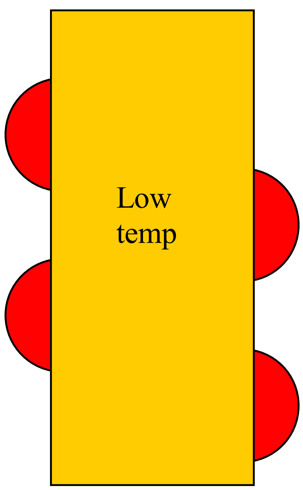
My Aims

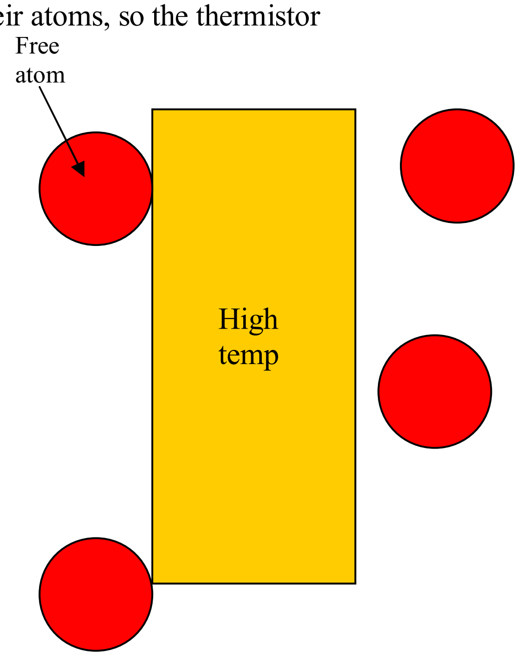
I aim to find how the resistance of a thermistor changes with temperature keeping the current constant and recording the voltage as the temperature changes. I will then record this data and try to explain it using scientific knowledge and detailed reasoning.

Background information - Thermistors

Thermistors are thermally sensitive resistors and have, according to type, a negative (NTC), or positive (PTC) temperature coefficient. They work because at low temperatures, electrons are fixed onto atoms and so cannot move. As the electrons get hotter they receive enough energy to escape from their atoms, so the thermistor becomes a better conductor.



As is shown the metal on the left at low temperature has not got many free atoms available for conducting, however the metal on the left at high temperature has a lot of free atoms, making it a far better conductor. This shows the action of a thermistor.



Materials that react like this are called semiconductors. Carbon, silicon are two materials whose resistance decreases as they get hotter. Thermistors can be used for the following functions:

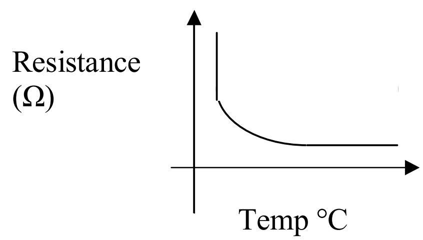
- Temperature sensing, switching at temperatures ranging from 60°C to 180°C, e.g. protection of windings in electric motors and transformers.
- Solid state fuse to protect against excess current levels, ranging from several mA to several A (25°C ambient) and continuous voltages up to 600V and higher, e.g. power supplies for a wide range of electrical equipment.
- Liquid level sensor

The equation used for calculation of the resistance of the thermistor is:

$$\text{Resistance} = \frac{\text{Voltage across thermistor}}{\text{Resistance of thermistor}} \quad \left(R = \frac{V}{I} \right)$$

Prediction

After research of this science I have found that the thermistor is made from a semi-conductible material which we have been told is an NTC (negative temperature coefficient). In this case I believe that as the temperature increases the resistance will decrease as more electrons are freed and the material becomes a better conductor. The graph produced at the end of this experiment should therefore look like this:



Preliminary Experiment

Before the main experiment is carried out a preliminary experiment is needed to clarify several problems such as equipment choices and temperature ranges. Also I have to find the time it takes to complete a trial of the experiment so I can work out how many readings it is possible to take in the given time.

