SC1

Aim: Our investigation is to find out whether layers of insulation and different materials can affect the rate at which the water cools down in the test tube

Research, background and prediction

When any hot thing cools down, its particles lose energy. The energy given out is called heat. Heat loss causes temperature to fall. For example if you leave some water to cool, as time passes, the particles of water lose energy to the air. They slow down, and the temperature falls. Eventually the water will cool to the same temperature as the air. Heat energy no longer flows from water to air because each water particle has exactly the same kinetic energy, on average, as each air particle.

Conduction

This is where heat energy passes through the walls of the test tube by making the particles of the test tube vibrate and then they will make the particles next to them vibrate causing the heat to pass through the walls of the can and out to the surroundings.

Convection

This is where the cooler water particles sink down to the bottom because they are closer together and denser. The warmer water particles move further apart and become less dense so they float up to the top. Convection will only affect my experiment if I did not have a lid. This is because the warm water will float up to the top and the heat energy will escape out of the top. If a test tube of water was being heated from below then the water particles at the bottom of the test tube will become warm as therefore become less dense, they will begin to rise to the top of the test tube. As the warmer water particles begin to rise, the cooler water particles at the top of the test tube will sink to the bottom, as they are less dense. Once at the bottom of the test tube they will start to get warmer and become less dense. This process will continue until the test tube of water is at the same temperature.

Radiation

This is when the warm water particles vibrate the water particles next to them. This will give them more energy and will make the water there warmer. The water particles at the top of the test tube will radiate the heat energy into the surrounding air. For heat to radiate it does not need to be in contact with matter. Heat cannot radiate from one body to another body through a complete vacuum.

Evaporation

When a liquid is heated some of the particles gain enough kinetic energy to completely break free of the surface and 'escape' into the air. This results in the average kinetic energy of the remaining liquid particles to be lower than it was before and the liquid drops in temperature.

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 I use a lid 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 be keeping the heat in for longer.

These factors will affect my investigation so I will try and control them to make the tests as fair as possible.

In theory, insulation should delay the rate of conduction and radiation which should maintain the temperature for longer and slow down the rate of cooling but different materials are likely to affect the rate at which water cools for example foil reflects most of the heat so it is more likely that the foil is going to insulate the water more efficiently than say black paper.

I would also expect that the rate at which the water cools to reduce as the insulation becomes thicker. While insulation is supposed to stop heat loss it will still act as a conductor of heat. Several layers will slow down heat loss more so than one thicker layer. With several thinner layers, air becomes trapped between each layer and as air is a relatively poor insulator, heat loss will be slowed down.

Method:

Water was heated to over 50ºC in a kettle and 50cm³ was measured out in a measuring cylinder. This was cooled by running cold water

on the outside of the measuring cylinder until 50ºC was recorded on a thermometer. The water was then poured into a test tube and its temperature recorded at 2 minute intervals until 8 minutes had passed.
A layer of tin foil was then wrapped around the test tube and held in place with a rubber band, and the whole procedure repeated again. Further readings were made for 2, 3, 4 and five layers of tinfoil and the results recorded. The procedure was repeated to obtain a second set of results for the tinfoil.
The whole investigation was then repeated using black paper layers instead of tinfoil and the results recorded, and once again a second run of results were made.

Apparatus:

Test tubes (×6), stop clock, plasticene, foil, black paper, Kettle, Water, measuring cylinder (to most appropriate size which will be of 50cm^3), elastic bands (×6) and thermometer

Safety:
Be cautious of boiling water and with electrical kettles as you could have an electrocution.
Any spilt liquids should be dealt with and cleared up.
Be careful with test tubes and thermometers as they can break easily and cause glass splinters which penetrate skin easily and cause nasty accidents.
School bags should be left on the bag rack and not left as obstructions to the laboratory

Results:

NO LAYERS OF SILVER FOIL INSULATION

	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	45	40	42.5
4	43	38	40.5
6	40	36	38
8	38	34	36

1 LAYER OF SILVER FOIL INSULATION

	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	48	41	44.5
4	45	39	42
6	41	37	39
8	39	36	37.5

2 LAYERS OF SILVER FOIL INSULATION

	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	42	42	42
4	40	40	40
6	38	37	37.5
8	36	35	35.5

