Mum's Mug of Hot Tea

Plymstock School Sc1 Scientific Investigations

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Aims of the investigation:

The aim of the investigation is to discover which variable prevents the most amount of heat loss through convection, conduction and radiation. Another aim of the experiment is to find the best insulator out of the materials given.

What factors might affect it?

- The temperature of the room
- The amount of water in beaker
- The size of beaker
- The type of insulator
- The time left between readings

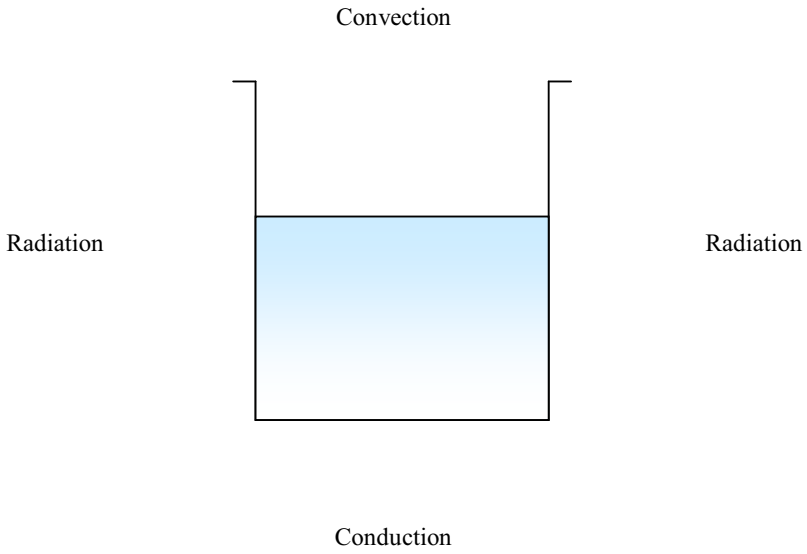
When you do your experiment, you will only investigate (look at) one of these factors:

The factor I will change will be the type of insulator the beaker of water will be covered with. I will keep one beaker without any insulation (control), of the other three, one will be covered with foil, one with a nappy and one beaker will have a lid.

Predict the effect of your factor and explain your prediction:

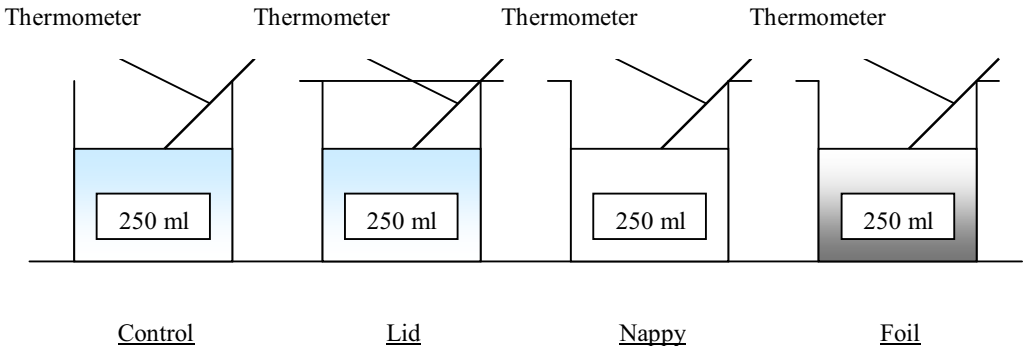
I predict that the nappy will prevent the most amount of heat loss from the beaker because, due to the composition of the nappy i.e.: several layers, air is trapped between the layers and so provides the best insulation. This is good because although the air warms up, if it is unable to move easily and so cannot carry the heat away by convection currents. Efficient insulators tend to be substances that have lots of holes or gaps in them. Sometimes in fibrous insulators, they work by trapping air inside – because air is a bad conductor of thermal energy. Heat spreads through air slowly, and so this is why insulators tend to be fluffy substances like wool and fibreglass matting. These substances trap air between their filaments.

A material will be a good insulator if neither heat nor electricity can pass through it easily. Although the plastic lid, in my experiment, is a good insulator, metals such as aluminium are good conductors. I think that the nappy will be the best material when preventing heat loss because it will slow down convection (the main way that heat will travel from the hot liquid in the beaker through the walls and base of the beaker and then to the outside world). Also the nappy will slow down radiation. However, I do think that the foil will prevent heat loss successfully. Foil reflects better than all the other materials in my experiment. This is because it is fairly light in colour and shiny. This enables the foil to reflect the radiation from the hot object back the way it came. Although, the nappy will not stop convection through the top of the beaker, I think it will be the most successful way of insulating the beaker of hot water. The nappy will not cover the top of the beaker, and so this will increase the amount of heat lost. I think the beaker will lose heat because above the liquid, the air will take heat from the liquid and rise (convection current). In addition, after prolonged periods, some of the liquid will evaporate, losing energy and causing its temperature to fall.



