Polar Bear Experiment

Aim

I am going to investigate how the size of a Polar Bear affects its loss of heat. I will be doing this by using beakers with hot water to represent the Polar Bears.

Variables

There are many factors that determine how quickly or slowly heat is lost. The factors are as follows: amount of water, shape, temperature and surface area to volume ratio, insulation and types of Beaker.

I am going to investigate how variations in surface area: volume ratios in beakers lead to variations in heat loss.

In order to make a fair test I will need to keep all other variables the same, these variables are amount of water, shape, temperature, insulation and type of beaker. The amount of water will have to be regulated because if I kept the amount o f water the same there would not be a variation in mass and so the experiment would not give as clear results so I will be filling the beakers to half their full capacity.

Prediction

I predict that in the smallest beaker the heat-loss will be the greatest and in the largest beaker the heat-loss will be the smallest. This is because with the small beaker there are a lot of spaces for the heat to escape from and there is little mass in the middle and so heat is lost quickly. The large beakers have a surface area larger than the small beakers but have a smaller surface area: Mass ratio because they have a very big mass. This means although heat escapes quickly it can not cool the centre of the water as quickly as with the small beaker because it has a larger Surface Area: Mass ratio.

Apparatus

- Thermometer
- 5 different sized beakers
- Boiling water
- Stop Watch

Method

Take a beaker and measure its length and diameter, to be used to find the mass and surface area later, then fill it with hot water. Put the thermometer in and choose a starting temperature to start the recording on which will be the same for each test. Once it has gone down to the starting temperature start the stop clock. Every minute record the temperature of the water for fifteen minutes. Then do the same for 4 other sizes of beaker.

During the experiment it is very important to be careful while dealing with hot water and always to keep the hot water away from the body and made sure the beaker being poured in to was stable and would not fall over.

I have decided to use larger thermometers for more accurate readings and have checked each of the beakers to make sure they are the same shape and make. I decided to take 20 readings at one minute intervals so I could get a good idea of the heat loss from the beakers. I also made sure I got the water I used from the same source which was a laboratory tap.

Preliminary Experiment

I did a preliminary investigation to decide on suitable equipment to use to achieve accurate and precise results. It has also helped me to decide on my starting temperature. I did the preliminary experiment with a 500ml Beaker because I thought this beaker would cool down the slowest and would give me an idea of how accurate my results were going to be.

The results I got were as follows:-

Minutes	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temperature	70	68	67	66	65	64	63	62	62	61	61	59	58	57	56	55

When I was doing my experiment I realised that the thermometer I was using was not accurate enough and that a more accurate thermometer was needed so I could more easily differentiate between different temperatures. When doing my experiment I also found that I needed a starting temperature between 75 and 70 degrees because when it pours from the kettle it very quickly cools down and starts at a temperature at around 85 degrees and so I chose a starting temperature of 70 degrees so it gave me plenty of time to settle down and get all the equipment ready and also let the water settle.

Results

Minutes	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
500ml	70	68	67	66	65	64	63	62	62	61	60	59	58	57	57	56
300ml	70	68	67	65	63	62	61	61	60	58	57	56	55	55	54	53
200ml	70	68	66	64	62	61	60	59	57	56	55	54	52	51	50	49
125ml	70	67	65	63	61	59	58	57	55	54	53	52	50	49	48	47
50ml	70	67	64	62	60	57	55	54	52	51	49	48	47	45	44	43

After obtaining the results I measured the height, diameter and circumference with a tape measure.

Surface area of Water

50ml Beaker - $2* \pi 2.45^2 = 37.715 + (16*2.75) =$ **$81.715cm^2$**
125ml Beaker - $2* \pi 3.4^2 = 72.633 + (22.3*3.75)$ **$= 156.258cm^2$**
200ml Beaker – $2* \pi 3.85^2 = 93.132 + (25.3*4.5)$ **$= 206.982cm^2$**
300ml Beaker – $2* \pi 4.6^2 = 132.952 + (28.7*5.0) =$ **$276.452cm^2$**
500ml Beaker - $2* \pi 5.3^2 = 176.495 + (33.2*6.2) =$ **$382.335cm^2$**