3 LAYERS OF SILVER FOIL INSULATION

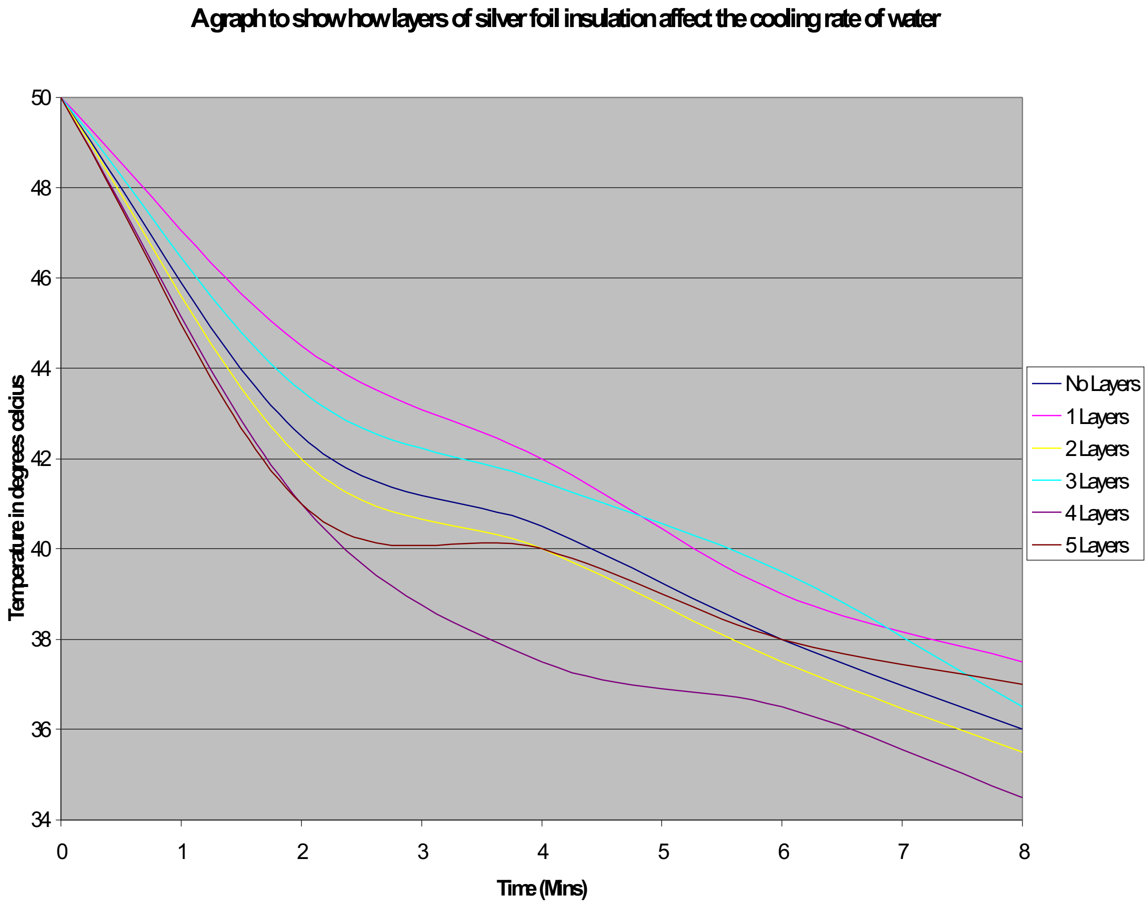
	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	44	43	43.5
4	41	42	41.5
6	40	39	39.5
8	37	36	36.5

4 LAYERS OF SILVER FOIL INSULATION

	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	42	40	41
4	39	36	37.5
6	37	36	36.5
8	36	33	34.5

5 LAYERS OF SILVER FOIL INSULATION

	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	42	40	41
4	40	40	40
6	38	38	38
8	38	36	37



NO LAYERS OF BLACK PAPER INSULATION

	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	38	36	37
4	36	34	35
6	33	33	33
8	33	32	32.5

1 LAYER OF BLACK PAPER INSULATION

	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	40	40	40
4	37	38	37.5
6	35	36	35.5
8	33	35	34

2 LAYERS OF BLACK PAPER INSULATION

	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	43	38	39.5
4	40	36	38
6	38	35	36.5
8	36	34	35