What apparatus will you need?

- Nappy
- Lid
- Foil
- 4 beakers (same size)
- Kettle
- Water
- 4 Thermometers
- Stop clock
- 2 Elastic bands



PRELIMINARY WORK:

I collected all of the equipment and filled 4 beakers up with boiled water from the kettle (200 ml). I then placed a nappy around one beaker and some foil around another using an elastic band. Next I placed a lid on one of the beakers and left the fourth beaker without any insulation (control). I then placed a thermometer in each beaker and measured the temperature, every minute in all four beakers. I then wrote down my results in the table below.

Results:

Temperature (ºC)

Insulator	1 Minute	2 Minutes	3 Minutes
Nappy	76	74	71
Lid	77	73	69
Control	76	73	68
Foil	74	70	64

I think that I should have been more accurate with timings between readings. Also, I should have attached the materials to each beaker before I poured the water into them. This would have made the results more accurate. This is because the beaker of water would have lost heat prior to starting the experiment. From this trial run I have learnt to be more accurate with the timings between readings. Hopefully, this will make my results more valid and accurate in the main experiment.

PLAN:

I will collect all of my equipment and gather all four beakers together. Around one I will attach a nappy, around the sides and bottom of the beaker. I will attach aluminium foil to the second beaker using an elastic band in the same way. On the third beaker I will place a plastic lid and the fourth beaker will be kept as a control. After the materials have been added to the beakers, I will place a thermometer in each of the empty beakers. As I set up my equipment I will boil a kettle of water and when it has boiled, I will pour the water into each beaker. I will then read the temperature of the water in each beaker. Using my stop clock, every minute I will look at the temperature on each thermometer and record my results in a clear table.

Safety and Skill:

- To insure that my experiment will be safe I will be careful when handling the kettle/beakers due to the very hot water inside them.
- When I take my readings I will look at the thermometers at eye level, this will mean that the readings are more accurate, than if were to read them at an angle.

List of factors I will not change:

- The temperature of water (°C)
- The amount of water (200ml)
- The time left between readings (1 minute)
- The room temperature (this may be difficult to control as the room temperature can vary, due to the weather or the number of people inside the room).

I am going to keep all of the variables listed above constant, except for the insulating materials I use to ensure my experiment is a fair test. I am going to keep the factors above the same. If I took the readings at different times for each beaker, the results would be invalid. To make my experiment simpler, I will only investigate one factor – the type of insulator.

Obtaining evidence:

During my experiment, I decided to measure the temperature of each beaker and then to find how much heat was lost. I followed the simple sum below:

> Original temperature of water – water temperature of last reading = heat lost to surroundings

Insulator	1	2	3	4	5	6	7	8	9	10	Temperature Lost (°C)
Control											
Try 1	77	72	69	65	64	61	59	58	55	54	77-55
Try 2	77	71	69	66	63	63	60	58	56	55	
Try 3	77	73	70	66	64	63	61	58	56	55	=22°C
Average	77	72	69	66	64	62	60	58	56	55	
Lid											
Try 1	76	72	68	67	68	64	62	60	59	57	76-57
Try 2	76	73	69	67	65	64	61	60	56	57	
Try 3	76	72	69	66	63	63	62	60	59	57	=19°C
Average	76	72	69	67	65	64	62	60	59	57	
Nappy											
Try 1	77	75	72	69	69	67	64	64	62	61	77-61
Try 2	76	74	72	71	68	67	67	62	62	61	
Try 3	77	75	72	73	69	66	66	65	63	62	=16°C
Average	77	75	72	71	69	97	66	64	62	61	
Foil											
Try 1	79	76	70	69	68	64	62	61	61	55	79-58
Try 2	80	75	69	75	68	67	64	61	58	61	
Try 3	79	72	73	68	64	65	64	60	60	58	=21°C
Average	79	74	71	71	67	65	63	61	60	58	

ANALYSING AND CONSIDERING EVIDENCE:

Explain why the straight line or curve that you drew is suitable:

The four curves for each beaker on my graph show negative correlation, as the temperature decreased due to heat loss. The curve for the beaker insulated by a nappy, is suitable, as it shows a steeper gradient compared to the other three beakers. The line of best fit for each beaker gives a visual representation of the underlying trend.

Explain simply what you have found out:

I have found out that the nappy was the best insulator and prevented the most heat loss and the worst insulator in my experiment was the beaker with no insulation. (Control).

