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Physics coursework : temperature change of water heated with an immersion heater

Planning

I am going to investigate the temperature change of water heated with an immersion heater. The following variables are going to be kept constant throughout the investigation.

Amount of water in the beaker
Length of the coil
Room temperature
Voltage

The variable I am going to investigate is how long the heater will be heated for. I am going to record the temperature of the water every two minutes for twenty minutes. I am going to repeat this test three times so that I will be able to get an average reading and improve the reliability of my results.

To ensure that my investigation will be fair, I am going to use the same equipment throughout the experiment. I am going to keep all of the variables constant except time. I am going to keep the voltage and the current the same during the investigation. I am going to make sure that I use the same amount of water throughout the experiment.

To make sure my experiment will be accurate, I am going to use suitable equipment and carefully record my results in sensible units.

To carry out my investigation I need to prepare an immersion heater. To do this I am going to use some copper wire and wrap it around a glass rod. I am going to attach a crocodile clip to each end of the wire and attach this to wires that lead to the power pack. Before I begin to time my investigation I am going to make sure that the ammeter, volt metre and power pack are kept at a constant reading.

I am going to use the following equipment; power pack, thermometer, (so that I will be able to record the temperature) beaker, crocodile clips, volt metre and an ammeter (so that I can ensure that the voltage and current remain the same during the experiment), a measuring cylinder (to precisely measure the amount of water), stop clock (to time how long the heater has been heated for), glass rod with a coil wrapped around it which will be used as the heater.

I predict that the amount of time the heater is heated for will be proportional to the change in temperature.

I will be able to predict my results by using the following formula.

$P = V \times I$

Where V is 2.75 and I is 3.4. I know this because I carried out a preliminary test.

$P = 2.75 \times 3.4$

$= 9.35W$ or $9.35 J/s$

Therefore the energy in two minutes $= 9.35 \times 120$

$= 1122J$ (every two minutes)

I can now use the formula $E = m \times c \times \Delta t$

Where $E = 1122J$

$m = 0.05 = 50ml = 50g = 0.05kg$(the amount of the water in the beaker)

$c = 4200$

I can rearrange this formula to predict the temperature change of the water every two minutes

$\Delta t = E / mc$

$= 1122 / 0.05 \times 4200$

$= 1122 / 210$

$= 5.3\ ^{\circ}$

The amount of energy from the heater is proportional to the time; therefore V and I have to be constant.

Predicted results

Time in minutes	Temperature
0	22
2	27.3
4	32.6
6	37.9
8	43.2
10	48.5
12	53.8
14	59.1
16	64.4
18	69.7
20	75

I have drawn a graph to show my predictions.

Obtaining evidence

Before I began my experiment I checked that the volt metre read 2.75 and that the ammeter read 3.4. After carrying out my experiment I have recorded the following results. The first column shows the independent variable, the variable I have deliberately changed. The other columns show the dependent variable, the size of this variable depended on the independent variable.

Time in minutes	Temperature in degrees˚c			Average results
	Test one	Test two	Test three	
0	22	21	21	21.3
2	25.5	24	25	24.8
4	29.5	29	30	29.5
6	33	33	34	33.3
8	36	36	37	36.3
10	39	40	41	40
12	42	42	42.5	42.2
14	44	44	44	44
16	46	46.5	47	46.5
18	48	48.5	49	48.5
20	50	50.5	51	50.5

Analysis

I drew a graph to show the average temperature change. From looking at my graph I can see that as time increases the temperature increases. Looking at the graph I used to predict my results, I can see that the predicted results are fairly similar to the results I obtained from my experiment. However the graph I used to predict my results is a straight line whereas the graph I used to show my results has a gentle curve. The highest temperature reached in the prediction graph was 75 degrees Celsius, whereas the highest temperature from my actual results was 50.5 degrees Celsius. This is because the results that I predicted were only for an experiment where no energy escapes from the water; this is why on my predicted graph the temperature is much greater. Whereas on the graph showing the results of the experiment the temperature is much lower because energy escaped from the water.

Using the formula P = V x I
I can work out the amount of energy every two minutes.
P = 2.75 x 3.4
= 9.35
Energy in two minutes = 9.35 x 120
= 1122J

I need to find out the temperature change for every two minutes so that I can work out the efficiencies. These are the temperature changes. (Δt)

Time in minutes	Amount of energy
2	1122
4	2244
6	3366
8	4488
10	5610
12	6732
14	7854
16	8976
18	10098
20	11220

These are the efficiencies during heating. I used the following formula to work out the efficiency during my experiment.

$$\frac{m \times c \times \Delta t}{v \times I \times \text{time}} \times 100$$

For example, the efficiency for 2 minutes.

$$\text{Efficiency} = \frac{(0.05 \times 4200 \times 3.53)}{(2.75 \times 3.4 \times 120)} \times 100$$

$$= 66\%$$

Minute	Efficiency
2	66%
4	87%
6	71%
8	56%
10	69%
12	41%
14	34%
16	47%
18	37%
20	37%

The longer we timed the heater for, the lower the efficiency became. The longer we heated the water, the less the temperature increase there was. This is because the longer the water was heated for, the more energy escaped. The experiment is not accurate, as the beaker was not closed; this means that there was an open system where energy could escape making the heating decrease in efficiency. If an insulation beaker had been used, less energy would have been lost during the experiment and more would have been kept in water. This would have made my final results more similar to my predicted results, as my predicted results are for an experiment where no energy was to be lost.

Evaluation

My investigation was fairly reliable. The method of obtaining sufficient results was fairly accurate. Before I did each experiment, I made sure that the water had been carefully measured and I checked that the voltage and the current were kept at a constant. However I did not use the same equipment for each time I did the experiment. This could have affected my results because some of the equipment that I used might have been faulty.

The results that I have obtained from this experiment are fairly accurate as I did the experiment three times. Doing the experiment three times meant that I could compare my final results and observe the average results.

To make the experiment more accurate I could have done the experiment more than three times, this would perhaps confirmed that there was a pattern in the results that were obtained. I could have also used different equipment that would have made my experiment more accurate. For example, I could have used an insulation beaker; this would have meant that less heat escaped from the beaker. I could have also used more precise ammeters and voltmeters.

The graph that shows my predicted results shows that the increase in time is proportional to the increase in time. However the graph showing my actual results does not show this as the graph is a curve. This means that my results do not back up my original hypothesis, however the results I did obtain show that as the amount of time increased so did the temperature.

The graph showing my results shows that the longer the water is heated for the more the temperature increases. However looking at my graph the results show a curve. Eventually this curve will straighten out showing that the temperature cannot increase anymore. To extend my experiment I could have heated the water for longer to see if the temperature change would have become less.

If I was given more time I could have investigated other variables such as the amount of water in the beaker and the voltage. I could have changed these to see the effect they would have on the temperature change.