Candidate Number-9006
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Year 10 GCSE Science Coursework
Physics- Heat Investigation

Aim: My investigation is to find out the rate of which heat transfer happens. Heat transfer is a process in which energy in the form of heat energy is exchanged between materials that are at a different temperature. Heat is generally transferred by conduction, convection, radiation and evaporation. All of these processes can all happen simultaneously but it is likely that one will give the greater heat exchange.

Plan:

These are the measurements that I intend to make:

- Measure the temperature every minute for 5 minutes
- Record the temperature of the substance before being used and then keep this as starting temperature
- Record the temperature every minute
- Make sure that all substances are 100cm^3
- To test different substance and different containers

Variables:

These are factors that may affect how long a substance will maintain its temperature.

- Size of Container
- Different Materials
- Different Substances
- Surface Area
- Thickness and Shape of Container
- Colour of Container

After considering the above variables and the affect they may have on maintaining the heat of the liquid, I have decided that I will look at each variable individually as if I change two variables at once I will not be able to tell which of the variables had the effect on the outcome-it may even be both!

Independent Variable:

- Volume of Substance- 100cm^3

I have decided to keep volume of substance as my independent variable (variable that I will keep the same throughout investigation) as this will also certify that this investigation is that of a fair test.

Fair Test:

To ensure that my investigation is a fair test I will follow the below list:

- If I were to change two variables I would carry out the same test more that once. This is to ensure a fair test. As if I do not carry out separate tests I will not know which one of the variables will be affecting the outcome of my results- it might be both of them! For instance I would firstly test how water affects my experiment. I would then go on to test if coffee (or any other substance) affected my experiment in a different way to water.
- Keep the measurement of chosen substance the same ($100cm^3$)
- Keep the starting temperature the same 88°C.
- Use the same equipment e.g. use same stopwatch, thermometer so that results are of the same accuracy.
- They must be accurate. Such as the stop watch, thermometer etc.

Safety Precautions:

During my investigation I will have to take several precautions such as:-

- Wear safety goggles
- Lab coats so that if hot water is spilt you have protective clothing on
- Wear gloves when we handle the hot containers or boiling hot water
- Use a heat proof mat to stand the hot containers and kettle on. If using a Bunsen burner to heat up water also place this on the heat proof mat also place used spills on heat proof mat.(this is to ensure no damages to any of the other equipment e.g. work surfaces, and also to stop me from getting burnt)
- Keep Bunsen burners in a safe place away from any flammable objects
- Ensure that cloths are near by just incase of any spillages
- Always use tongs when handling hot containers or boiling water
- Tie hair back and also remove any lose or hanging clothing, ties etc

Equipment Needed:

- Some spills (if using Bunsen Burner)
- A Bunsen burner-if it is being used
- Different types of cups- with lids etc
- Thermometer
- A heatproof mat
- Tongs
- Different substance-water, coffee etc
- A measuring cylinder
- A stopwatch

Research:

Throughout my research I discovered that certain factors will affect this experiment- the main four factors are:

Conduction:

It mainly occurs in solids. Conduction of heat can occur in two ways by vibrations or electrons.

Electrons:

The heat will be carried through a metal by the electrons which are free to move around. All metals are good conductors. Liquid however are often poor conductors and heat travels through them by convection.

Vibrations:

The heat at one end of a metal causes the particles there to vibrate rapidly and the temperature rises. This vibration is passed on through the next layer of particles. As they bump into each other and the heat energy is passed from one layer to the next until it reaches the colder end. An example of this is a vacuum flask.

Convection:

This is the main way in which heat energy is transferred through liquids and gas. (Liquids and gases are called fluids be cause they are free to move.) When part of a fluid is heated it expands and becomes less dense. It will take its place and the process is repeated. This results in currents of rising warm fluid and falling cooler fluids. This can be shown I a heater system.

Radiation:

Radiation is when waves travel outwards from a source carrying energy. Heat is radiated from hot objects as infra-red radiation. Heat radiation can travel through a vacuum. This process is different from the other two it travels in straight lines and at the speed of light and like light can be reflected of shiny surfaces. This is the only way heat can reach us from the sun. Heat radiation travels through transparent media like air, glass, and water. This can be shown in a kettle.

