IB Group 4   Internal Assessment   Chemistry   Biology   **Physics**

Name:_____ Date(s):__14/2/12_____

Candidate Number: 00-3072-074_____ Session:_____ Level:___HL_____

Investigation Title: _____THE DIAMETER OF NICHROME WIRE_____ _____

Internal Assessment Marking Form

Criterion	Required Aspects			Level
	Complete (2)	**Partial (1)**	**Not at All (0)**	
Data Collection and Processing **Aspect 1 –** Recording Raw Data	Records appropriate quantitative and associated qualitative raw data, including units and uncertainties where relevant.	Records appropriate quantitative and associated qualitative raw data, but with some mistakes or omissions.	Does not record any appropriate quantitative raw data **or** raw data is incomprehensible.	2
Aspect 2 – Processing Raw Data	Processes the quantitative raw data correctly.	Processes quantitative raw data, but with some mistakes and / or omissions.	No processing of quantitative raw data is carried out **or** major mistakes are made in processing.	2
Aspect 3 – Presenting Processed Data	Presents processed data appropriately and, where relevant, includes errors and uncertainties.	Presents processed data appropriately, but with some mistakes and / or omissions.	Presents processed data inappropriately **or** incomprehensibly.	2
Conclusion and Evaluation **Aspect 1 –** Concluding	States a conclusion, with justification, based on a reasonable interpretation of the data.	States a conclusion based on a reasonable interpretation of the data.	States no conclusion **or** the conclusion is based on an unreasonable interpretation of the data.	2
Aspect 2 – Evaluating Procedure(s)	Evaluates weaknesses and limitations.	Identifies some weaknesses and limitations, but the evaluation is weak or missing.	Identifies irrelevant weaknesses and limitations.	1
Aspect 3 – Improving the Investigation	Suggests realistic improvements in respect of identified weaknesses and limitations.	Suggests only superficial improvements.	Suggests unrealistic improvements.	2

Aim:

To calculate the diameter of a piece of nichrome wire from its electrical resistance by varying the length of the wire.

Background Information:

The resistance of a conductor can be found through the following equation:

$$R = \frac{\rho l}{A}$$

Where: R = resistance (measured in Ω)

                    l = length (measured in m)

                    ρ = resistivity of material (measured in Ωm)

                    A = cross sectional area (m^2)

The electrical resistivity of the nichrome wire is between 1.0×10^{-6} to 1.5×10 Ωm at room temperature (WireTron-Inc.). There is a range of electrical resistivity because nichrome wire is made out of nickel, chromium and often iron. Therefore, the compositions between the metals vary, thus the electrical resistance also vary. Therefore, the median of the range, 1.25×10^{-6} Ωm, will be used. The cross sectional area for a wire is $\pi \frac{d^2}{4}$. By substituting this in the equation and simplifying, the equation becomes:

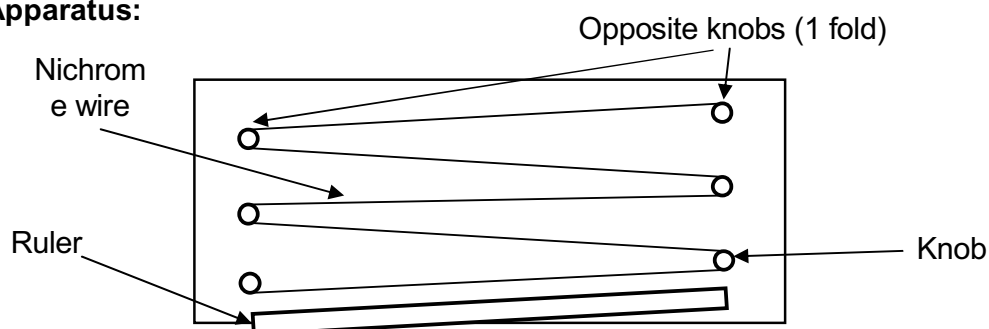$$R = \frac{4\rho l}{\pi d^2}$$

If the resistance and length becomes the subject, the equation will be:

$$\frac{R}{l} = \frac{4\rho}{\pi d^2}$$

By making the resistance and length the subject, when graphed, the gradient will be equivalent to $\frac{4\rho l}{\pi d^2}$, and from this, the diameter can be determined.

Diagram of Apparatus:

Fig 1. Apparatus:

Raw Data:

Table 1. Quantitative Raw Data Table:

Length (cm)	Uncertainty of length	Resistance (Ω) (±0.1Ω)				
		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
37.3	±0.1	2.5	2.6	2.4	2.6	2.5
74.6	±0.2	4.4	4.5	4.6	4.5	4.6
111.9	±0.3	6.4	6.4	6.5	6.3	6.3
149.2	±0.4	8.6	8.4	8.5	8.4	8.5
186.5	±0.5	10.6	10.5	10.4	10.6	10.5

Sample calculations:

Sample calculation 1. Calculating the length and uncertainty of Nichrome wire using error propagation:

The length of one knob to the opposite knob (1 fold) was measured, shown in fig 1 above. It was assumed that this length was the same length between each opposite knobs (fig 1). The measured length was found to be 37.3cm with the ruler having an uncertainty of ±0.1. Therefore, the uncertainty increases by a magnitude of ±0.1 and the length increases by 37.3cm for each length trial. Calculation s show in sample calculations 1 below.