Method

I need to set up the experiment in the way (shown later) I had pre-determined which included both an ammeter and a voltmeter, first preparing the pot by wrapping foam round it for insulation. I will put 3 layers of the foam on attached with elastic and a layer (cut in a circle) on the bottom after deciding that the time needed for each trial did not require masses of insulation. I will then make the decision of whether to just the voltmeter and keep the ammeter at a constant by varying the voltage and using the variable resistor or whether to keep the ammeter independent and record both sets of data. I will also need to find out the hottest temperature of the boiling water and therefore determine the range of temperatures over which data will be collected. Also the number of recordings will have to be decided on depending on the time it takes to test at one temperature (of course certain other readings will have to be made if there is a large gap between the results). The last decision to make is the accuracy of my results.

When the equipment is set up the water will have to be put in the pot, boiling for the hot temperatures and ice for below temperatures. Then it is stirred and adjusted to the temperature needed. The thermistor is then put in the pot and given a minute or so to adjust to the temperature (the water periodically will need stirring to retain its temperature). A reading is then taken and recorded.

Here are the results of the preliminary experiment:

Temperature (°C)	Voltage (V)	Amperes (mA)	Resistance (Ω)
10	11.67	15	0.78
26	4.45	15	0.30
80	1.43	15	0.10

Evaluation of the preliminary experiment

From these results and other information I have collected during the trial of the equipment I have found that the peak water temperature is around 85°C. This means that the first reading I need to make should be at 80°C. Judging by the time it takes to record one temperature I will record a reading ever 10°C and then fill in the data if there are too large gaps in the results. In the final the current will have to be kept at a constant or else the sheer number of results will become confusing and mistakes will be made. As previously stated this will be achieved by combining changing the voltage and using the variable resistor. With regards to the accuracy of my results, these should be to 1 decimal place or 3 significant figures as this provides a reasonable accuracy without becoming over-accurate.

The independent variable (the one changed to produce to results) is the temperature whilst the dependant variables (the ones measured) are the voltage and so the resistance. The constant is the current.

Apparatus list

Here is a diagram of all the equipment used in the preliminary experiment, plus a circuit diagram which is followed by a list of all the equipment and its function:

- Rheostat (variable resistor): used to keep the current constant and minimise the number of variables in the experiment.
- Multimeter : can be used for many functions but for this experiment is used as an ammeter
- Voltmeter: gives the voltage passing round the circuit and needed to provide a basis for the results
- Thermometer: to measure the temperature of the water to the nearest degree°C
- 6V battery pack: used to provide current for the circuit and low voltage so it will not provide a hazard.
- Thermistor: to provide the main dependant variable in the experiment
- Glass rod: used to even the temperature throughout the water and provide an accurate reading
- 2 measuring beakers: to provide a container for the water and to a certain extent insulate against heat loss and to hold cold water for adjusting the temperature.
- Polystyrene wrap: to add to the insulation of the container to minimize heat loss.

Method for the final experiment

Firstly collect all the equipment that is needed for this experiment and put it in a labelled tray. Lay this tray on your place of work. Set up the circuit and check it is working by just testing the thermistor without immersing it. Make sure the variable resistor has an effect on the current and that the voltmeter is giving a positive reading (if not swap the wire terminals). Take the non-insulated beaker and fill it with cold water. Then fill the beaker insulated with foam from the preliminary experiment with the boiling water from the vat. Proceed with care of others as the water presents a major hazard. Take the water back to the place of work and add cool water if needed to correct the temperature. As the water is at 85°C and readings will have to be taken at 80°C, 70, 60, 50, 40, 30, 20, 10 at some point this will be needed. After the correct temperature is attained the thermistor should be submersed. It should be left to settle for about a minute with stirring to retain the temperature then a reading should be taken. This should be recorded in a table from where it can be analysed and plotted as a graph.

Risk Assessment

There is only element that provides a major risk in this experiment this being the extremely hot water. There is no real protection against this but if precautions and care is taken with regards to the surroundings and others working in the vicinity. If scalding occurs then the skin will have to be submersed in ice water to minimise the pain. Although water and electricity are not usually a good combination the fact that only 6V are passing round the circuit there is no real danger from the charge.