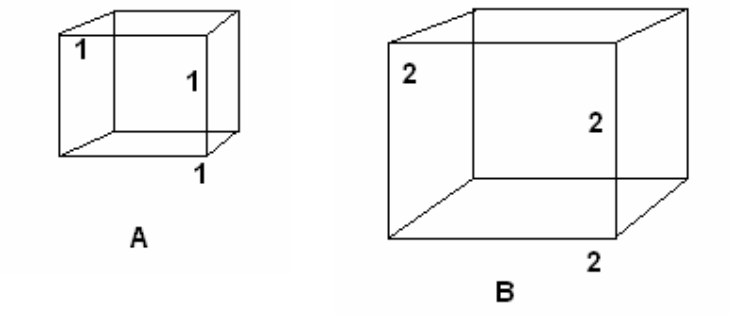
Aim
In the experiment, I intend to find out if volume is related to how fast heat is lost from beakers, I will use 5 different sizes of beakers, 1000ml, 400ml, 200ml, 75ml and 10ml. I will do this by filling the beakers with boiling water but make sure they start at 80c, then timing them for 10 minutes, recording their temperature every minute. By doing this I will be able to compare the heat-loss to the size of the beaker ratio and see the difference between them.

Introduction
As a beaker's surface area increases, the volume decreases, e.g.



Surface area = X x X x 6 = $6X^2$

Volume = B x H x W = X x X x X

A
Surface area = $6cm^2$
Volume = $1cm^3$
Ratio = 6:1

B
Surface area = $24cm^2$
Volume = $8cm^3$
Ratio = 3:1 (cancelled down)

A elephant is bigger than a mouse, so it's surface area: volume ratio is smaller than the mouse's and it will loose more heat than the mouse for it's size and therefore has to eat less than a mouse for it's size. The mouse may have to eat 100% of it's body weight but the elephant will only need to eat 5%. A polar bear is much bigger than the sun bear, so it looses less heat than the sun bear and the sun bear can loose more heat to keep it cool.

Plan
I am going to take 5 beakers (1000ml, 500ml, 200ml, 75ml and 10ml of which I will measure the depth and radius of the beakers for calculations (explained later.) Then I will fill them with water that is exactly 80c, and then I will put the thermometer in the beaker (holding the thermometer in a clamp) and time it with a stop clock for 10 minutes, recording the

temperature every minute. I will do this once without cling film on and once with cling film on. I will use the same beakers for both the experiments to make sure that the thickness of the beakers is always the same, because this could make a difference to the results. The variables are the volume of the three beakers, the surface area: volume ratio is also going to change with beakers, as will the rate of heat loss and when I use cling film. Once I have the results I can use them to draw tables of beakers with and without cling film, and hopefully there will be an immediate pattern. I will also draw graphs a graph for time/heat loss, then using this I can draw surface area: volume/ heat loss. To calculate the surface area: volume, firstlv I will work out the surface area using the formulae: $2\pi r2+2\pi rd$
d being depth. Then I will put the surface area over the volume., which is the same as the size of the beaker in ml because ml are the same as cm^2

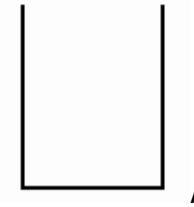
Prediction

I predict that the smaller the beaker the more the heat loss, and the larger the beaker, the less the heat loss and when using insulation (cling film) the heat loss will be slower but the same speed in order of heat loss.

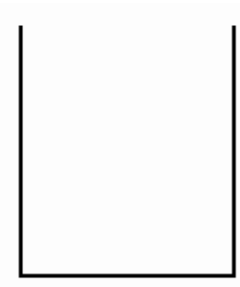
Apparatus

For my experiment I will use:

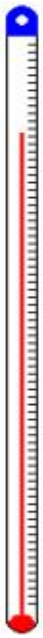
A 10ml beaker



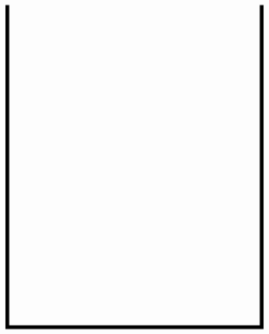
A 75ml beaker



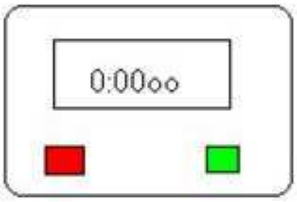
A 200ml beaker



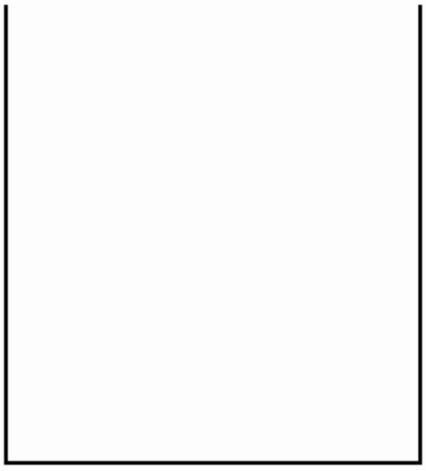
a thermometer



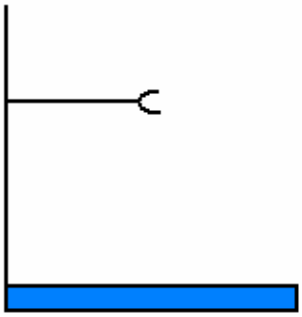
A 500 ml beaker



a stop clock



A 1000ml beaker



a clamp.

and some cling film.

Method

Firstly, I took a beaker and filled it with hot water. Then I made sure that the temperature of the water was exactly 80c by adding hot or cold water accordingly.

I put the thermometer in a clamp and put the clamped thermometer in the beaker of water. Then when it was 80c I started the stop clock and every minute I recorded the temperature I will do this for 10 minutes. Then do the same with the other 4 beakers, including once again for them all with cling film on. I will be using the non cling film beakers as a control.

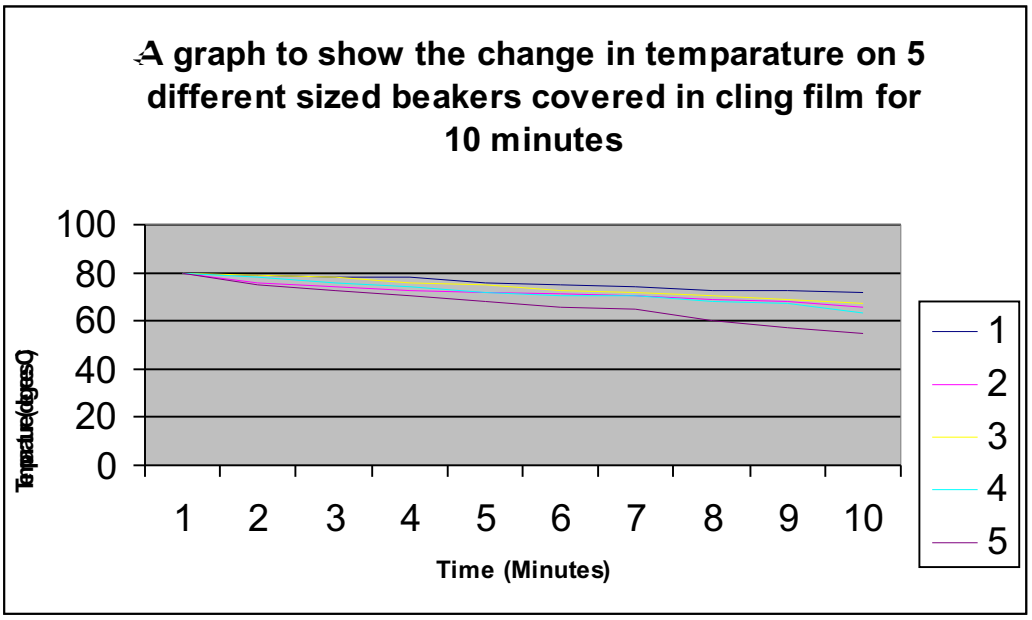
Results

1 = 1000ml
2 = 500ml
3 = 200ml
4 = 75ml
5 = 10ml

Beakers **with** cling film:

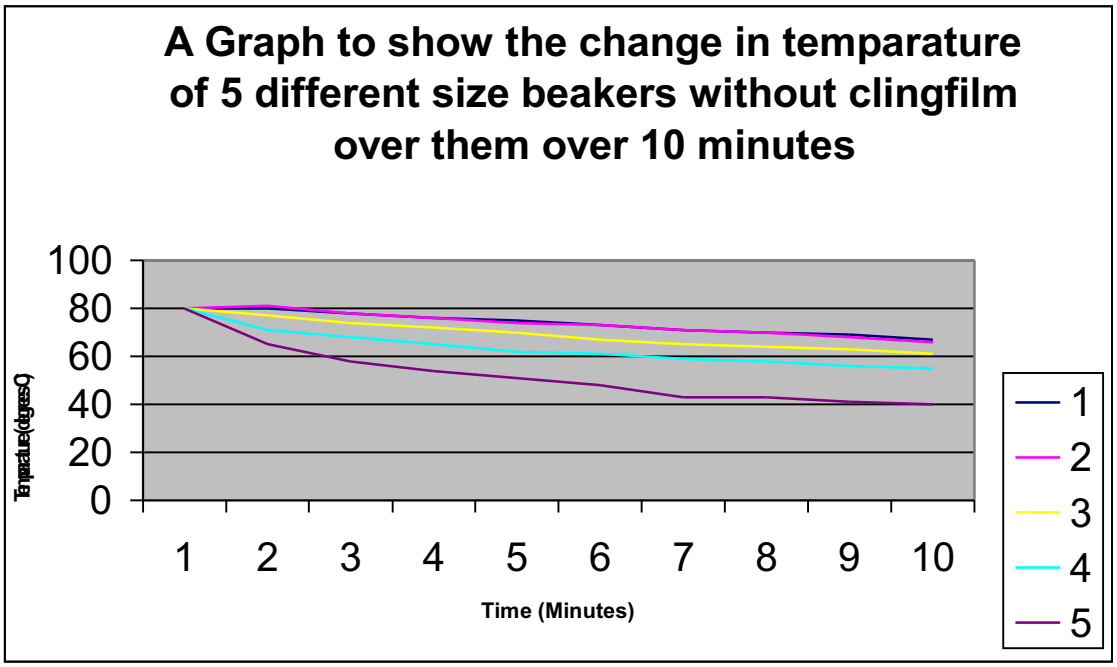
Minutes/beaker size	1	2	3	4	5
1	80	80	80	80	80

2	80	81	77	71	65
3	78	78	74	68	58
4	76	76	72	65	54
5	75	74	70	62	51
6	73	73	67	61	48
7	71	71	65	59	43
8	70	70	64	58	43
9	69	68	63	56	41
10	67	66	61	55	40
Heat lost:	13	14	19	25	40



Beakers **without** cling film:

Minutes/ beaker size	1	2	3	4	5
1	80	80	80	80	80
2	79	76	79	78	75
3	78	74	78	76	73
4	78	74	76	74	70
5	76	73	75	72	68
6	75	72	73	70	66
7	74	71	72	70	65
8	73	70	70	68	60
9	73	68	69	67	57
10	72	66	67	63	55
Heat loss:	8	14	13	17	25



A graph to show how volume affects heat loss:

1000ml beaker
Surface area = 2 x pi x 27 ^{2} + 2 x pi x 27 x 11 = 4578.12 + 1865.16 = 6443.28
Volume = 1000 cm^2
Surface area: volume = 6443.28 : 1000 = 6.4 : 1

500ml beaker
Surface area = 2 x pi x 25 ^{2} + 2 x pi x 25 x 9.1 = 3925 + 1428.7 = 5353.7
Volume 500 cm^2
Surface area: volume = 5353.7 : 5000 = 5.3 : 5

200ml beaker
Surface area = 2 x pi x 23 ^{2} + 2 x pi x 23 x 8.5 = 3322.12 + 1227.74 = 7549.86
Volume = 200 cm^2
Surface area: volume = 7549.86 : 200 = 7.5 : 0.2

75ml beaker
Surface area = 2 x pi x 17 ^{2} + 2 x pi x17 x 7 = 1814.92 + 747.32 = 2562.24
Volume = 75 cm^2
Surface area: volume = 2562.24 : 75 = 2.5 : 0.075