1 fold = 37.2 ±0.1cm

2 folds = (37.2 ±0.1cm) + (37.2 ±0.1cm)
     = 74.6 ±0.2cm

3 folds = (37.2 ±0.1cm) + (37.2 ±0.1cm) + (37.2 ±0.1cm)
     = 111.9 ±0.3cm

Sample calculation 2. Converting length from cm to m:

$$\frac{1cm}{100} = 0.01m$$

Example using the trial from the length of 37.3cm:

$$\frac{37.3cm}{100} = 0.373m$$

Sample calculation 3. Calculating the average resistance:

$$Average\ resistance = \frac{\sum Resistance\ results}{\sum Number\ of\ trials}$$

Example using the trial from the length of 37.3cm:

$$Average\ resistance = \frac{2.5 + 2.6 + 2.4 + 2.6 + 2.5}{5}$$
$$= 2.52\Omega$$

Answer has to have the same number of decimal places as uncertainty

□ Average resistance ≈ 2.5 Ω

Sample calculation 4. Calculating the uncertainty of the average resistance using maximum deviation:

The highest and lowest value of the resistance is subtra cted from the average result. The highest magnitude of the result will be used as the uncertainty. However, if the order of magnitude of the uncertainty is lower than the instrumental uncertainty, the instrumental uncertainty will be used (±0.1 Ω). The uncertainty is rounded to 1 significant figure.

Example for average resistance of 2.52 Ω:

Uncertainty = Highest value – average values	Uncertainty = Lowest value – average value
= 2.6 – 2.52	= 2.5 – 2.52
= |0.8|	= |-0.2|
= ±0.08 Ω	= ±0.2 Ω

The uncertainty would be ±0.08 Ω, however, it is smaller than the instrumental uncertainty.
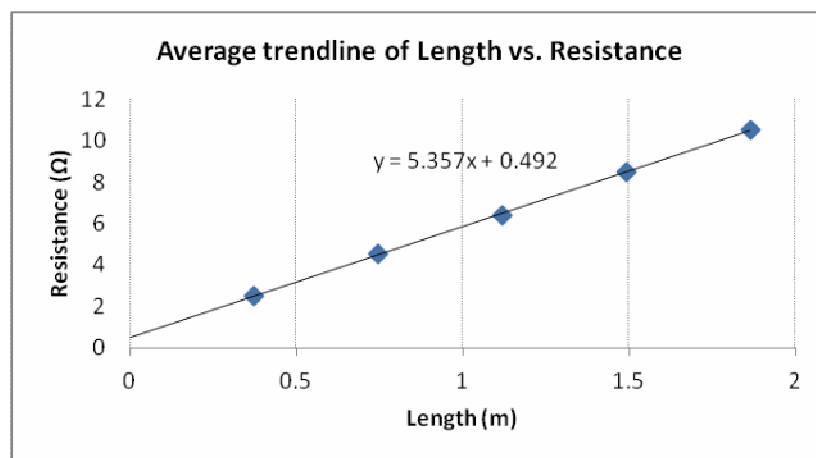
□ The uncertainty for the average resistance is ±0.1 Ω.

Processed Data:

Table 2. Quantitative Processed Data:

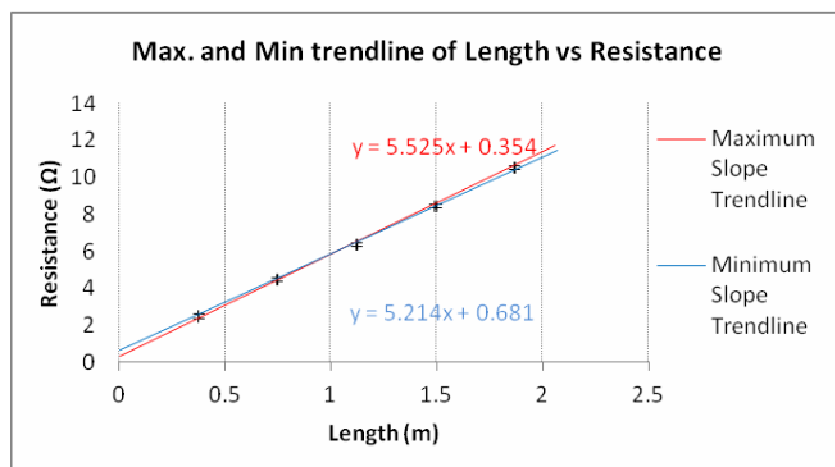| Length (m)	Uncertainty of length (m)	Average Resistance (Ω)	Uncertainty of average resistance (Ω)
0.373	±0.001	2.5	±0.1
0.746	±0.002	4.5	±0.1
1.119	±0.003	6.4	±0.1
1.492	±0.004	8.5	±0.1
1.865	±0.005	10.5	±0.1

