetic particles escape, as a result the liquid gets cooler.

Preliminary Test

I did a preliminary experiment, to see if the method I took was good. My concerns were, if my experiment showed dependable reading, and whether or not I would need to change the way I did my readings. Here is my preliminary result:

Time (mins)	2	4	6	8	10	12	14	16	18	20
Tenperature °c	78	72	67	63	59	57	55	51	50	48

This experiment was for no insulation. At first, I was going to weigh my cotton wool, but this took up a lot of the experiment time, and the hot water, became lukewarm water. Therefore, I decided to do it cm by cm, this did not take up so much time. Also I had to measure the temperature at the correct and accurate time, so that the experiment would be reliable.

Experiment

I have chosen to use cotton wool as the insulation, the reason why is because cotton wool is a good insulator, and it is very cheap, this is good because it is easy to obtain.

Method

I will carry out my experiment by following these stages:

-I will collect and set up apparatus
-Boil the water in the kettle
-Pour this in the calorimeter
-Time the rate
-Measure the temperature every 2 minutes
-When reached 20 minutes stop the experiment
-Repeat experiment but add an extra cotton wool.

The preliminary test helped me to do my plan, because it made me aware of what equipment I will need and which way I would do it to save up as much time as possible.

The apparatus which I will be using for this experiment are:

-Cotton wool. This would be used as insulation.
-Stop clock. This would be used to time the rate of cooling.
-Ruler. This would be used to measure the thickness of cotton wool.
-Measuring cylinder. This would be used to measure the volume of water.
-Elastic bands. This would be used to secure the cotton wool in its position.
-Calorimeter. This would be used to contain water, 100ml it is metal so it is a good conductor of heat. The cotton wool would be wrapped around it.
-Kettle. This would be used to boil water, 100°c.
-Glass beaker. This would be used to measure the volume of water
-Thermometer. This would be used to measure the temperature of the water.

Control of Variables

The independent variable will be the temperature. My dependant variable will be the temperature. My controlled variable will be the time of the experiment, and

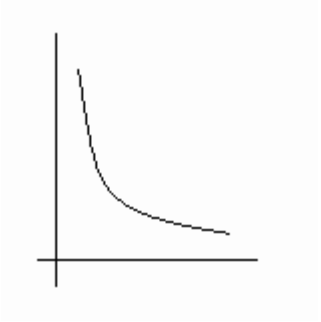
the size of the cotton wool, and the volume of water. Therefore, my results will be fair and reliable.

Safety
To be safe I am going to careful when handling objects that are hot. Laboratory rules must be taken into account

Fair test
The factors which I would keep the same, is the volume of water. This is because; the experiment will not be reliable as the results will differ each time. This would not help me to conclude my experiment.

Measurements to Be Made
Readings
I will take results every two minutes, adding one centimetre of cotton wool each time. I will start with no cotton wool, timing the experiment every 2 minutes up until 20 minuets. I will do the same for 1cm; 2cm and then ending with 3 centimetre of cotton wool. I will repeat my experiment, to make it more accurate and reliable, and compare it with another person. My overall results should be averaged so that it should be more accurate.

Prediction
I predict that insulation would affect the rate of reaction. The more cotton wool wrapped around the calorimeter, it would take longer for the temperature to fall. I think the results will look like this on the graph:



This graph is not proportional. The graph is a curve because, at the start of the experiment the rate of cooling rapidly cools down during the rate of cooling still cools down but this time taken is slower than the time taken at the start of the experiment, at end it gradually cools down.
When the thickness of the insulator increases, the rate of reaction will slow down.

Explanation
This is because, air is a good insulator, cotton wool has tiny holes trapped with air inside it, and cotton wool has not got strong bonds like conductors which are mostly metals. They can only pass kinetic energy by the much slower method of bumping into each other. This means that cotton wool is a good insulator.

O OBTAINING RESULTS

Table of Results

First results

	0 centimetres	1 centimetres	2 centimetres	3 centimetres
Time	**Temperature °c**	**Temperature °c**	**Temperature °c**	**Temperature °c**
0	100.0	100.0	100.0	100.0
2	72.0	73.0	78.0	80.0
4	63.0	65.0	75.0	78.0
6	60.0	63.0	70.0	73.0
8	57.0	60.0	67.0	70.0
10	55.0	57.0	64.0	67.0
12	52.0	55.0	62.0	65.0
14	50.0	52.0	60.0	62.0
16	48.0	50.0	58.0	60.0
18	45.0	48.0	56.0	58.0
20	42.0	45.0	55.0	56.0