10ml beaker
Surface area = 2 x pi x 8 ^{2} + 2 x pi 8 x 4 = 401.92 + 200.96 = 602.88
Volume = 10 cm^2
Surface area: volume = 602.88 : 10 = 0.6 : 0.01

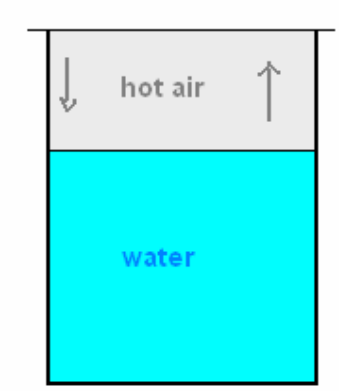
Heat loss of beakers with cling film
1000ml -13c loss in 10 minutes = 1.3c per minute
500ml – 14c loss in 10 mins =1.4c per min
200 –19c loss in 10 mins = 1.9c per min
75 – 25c loss in 10 mins = 2.5c per min
10ml – 40c loss in 10 mins = 4c per min

Heat loss of beakers without cling film
1000ml – 8 loss in 10 mins = 0.8 per min
500ml – 14 loss in 10 mins = 1.4 per min
200ml – 13 loss in 10 mins = 1.3 per min
75ml – 17 loss in 10 mins = 1.7 per min
10ml – 25 loss in 10 mins = 2.5 per min

Conclusion
I conclude that as surface area: volume goes up; the heat loss rate goes down. This means the 10ml beaker lost more heat in the same amount of time than the 200ml beaker, and the 200ml beaker lost more hea t then the

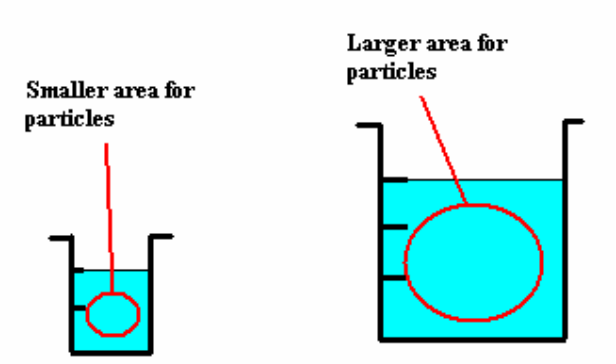
500ml beaker in the same time etc. My results also show that with cling film each beaker lost approximately half as much heat as the beakers without the cling film. My results also show that as the water gets cooler it losses heat slower. These results support my plan and also show me other things I didn't mention in my plan. All my results support my conclusions and I have a few results that didn't fit in, such as the second reading for the 500ml beaker with cling film, which went up from 80c o 81c which is not very likely to have happened, it is more likely that it was written down wrong. These results are as reliable as I could make due to restrictions I had, E.G. time limits, and the materials used. On the whole they are fairly reliable and I think they are sufficient to support a firm conclusion.

I think that the beakers with the cling film over lost heat slower because the heat had no-where else to go so it just stays in the beaker, heating up the water. I have drawn a diagram to explain.



There are many sources of possible error such as human error, which could have been made any time during the experiment take temperature etc… Another factor effecting the results it they smaller the beaker the smaller the thickness of the sides of the beaker, i.e. the 500ml beaker side is much thicker than the 75ml beakers side and the 200ml beakers side size is roughly in the middle. This could affect the heat loss out the sides of the beaker, because the 75ml beaker is going to loose heat from the sides slightly faster than the 200ml beaker. And to make this test completely fair you would have to make sure that all the beakers were of the same thickness. TO make the test more accurate by using a digital thermometer and using a 'point' something reading, and by checking the temperature at exactly the right time, because the results were checked to the nearest second, they could have been checked to the nearest 'point' second.

The hot particles in the water in the smaller beaker nea r the outside of the beaker were larger in numbers and there fore there were more particles close to the edge to loose heat, the ratio of hot water particles: edge of beaker is larger in the smaller beaker, since a larger beaker would have more room in the centre for particles to be in. I have tried to explain this in the following diagram:



To make my experiment more accurate I could have taken more results, this was not done due to not having enough time.