Mass of Water

50ml Beaker - $2* \pi 2.45^2 = 37.715 * 2 .75 =$ **$103.716cm^3$**
125ml Beaker - $2* \pi 3.4^2 = 72.633 * 3.75$ **$= 272.373cm^3$**
200ml Beaker – $2* \pi 3.85^2 = 93.132 * 4.5$ **$= 419.054cm^3$**
300ml Beaker – $2* \pi 4.6^2 = 132.952 * 5.0 =$ **$664.76cm^3$**
500ml Beaker - $2* \pi 5.3^2 = 176.495 * 6.2 =$ **$1094.269cm^3$**

Ratios Surface area: Mass

50ml Beaker = $81.715cm^2 : 103.716cm^3 = 0.79$
125ml Beaker = $156.258cm^2 : 272.373cm^3 = 0.57$
200ml Beaker = $206.982cm^2 : 419.054cm^3 = 0.49$
300ml Beaker = $276.452cm^2 : 664.76cm^3 = 0.42$
500ml Beaker = $382.335cm^2 : 1094.269cm^3 = 0.35$

Heat-Loss Rate

500ml Beaker = $14^0C/15min = 0.93^0C/1min$
300ml Beaker = $17^0C/15min = 1.13^0C/1min$
200ml Beaker = $21^0C/15min = 1.4^0C/1min$
125ml Beaker = $23^0C//15min = 1.53/1min$

50ml Beaker = 27^0C/15min = 1.8^0C/1min

Calculations

The sum to work out Surface Area is **$2 \pi r^2 + (c*h)$**
The sum to work out Mass is **$2 \pi r^2 * h$**
The sum to work out Surface Area: Mass ratio is **Surface Area/Mass**
The sum to work out heat-loss per Minute is **Heat-loss/Time (Minutes)**

Conclusion

My results show that as Surface Area: Volume goes up the heat-loss rate also goes up. This means the 50ml beaker lost more heat in the same amount of time as the 200ml beaker, and the 200ml beaker lost more heat than the 500ml beaker in the same time.

This is because with the small beaker there are a lot of sp aces for the heat to escape from and there is little mass in the middle and so heat is lost quickly. The large beakers have a surface area larger than the small beakers but have a smaller surface area: Mass ratio because they have a very big mass. This means although heat escapes quickly it can not cool the centre of the water as quickly as with the small beaker because it has a larger Surface Area: Mass ratio.

These results support my prediction and show that Surface Area : Volume and Heat-loss are directly proportional, which means as one goes up the other goes up at the same rate, this is shown by the straight line of best fit. All my results support my conclusions and the line of best fit travels through the origin. These results are reliable enough to s upport my prediction.

Evaluation

I do not think that taking readings from only five sizes of beaker gave sufficient evidence to support a firm conclusion it only supported my predictions a little bit and a test on a larger scale would be needed to get more conclusive results. I believe that the temperature readings were accurate enough to prove my prediction but to go further with the investigation I would need to use a digital thermometer. There are no results that stray to far from the line of best fit which is a reassurance that the test was conducted fairly. If I did the investigation again I think that I would also use lids on the beakers because the addition of a lid will reduce the rate of heat lost. The reason for this is that heat is lost in 4 main ways in the experiment: evaporation,

conduction, convection, and radiation. By adding a lid I would be cutting out evaporation because the hot air can't escape, and I am cutting out convection because there are no currents of air taking away the hot ai r. I think this would mean that heat-loss would be reduced by about half and would make a fairer test. Another factor that may have affected the fairness of the test is that even though the water level was half way down the beaker, because of the different sizes of the beakers the water could be different distances from the top of the beaker where they may be more air flow or temperature change. The introduction of a lid would also solve this problem. If I did the experiment again I could also do the experi ment over a longer time period and see if the rate at which the beaker loses heat slows down as the water temperature begins to reach room temperature.

The aim of the experiment was to find out how the size of a polar bear affects its loss of heat and in doing this experiment I have found out that surface area: mass ratio is proportional to the heat-loss. Although the Polar Bear does not retain heat by just being big it has many other complex systems that keep it warm, homeostasis is the controlling of the internal environment in the body and has many ways of losing or gaining heat to keep the body at a constant temperature. Also the Polar Bear lives in very cold climates and so as to get fair results next time I would try to replicate that temperature difference between the body and environment. The Polar Bear has a body temperature of about 37 degrees and so I would try to get the water to this heat and then place the beakers in a sealed and temperature regulated room and put the temperature to about – 40 – 50 degrees to try to replicate the polar bears natural climate.