Identify any patterns or trends in your measurements:

The results of the experiment do give reasonably clear plots, but there are some anomalies. One of these anomalies occurred for the foil beaker on the third and forth tries. The averages for the third and forth minutes are the same – this shows that the temperature did not decrease as it had done in all other minutes. However, I have noticed that the water in the beaker, insulated with the nappy, was the second hottest after 1 minute. After 2 minutes, it was the hottest and so had kept the most heat in. The curve for the beaker covered with foil, has a gentler slope compared to that of the controlled beaker.

Try to explain your conclusions:

In conclusion, I have proved that the beaker insulated with the nappy was the best at preventing heat loss. The nappy was the most successful insulator because it was the only material containing layers of material that could trap air and therefore heat. The trapped air could not move easily and so could not carry the heat away in convection currents. The main reason why the nappy was the best insulator is because of its composition. The nappy was also the most successful because of the layers, which trapped the hot air given off by the hot water in the beaker. However I have discovered that as Foil reflects better than all the other materials in my experiment (it is fairly light in colour and shiny), it enables the foil to reflect the radiation from the hot object back the way it came. The air took heat from the liquid and rose (convection current). In addition, after prolonged periods, some of the liquid evaporated, losing energy and caused its temperature to fall.

Explain how your results supported or undermine your original prediction:

My results supported my original prediction, as the nappy has been proved to be the most successful at preventing heat loss from the hot water in the beaker. However, the results for the beaker with the lid, and also the controlled beaker, have a difference of only 1°C. I would not expect this because I predicted that the beaker without any insulation or a lid would of shown a much larger heat loss.

EVALUATING:

Make a simple comment about how you did your experiment or about your results:

I think that although I successfully proved that my results supported my prediction, I think that I could have made the experiment more of a fair test. The starting temperature was far less accurate than I had hoped - the kettle may have been stopping at 100°C, but it was in constant use and by the time the thermometer had warmed up and the timer started, there may have already been 2-3 minutes of time elapsed. This made my experiment less accurate.

Comment on any results that did not fit in properly:

Some results did not fit in properly, such as the reading for the foil beaker at the third and fourth minutes. The temperature seemed to have stayed the same, when the beaker was losing heat. This was probably because I was not reading each temperature as accurately as I should have and therefore when I took the averages of each minute, it appeared to be the same result as the previous minute.

How accurately could you take your readings?

I took my readings quite accurately, however I should have ensured that the readings were taken exactly every minute. Sometimes, results were recorded that did not fit into the pattern. This may have

been because of the way I looked at the thermometer reading, or perhaps because I wrote the results in the wrong time sections. Also, I did not read the temperatures off the thermometer e very minute. Although we were all very accurate, one person may have been less accurate at taking readings than another – this could of affected some of the results or made them less accurate. Also, there may have been faults in the equipment and this could of affected the readings.

Comments on the suitability of the way you did your experiment- what were the problems? Suggest changes to the experiment, which would improve the quality of the results.

When I carried out my experiment, conditions were not perfect to carry out a fair test. For example, the room temperature could have changed due to the weather. Also, I found many problems (mainly involving the timing). I was under pressure to take the readings on each thermometer every minute, but it was not possible to take all four readings at once. If I were to carry out the experiment again, I would have four people in my group. This would mean that when every minute had passed, each reading would be taken simultaneously. Thereby, three readings would be taken for each beaker every minute. From these readings, I could find the average (this would have made the results more accurate by finding the mean).

Comment on the reliability of your evidence; accounting for any results, which did not fit in. Do you have enough evidence to support a firm conclusion?

Using my results table, I can see that one or two results did not fit in. This was due to mistakes made when recording the temperature readings. However, this did not alter the results gre atly (if at all). The beaker covered in foil showed an anomaly in the results for the third and forth minute. This was probably due to inaccuracy when taking the readings. However, I believe I have enough evidence to support my conclusion, that the best insulator was the nappy in my experiment.

Suggest improvements or further work, which would supply extra evidence to help with your conclusion.

To improve the experiment, and add to my conclusion, I could conduct the experiment for a longer period of time. For example, I would record the temperature of the water after 5 -minute intervals. This further work may show changes in the heat lost from the different beakers. I could also use a more accurate stop clock and/or thermometer. To make my results even more accurate I could also use a sensor, which automatically takes the temperature and displays it on a screen. If I were to use a piece of apparatus such as this, I would not need to read off the thermometer, where most problems were in the experiment. I could also repeat my experiment as to gain more results. The more results I have to find the average of, the more accurate the end result will be. By repeating the experiment for around three of four times, it would improve the reliability of the e vidence. I could then make a more reliable conclusion. I could also improve the range of materials that I use in my experiment. For example, I could use a different range of shiny materials, a range of thick materials etc. I did not do this in the original experiment as I had only limited materials and lack of time, but from experimenting with different materials, I could gain results to support a different conclusion.