3 LAYERS OF BLACK PAPER INSULATION

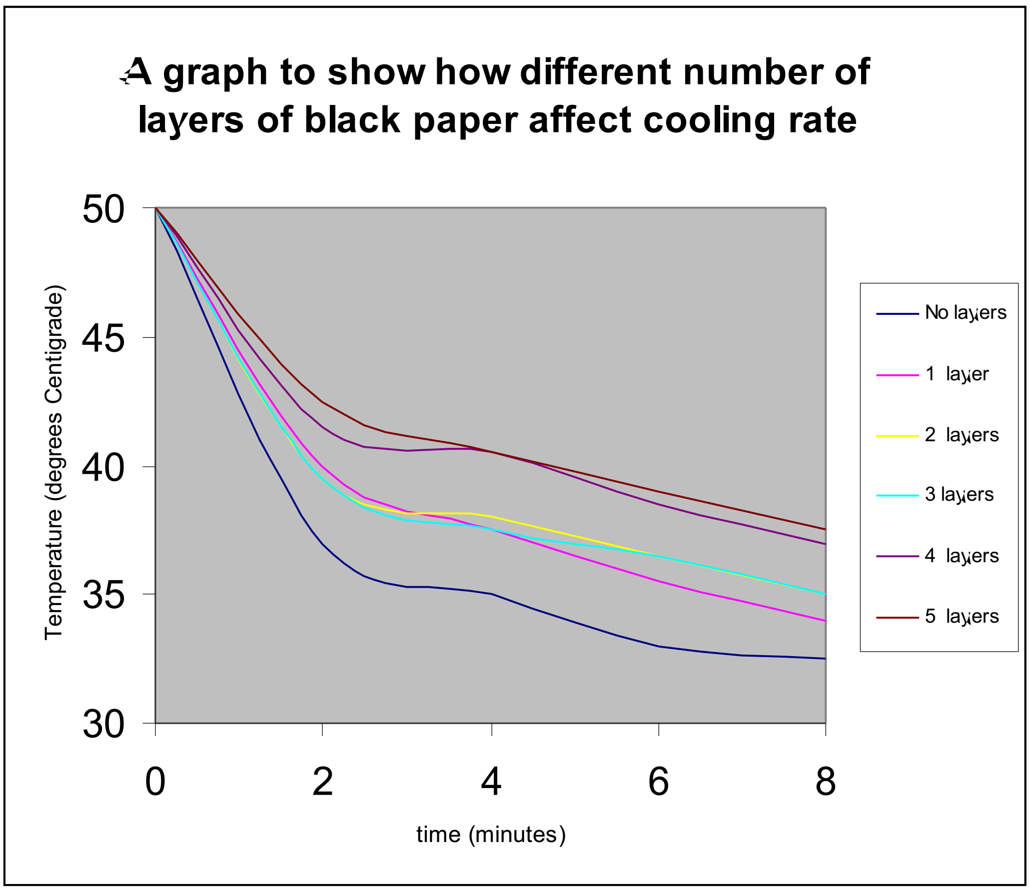
	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	41	38	39.5
4	38	37	37.5
6	37	36	36.5
8	36	34	35

4 LAYERS OF BLACK PAPER INSULATION

	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	41	42	41.5
4	40	41	40.5
6	38	39	38.5
8	37	37	37

5 LAYERS OF BLACK PAPER INSULATION

	1ST TEST	2ND TEST	
TIME (mins)	TEMP ˚C	TEMP ˚C	AVERAGE
0	50	50	50
2	43	42	42.5
4	41	40	40.5
6	39	39	39
8	37	38	37.5



Conclusion:

The results for the varying number of layers of black paper were more or less in line with my prediction that the heat loss was

greatest with no layers of black paper and that increasing the number of layers of paper reduced the heat loss with the five layers having the least heat loss after 8 minutes. The difference between having 2 and 3 layers was not very clear but the 4th and 5th layers reduced the heat loss further.
The results with the layers of tin foil were a little more surprising. The no layers tests resulted in a lower heat loss than both the 2 layers and the 4 layers, the 4 layers showing the greatest loss of heat overall.

I predicted that the tinfoil would reflect the heat back as well as the layers building up the insulating properties. Although this may have been the case in part, the metallic foil is also a good conductor of heat and is better than paper. This is because metals have free electrons which quickly transfer heat energy away through the foil. As the layers of foil touch each other the heat would be conducted away quite quickly despite the air gaps and the multiple layer theory would have less effect on slowing down heat loss.
After 8 minutes of cooling with the foil layers the range of difference between the highest and lowest heat loss was 2.5 ºC, compared to 5ºC for varying layers of paper. This suggests that the material used for layering was significant to the rate of heat loss.
For both materials the highest rate of heat loss was in the first 2 minutes which is to be expected as the difference between the water temperature and room temperature is the greatest. In other words the temperature gradient is the greatest and both the tin foil and the paper results showed a typical cooling curve.. Since the water cools the temperature gradient falls and the rate of cooling falls exponentially (negative gradient).

Evaluation

As with any scientific investigation accuracy of procedure and equipment used are essential for good results. The number of readings is improved by increasing the number of trials undertaken. I only had time to take two sets of readings for each number of layers for each material. These were averaged but in some cases the variation between the two readings was quite large. For example 2 layers black paper after 2 mins (difference 43-38 = 5ºC). By increasing the number of times readings were repeated would lessen the effect of anomalous results. Four readings were actually made for no insulation; two before the tin foil series and two before the black paper. These both started at the same 50 degrees C, but the final temperatures after 8 minutes were quite different. I t would be reasonable to expect these to be similar or at least the averaged value. In fact there was a range of final temperatures between 32 and 38 degrees C. I should have taken more care with the recording of readings and been more aware of anomalous results. Where there were larger differences between the two sets of readings I should have taken a third set of results, and taken an average of three.

A more accurate thermometer would have been useful perhaps a temperature probe which could measure tenths of a degree. Room temperature could have varied throughout the experiment. This is very likely with all the kettles heating water and causing the room temperature to rise slightly and this would decrease the temperature gradient at the beginning of each investigation. Alternatively draughts in the laboratory could reduce room temperature and increase heat loss from the water by convection.

If I were to repeat this investigation I would make a number of changes. I would increase the number of readings taken and be more aware of anomalous results.
I would choose a more accurate thermometer.
Make accurate measurements of room temperature and avoid draughts by keeping doors and windows closed and not moving about too quickly to cause draughts.