Graphing:

Graph 1. Average trendline of Length vs. Resistance:

Graph 2. Maximum and Minimum trendline of Length vs. Resistance:

More sample calculations:

Sample calculation 4. Calculating the percent uncertainty of the average gradient:

$$Uncertainty\ of\ average\ gradient = \frac{Slope_{max} - Slope_{min}}{Slope_{average}} \times 100$$

$$\approx \frac{5.525 - 5.214}{2} \times 100$$

$$\approx 5.805\%$$

$$\therefore \quad \frac{R}{l} = 5.357 \pm 5.805\%$$

Sample calculation 5. Calculating the diameter

$$\frac{R}{l} = \frac{4\rho}{\pi d^2}$$

Substitute in known values:

$$5.357 \pm 5.805\% = \frac{4(1.25 \times 10^{-6})}{\pi d^2}$$

$$d = \sqrt{\frac{4(1.25 \times 10^{-6})}{\pi(5.357 \pm 5.805\%)}}$$

The square root of the uncertainty is half the percent uncertainty:

$$d = \sqrt{\frac{4(1.5 \times 10^{-6})}{\pi(5.357)}} \pm \left(\frac{5.805\%}{2}\right)$$

$$= 0.000000545\ m \pm 2.9025\%$$

$$= 0.000545 \pm 0.000016m$$

Round uncertainty to 1 significant figure and diameter to the same number of

$$= 0.00055 \pm 0.00002m$$

Conclusion:

From the graphs 1 and 2 above, it is evident that the length is directly proportional to the resistance as the trendline is linear. From graph 1, the average gradient was found and from graph 2, the uncertainty of the a verage gradient was determined. The gradient can then be substituted into the equation and rearranged to find the diameter.

The diameter of the experiment was found to be 0.00055m with an uncertainty of ±0.00002m, where as the actual diameter is 0.000559m given by the manufacturer (Science Supplies Australia Pty, Ldt). From this, the experimental error can be calculated.

$$Experimental\ error = \frac{|Experiemental - Theoretical|}{Theoretical} \times 100$$

$$= \frac{|0.00055 - 0.000559|}{0.000559} \times 100$$

$$= 1.61\%$$

As shown above, the experimental error is 1.61%. This means that the difference between the experimental and theoretica l value has a difference of 1.61%. This experimental error is less than the uncertainty. This also shows that the theoretical value lies within the uncertainty of the experimental result. Therefore, the experiment supports the relationship between the diam eter, length and resistance, which is:

$$R = \frac{4\rho l}{\pi d^2}$$

Which could be arranged to make diameter as the subject:

$$d = \sqrt{\frac{4\rho l}{\pi R}}$$

Sufficient concordant results were found in the experiment as the value between the maximum and minimum resistance found in the trails had the greatest dif ference of 0.2Ω. This shows that the results were consistent.

The method to calculating the uncertainty of the average resistance was maximum deviation. This method considers the greatest possible error in the experiment. The uncertainties were all found to be ±0.1Ω which is the same as the uncertainty of the instrument. Considering that the greatest possible error found for the average resistance was the same as the instrument, the error is considered to be quite low. The uncertainty of the length of nichr ome wire was found using rules from error propagation.

The method of measuring the length required that the errors must be added together, therefore increasing the error in the experiment. This error can be improved if the nichrome was set up as a straight line and using a tape measure so that the error does not build up.

Evaluation:

Limitations:	The effect on the experiment:	How this can be improved
Crooked nichrome wires	The length of the opposite knobs was measured which assumes that the nichrome wire was straight. However, the nichrome wire was actually crooked. Therefore, the actual length of the nichrome wire would be greater than the measured length. From the experiment, It was found that the length is directly proportional to the resistance. Since the actual length was longer than the measured value, the value of the resistance was larger than it should have been.	This limitation can be improved by tightening the nichrome wire. By tightening the wire, it would become straighter.
Nichrome wires were bent around the knobs	The nichrome wires were bent around the knobs. Thus the measured length of the nichrome wire was smaller than it should have been. As the wire was longer than the measured value, the value of the resistance was larger than it should have been.	If the size or diameter of the knobs were decreased, the length of the sector where the wire wraps around it would also decrease and minimises this limitation i.e. the size of a screw driver so that the length which wraps around the knob would be insignificant. Alternatively, the nichrome wire could be measured in a straight line so that it did not have to bend around the knobs.
The varying electrical resistivity of the nichrome wire.	The composition of the nichrome wire varies and also the electrical resistivity. Therefore, the median was assumed to be the electrical resistivity. The actual electricity may have been different from the assumed value which affects the calculations of determining the diameter.	By finding the percent composition of the nichrome wire, the electrical resistivity may have been estimated which will improve the accuracy of the experiment instead of assuming that the value is the median.

Bibliography

(n.d.). *Science Supplies Australia* , 12.

WireTron-Inc. (n.d.). *Nichrome 80 & Other Resistance Alloys - Technical Data & Properties*. Retrieved February 13, 2012, from Wiretron: http://www.wiretron.com/nicrdat.html