Second results

	0 centimetres	1 centimetres	2 centimetres	3 centimetres
Time	**Temperature °c**	**Temperature °c**	**Temperature °c**	**Temperature °c**
0	100.0	100.0	100.0	100.0
2	75.0	76.0	78.0	80.0
4	65.0	73.0	75.0	78.0
6	62.0	69.0	70.0	72.0
8	59.0	65.0	68.0	70.0
10	56.0	62.0	64.0	67.0
12	54.0	59.0	63.0	64.0
14	50.0	56.0	60.0	63.0
16	48.0	53.0	59.0	62.0
18	46.0	49.0	57.0	58.0
20	43.0	44.0	54.0	56.0

Average of all results

	0 centimetres	1 centimetres	2 centimetres	3 centimetres
Time	**Temperature °c**	**Temperature °c**	**Temperature °c**	**Temperature °c**
0	100.0	100.0	100.0	100.0
2	73.5	74.5	78.0	80.0
4	64.0	69.0	75.0	78.0

6	61.0	66.0	70.0	72.5
8	58.0	62.5	67.5	70.0
10	55.5	59.5	64.0	67.0
12	53.0	57.0	62.5	64.5
14	50.0	54.0	60.0	62.5
16	48.0	51.5	58.5	61.0
18	45.5	48.5	56.5	58.0
20	42.5	44.5	54.5	56.0

A ANALYSIS

Graph

Conclusion

The graph shows that as the time increases the temperature decreases. The line of best fit is as predicted. From the graph, when there is no insulation the temperature decreases at a lower rate to it with insulation.

With all of the types of insulation and no insulation the steepest time is for the first two minutes. This is because the calorimeter has a lot of energy; energy is needed for heat transfer, so therefore it is loss more to the atmosphere. It then gradually decreases, because there is less kinetic energy.

Conduction is used in this experiment. The calorimeter can is made out of metal; metal is a good conductor of heat. Therefore the heat can easily escape, that is why, when there was no insulation the temperature decreased more than the insulated experiments.

This is because the particles of the calorimeter can, are joined together. A fairly still part in a cold part of the material can pick up vibration from an atom in a hot part of the metal. The energy is transferred from one particle to another very quickly.

Convection is used in this experiment, because water is used which is heated. In convection, particles in a fluid moves all the time. When you heat a fluid, energy is transferred to the particles. The particles move faster and get further apart, so the heated part of the fluid expands. This makes the heated fluid less dense than the unheated fluid. Because the fluid is less dense, the warm fluid floats above the cool fluid, taking its extra energy with it.

Radiation is used the experiment because the calorimeter can was a shiny colour; therefore, the hot water does not emit much radiation. That is why the heat loss was not as much as it would be if the surface was dark.

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For the first 2 minutes of the experiment the rate of cooling is similar to all the types of insulation. After this, the less the layer of insulation, the lower the temperature. Between the 2cm of insulation and 3cm of insulation there is a bigger temperature difference than the rest. This is because the more the layer of cotton, the better the insulation so the air traps the air, this is to avoid warm air escaping and taking the energy.

The results prove my prediction which is that the insulation does affect the rate of cooling. I found out that the more insulation the slower the rate of insulation. My results confirmed this because the more insulation, it takes longer for the heat to be transferred, as the molecules takes slower to transfer, so if more was wrapped, it would be harder for the molecules to escape as the air traps this.

E Evaluation

As the time increases the temperature decreases, also as the insulation increases, the rate of cooling is less than it would be with no insulation. My results support this because it was accurate and clear and it was a fair test.

Procedures
Problems I had during the experiment were that it was hard to measure the temperature during the exact time. Also when the water had been boiled, the temperature decreases a lot, it was hard to get the temperature the same for each experiment.

Data
The results were reliable, the reason why is because I repeated results, and averaged it out. Also there were not anomalies; therefore my results were accurate as well. Although factors which could have made my results not reliable could have been, the wind form the open windows, the temperature of the boiled water may not be the same readings at the start of the experiment, also the cotton wool may have not been exactly the correct size. I do not think that I can form a firm conclusion with them.

Further Work
Any other alternative experiments I would do to help me investigate the problem is to compare with other materials not only cotton wool, like newspaper. This is because I could see if changing the material for the insulation would change the rate of cooling.
Extending the range of my experiment, by timing every one minute rather than two, and by having more layers of insulation would help me get a more reliable experiment because my results will be more accurate. However, I would need more time because it would take long to have a larger range. Although, the range which I have, is a good range to have as it is not too small or too big.