LITTLE BIG FUTURES

Activity 3 mark scheme

Investigation 1 - bimetal strip demo

Q. What did you observe when you heated the bimetal strip?

The strip bends.

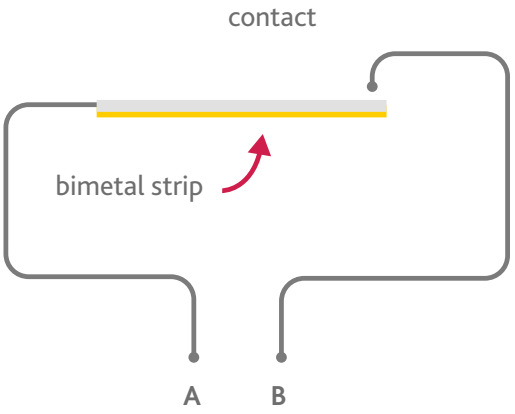
Q. When hot, did the strip bend towards the brass or towards the iron?

With the iron on the inside of the bend.

Q. Which of the two metals expands most when heated, brass or iron? Brass

Q. How might the circuit shown be used by a computer control system that needs to sense a change in temperature?

The contacts A and B would be connected to the two input terminals of a control interface. When the temperature rises, the strip will bend upwards (towards the iron). When the strip touches the contact it will complete the circuit, switching on the input.



Research question

Q. How are bimetal strips used, find as many examples as you can?

A list of four or five practical applications of a bimetal strip.

Investigation 2 - thermistor

Thermistor	Resistance (ohms)
1. In air	
2. In cold water	
3. In warm water	
4. In hot water	

Q. What happens to the resistance of the thermistor as the temperature increases?

There are two types of thermistors: Negative Temperature Coefficient (NTC) and Positive Temperature Coefficient (PTC). With an NTC thermistor, when the temperature increases,resistance decreases. Conversely, when temperature decreases, resistance increases. This type of thermistor is used the most.

Q. Can you spot a relationship between the temperature and the resistance?

For an NTC thermistor – as the temperature increases, the resistance decreases exponentially.

Q. How could the data on the graph (printed on the instructions) be used in a program for a computer control system so that is triggers at a specific temperature?

Use a device that can measure analogue current. Apply a known voltage to the thermistor and feed the current through an analogue input. Using Ohm's law (V=IR) calculate the current that will be passed by the thermistor at the target temperature. (note: devices often do not directly measure current in Amps, but rather a value – often between 0 and 1024. Some calibration might be needed). Then, write a program that is triggered at this current level. This is because devices don't measure resistance, they measure current

In which of the following situations might the thermistor be applicable:

A delicate electrical component such as a thermistor may well be damaged by high temperatures.
The thermistor tested may not be suitable for temperatures of 200°C or above.

Situation	Normal temperature range	Threshold temperature to trigger alarm	Applicable (Y/N)
An outside garage	0°C - 15°C	Above 20°C	Y
Bedroom	18°C - 25°C	Above 20°C	Y
Drying room	30°C - 50°C	Above 80°C	Y
Gas boiler	100°C - 150°C	Above 200°C	N

Investigation 3 - a flashing filament lamp

My sketch of the lamp

Students should be able to observe the filament and notice that this is attached on one end to a piece of wire and on the other to a bimetal strip. They should also observe that the bimetal strip is touching another piece of wire.

Q. Giving as much detail as possible, describe what happens inside the lamp when the switch is closed.

The filament heats up and produces light. The bimetal strip bends away from its contact point and the circuit is broken. The filament cools down and the lamp goes out. The bimetal strip straightens and once more touches its contact point and the cycle is repeated.

The sensitivity of a bimetal strip based temperature sensor can be adjusted so that it will trigger an alarm at a range of different threshold temperatures.

In which of the following situations might it be used as a temperature sensor?

The flashing light is triggered only at the high temperature found within a light bulb – it would not respond to low temperature rises.

Situation	Normal temperature range	Threshold temperature to trigger alarm	Applicable (Y/N)
An outside garage	0°C - 15°C	Above 20°C	N
Bedroom	18°C - 25°C	Above 20°C	N
Drying room	30°C - 50°C	Above 80°C	N
Gas boiler	100°C - 150°C	Above 200°C	Y

Investigation 4 - melting wire

Q. Why must you keep the two crocodile clips apart?

To prevent a 'short circuit'.

Q. Record and explain your observations when you heated the wire.

The wire heats up and reaches its melting point. As the wire melts, the circuit is broken and the lamp goes out.

Q. In a fire alarm system, which of the algorithms on the instructions would you use to process the input from the melting wire, Option 1 or Option 2? Option 2

Research questions

Q. What is the melting point of lead free solder? 183°C or thereabouts.

Q. Would this fire detection system be more or less sensitive if you used a length of aluminium wire in place of the solder? Circle your answer below.

The melting point of aluminium is 660°C so it would be much less sensitive. **More** **Less**

The sensitivity of a melting wire based temperature sensor cannot be adjusted. It will only trigger an alarm when it reaches its melting point, the threshold temperature.

In which of the following situations might the melting wire be applicable:

A melting solder wire-based temperature sensor would detect relatively high temperatures and may not be suitable for detecting house fires.