Evaporation:

This could cool down the water, as when the water evaporates it will take the heat away with it in the same way evaporating sweat cools down our bodies. If a lid was used this could slow down this process. As the water vapour will not be able to escape into the air as quickly as it would normally keep the heat in for longer. Also you can control the amount of heat loss depending on the surface area. If the container has a larger surface area it can result in more heat loss as the bigger the surface area the quicker evaporation can take place. Evaporation is the change of water in to a gas, steam, which will then rise into the air.

Prediction:

I predict that these factors will affect the out come of my experiment.

- Size of Container
- Different Materials

- Different Substances
- Surface Area
- Thickness and density
- Colour of Container
- Volume of water
- If a lid is used
- If the Container is insulated
- How many layers of insulation
- Starting temperature

Size of Container:

This will affect my experiment because the lighter the material in colour the better insulator it will be. I predict this because light colours are poor radiators, therefore they will reflect the heat back into the boiling tube.

The darker materials will absorb the heat and release it the other side so is a bad insulator.

Thickness and density:

The thickness and density of the material will also have a significant impact on the amount of heat loss. Containers with a lower density and are very thick will have a lot of air in them, as air is a very poor conductor it will become a good insulators as the container will be filled with air. The air trapped in the pockets will prevent convection currents and trap warm air. These factors will help to reduce heat loss.

If a lid is used:

If a lid is used then it will obtain more heat as it will not be able to escape the container. The heat will rise in a gas form then it will condense on the colder surface of the lid. It will then turn back into a liquid and start the same process again. Therefore if I use a lid it will slow down these processes.

Volume of water used:

The volume of water must be kept at constant if fair test is to be carried out. Also the more water the longer it will take to loose heat as there is more layers for conduction and convection to take place, prolonging the temperature.

If the container is insulated:

If the container is insulated then the water will stay warmer for longer. As this will make it harder for conduction to take place as the material/ container is thicker. Different types of insulators will affect the result in different ways i.e.

Tin foil will quicken heat loss as it is a metal which is a better conductor. But if the tin foil is double layer then the it may have the opposite effect as the first layer will conduct the heat out but the second layer will reflect the heat back in as it is a shiny surface.

What the container made of:

The material of the container could change the rate of heat loss. If it is made from polystyrene it will not allow much heat to pass through it is a different thickness to other materials, also it depends on the density of the actual container. Where as if it is made of plastic, it may allow more heat transfer to occur.

If the inside of the container is painted it will make a difference. If it is painted silver then it reflect some heat back to the water, but if it is painted black it will absorb the heat and this will make the heat loss greater.

Starting temperature of the water:

If the starting temperature is very high then more heat will escape quickly so this must be kept the same at all times to make sure test is fair.

I have decided that I will keep my starting temperature at 80°C

* Also the things that I have found out throughout my research will also affect my results.

So a lot of the experiment will depend on the container and it properties i.e. surface are, thickness, material etc.

So I think that the metal container will keep the heat in longer than the plastic container, the bigger the container the, or bigger surface area the more heat loss than a smaller container/ surface area. The formula I will be using to find out the surface area is πr^2.

Method:

I will get all the needed equipment which was needed and set up the apparatus. I will then collect the water from the boiling tank and I will measurement the amount of water in a measuring cylinder. I will measure the water as accurately as possible (to the nearest cm^3). I will then take the temperature of the water to make sure that it is a fair test as the starting temperature must always start at 80°C. I will then pour it into the containers and allow it to cool to the chosen starting temperature. Once it reaches the chosen starting temperature then I will then take the temperature each minute for five minutes. I will record these results in my result tables. I will then calculate the total loss and I will calculate

the average heat loss per minute. I will then repeat this process for each variable i.e. each size of container.

Results:

Using water as a liquid and size of container as variable:

Size of Container	0 min	1	2	3	4	5	Total heat lost	Average loss per min
Extra Large	80 °C	76	74	68	65	64	16°C	3.2oC
Large	80 °C	77	77	75	68	66	14°C	2.8°C
Medium	80 °C	77	75	74	72	69	11°C	2.2°C
Small	80 °C	79	77	75	72	71	9°C	1.8°C

Using coffee as liquid and size of container as variable:

Size of Container	0 min	1	2	3	4	5	Total heat lost	Average loss per min
Extra Large	80 °C	76	76	74	68	65	15°C	3 °C
Large	80 °C	76	75	73	70	69	11°C	2.2 °C
Medium	80 °C	78	77	75	74	70	10 °C	2 °C
Small	80 °C	79	78	75	73	72	8 °C	1.6 °C

Using water as liquid and results using different materials as material:

Material of Container	O min	1	2	3	4	5	Total heat lost	Average loss per min
Plastic	80 °c	75	74	74	73	71	9 °C	1.8°C
Glass	80 °c	76	75	74	74	73	7°C	1.4 °C
Polystyrene	80 °C	74	73	71	70	69	11 °C	2.2 °C
Metal	80 °C	78	78	77	76	74	6 °C	1.2 °C

Using coffee as liquid and material of container as variable:

Material of Container	O min	1	2	3	4	5	Total heat lost	Average loss per min
Plastic	80 °C	76	74	73	71	69	11 °C	2.2 °C
Glass	80 °C	77	75	74	73	71	9 °C	1.8 °C
Polystyrene	80 °C	75	73	71	69	65	15 °C	3 °C
Metal	80 °C	78	77	76	74	73	7 °C	1.4 °C

Using water as liquid and thickness of container as variable:

Thickness of container	O min	1	2	3	4	5	Total heat lost	Average heat loss per min
Extra Thick	80 °C	78	76	74	71	70	10 °C	2 °C
Thick	80 °C	76	76	75	73	72	8 °C	1.6 °C
Medium	80 °C	77	75	74	71	70	10 °C	2 °C
thin	80 °C	75	74	71	70	68	12 °C	2.4 °C

Using coffee as liquid and thickness of container as variable:

Thickness of container	O min	1	2	3	4	5	Total heat lost	Average heat loss per min
Extra Thick	80 °C	77	77	75	73	70	10 °C	2.2 °C
Thick	80 °C	77	74	74	72	71	9 °C	1.8 °C
Medium	80 °C	76	74	72	71	69	11°C	2.2 °C
thin	80 °C	75	73	72	70	68	11 °C	2.2 °C

Using water as liquid and using colour of container as variable:

Colour of Container	0 min	1	2	3	4	5	Total Heat loss	Average heat loss per min
Black	80 °C	73	70	68	65	64	16°C	2.67°C
White	80 °C	70	63	61	57	56	24°C	4°C
Silver	80 °C	75	73	71	68	67	13°C	2.17°C
Brown	80 °C	72	68	64	61	59	21°C	3.5°C

Using coffee as liquid and colour of container as variable:

Colour of Container	0 min	1	2	3	4	5	Total Heat loss	Average heat loss per min
Black	80 °C	72	70	67	65	64	16 °C	2.67 °C
White	80 °C	70	67	66	62	61	19°C	3.17°C
Silver	80 °C	74	72	70	67	66	14 °C	2.33 °C
Brown	80 °C	72	71	69	64	62	18°C	3°C

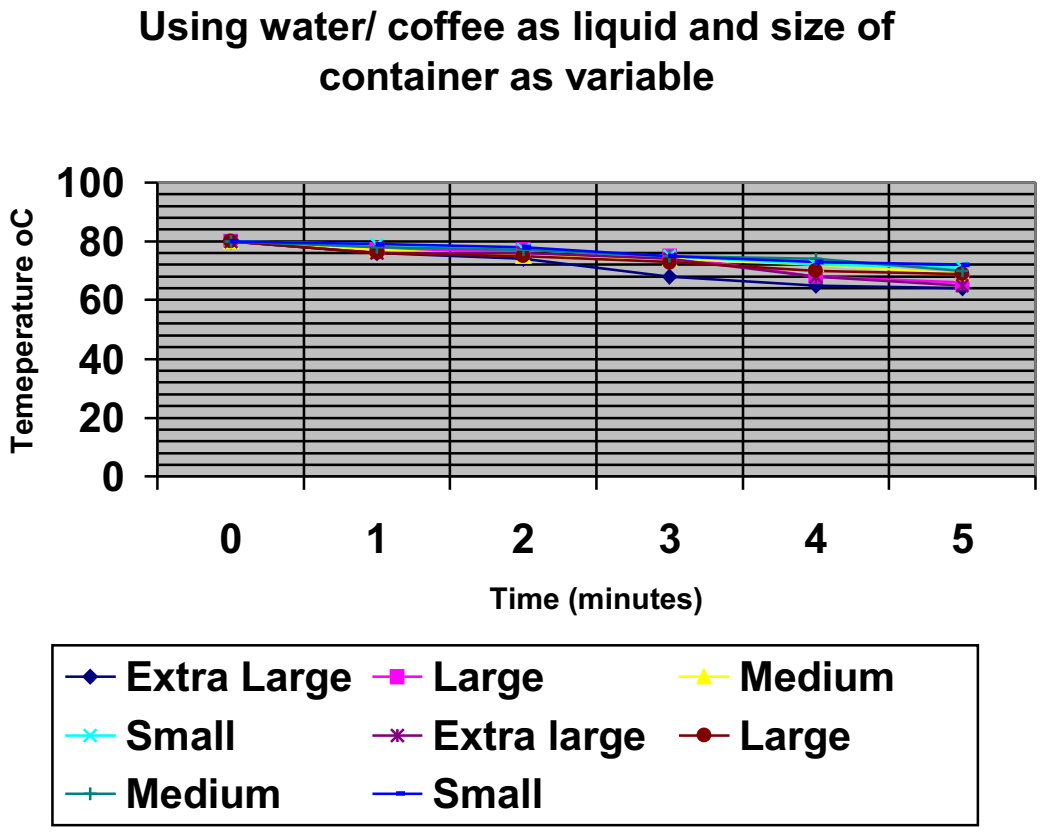
Final Results:

ALPM= Average Loss per Minute/W=water C=coffee

Size of Containers	ALPM °C	Material	ALPM °C	Thickness	ALPM °C	Colour of Container	ALPM °C
Extra Large	W=3.2 C=3	Plastic	W=1.8 C=2.2	Extra Thick	W=2 C=2.2	Black	W=2.17 C=2.67
Large	W=1.6 C=2.2	Glass	W=1.4 C=1.8	Thick	W=1.6 C=1.8	White	W=4 C=3.17

Medium	W=2 C=2	Polystyrene	W=2.2 C=3	Medium	W=2 C=2.2	Silver	W=2.6 C=2.3
Small	W=2.4 C=1.6	Metal	W=1.2 C=1.4	Thin	W=2.2 C=2.2	Brown	W=3.5 C=3

Graphs:



Conclusion;

I have realised that several factors affect my results.

The following are the containers that kept the heat in the longest:

- Metal container
- Small container
- Extra thick

- Silver container

Whilst doing my research I realised that water cools quicker than coffee . This might have something to do with that it is a solution which has been mixed with different substances. Also the layers are thicker, less soluble than water so it is harder for the particles to move through coffee than water.

As I predict metal kept the heat the longest as the shiny surface reflects the heat waves back into the container and also metal is also a good conductor, it can transmit heat through its surface therefore will warm up the actual container which in turn will keep the substance warm. The metal container can loose heat as well through convection the circularly process through heat is moved. Evaporation can play a role as heat rises and when it comes to the surface and then evaporation takes place. This can be prevented also metal is quite good at stopping radiation as like sun rays radiation waves can be reflected of shiny surfaces.

The smaller container kept the heat in longer than any other sizes this is due to less surface area as the bigger the surface area the more evaporation can take place. So less vapour would escape. If y ou have a lid on the container this can stop convection.

Also I predicted that the silver cup would be the best at keeping the heat in as it has a shiny surface and acts like a mirror so stops radiation from taking place. This is like in the vacuum flask a s it acts like the silver liner and it reflects the heat back in to the container.

Lastly I expected the thickness to change the amount of heat loss but I did not expect it to affect the heat loss to such an extent. The thicker the container the less heat loss whereas a thinner container lets a lot of heat escape. The thickness of the container works as another insulator so slows down the rate of heat loss.

As I stated at the beginning of my experiment the four main factors that would affect my experiment w ere

- Convection
- Conduction
- Evaporation
- Radiation

Evaluation:

My results are reliable because I used a thermometer accurate to 1 °C. If I were to repeat this experiment again I would have used a digital thermometer as the rate of accuracy is higher than by taking the measurements manually. I would also use a boss stand and clamp which would hold the thermometer in the same place and would not touch the sides of the container, if this had happened the temperature would not have been accurate enough as it is taking the temperature of the container not of the substance.

I could have done my experiment in controlled conditions if possible to make my results even more reliable.

My evidence supports my conclusion.

I could repeat my experiment and taken repeat results for water and coffee as separate results to increase accuracy.

Thermometer should not touch the glass; otherwise it is measuring the temperature of the glass, not the water.

Stirring the water would allow an average temperature to be recorded, not a local temperature.

I made sure that my experiment was safe, fair and organised which would decrease the possibility of human error. My results are as accurate as possible, with out human error. Also my results are as accurate as possible with a manual thermometer and stopwatch.