Situation	Normal temperature range	Threshold temperature to trigger alarm	Applicable (Y/N)
An outside garage	0°C - 15°C	Above 20°C	N
Bedroom	18°C - 25°C	Above 20°C	N
Drying room	30°C - 50°C	Above 80°C	N
Gas boiler	100°C - 150°C	Above 200°C	Y

Investigation 5 - melting wax

Record your observations.

The wax melts allowing the two nails to touch each other. The circuit is completed and the lamp lights up.

Q. Explain why the lamp came on when the ends of the nails were heated?

The liquid wax drips down away from the nails, allowing the two nails to touch each other.
The circuit is completed and the lamp lights up.

Research questions

Q. What is the melting point of paraffin wax? 37°C or thereabouts.

Q. Is paraffin wax a conductor or an insulator? Insulator

Q. Suggest another substance that might be placed between the ends of the nails?

In theory, any low melting point solid would work as long as it is not a conductor of electricity.

How might this fire detection method be adapted to make it sensitive to a smaller temperature rise?

Replace the wax with a material that has a lower melting point, such as butter or chocolate.

How might this fire detection method be adapted to be less sensitive - so that a large temperature change is needed to trigger it?

Decreasing the thickness of the piece of wax would make it more sensitive as less heat would be needed to melt it.

The sensitivity of a melting wax based temperature sensor cannot easily be adjusted. It will only trigger an alarm when it reaches its melting point, the threshold temperature.

In which of the following situations might the melting wax be applicable:

A wax based temperature sensor will trigger at a temperature of 37°C and there is limited scope to change this so it is not applicable in any of the situations below.

Situation	Normal temperature range	Threshold temperature to trigger alarm	Applicable (Y/N)
An outside garage	0°C - 15°C	Above 20°C	N
Bedroom	18°C - 25°C	Above 20°C	N
Drying room	30°C - 50°C	Above 80°C	N
Gas boiler	100°C - 150°C	Above 200°C	N

Investigation 6 - expanding water

Record your observations – what was the distance between the two marks?

_____ mm.

The distance will vary depending on the temperature difference of the water and the diameter of the glass tube

Q. How could you adapt this apparatus to trigger a fire alarm? Can you think of a way of using the rising water level in the tube as an input into an electronic control system?

If a long thin float is placed in the water, to that the top of the float rises above the top of the glass tube, this could be used to close a gap in a circuit and trigger an alarm. Water containing dissolved ionic solids can conduct electricity so could be used to complete a circuit.

Q. Suppose that the water were replaced by the liquid metal mercury. Can you think of a way of using the rising mercury level in the tube as an input into an electronic control system?

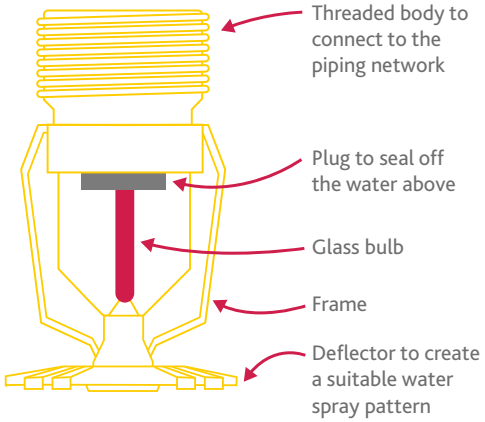
Two wires connected to an alarm circuit could be positioned above the level of the mercury in the tube. As the mercury level rises to touch the two wires, the mercury will complete the circuit, triggering the alarm.

Research questions

Q. How is the expansion of a liquid used to trigger sprinkler systems?

The glass bulb is filled with liquid. When the liquid heats up it expands. This breaks the glass bulb allowing the plug to drop away. This releases the water in the pipe network. The deflector plate is to spread the water over a larger area.

http://www.argusfire.co.nz/images/fireSprinklerSystems_clip_image002.gif



Q. Why might you NOT want to use mercury in a fire detection system?

Mercury is poisonous and particularly dangerous when heated.

In which of the following situations might expanding water be applicable:

The amount of expansion up to 20°C would be too negligible for a reliable system. As the boiling point of water is 100°C it would be totally unsuitable for a system that must not trigger until a threshold of 200°C is reached.

Situation	Normal temperature range	Threshold temperature to trigger alarm	Applicable (Y/N)
An outside garage	0°C - 15°C	Above 20°C	N
Bedroom	18°C - 25°C	Above 20°C	N
Drying room	30°C - 50°C	Above 80°C	Y
Gas boiler	100°C - 150°C	Above 200°C	N

Investigation 7 - expanding air

Syringe temperature	Volume of air (ml)
Iced water	
Hot water	
Change in volume	

The change will depend on the volume of air and the difference in temperature. An increase of 5 ml per 15 ml of should be achievable.

Q. Did the movement of the syringe plunger close the circuit?

It should if the apparatus is designed properly and the distance between the two contacts is not too great.

Q. How did you make the system more sensitive?

Decrease the distance between the two contacts.

Q. How did you make it less sensitive?

Increase the distance between the two contacts.

Q. How could you calibrate your sensor so that it triggers an alarm at a specific temperature?

Heat some water to the required temperature. Allow sufficient time for the air to stop expanding. Set up the two contacts so that they just touch. Remove the water from the beaker. Wait until the contacts open. Connect the circuit to 'arm' the alarm.

Research question

Q. Why do substances expand when they are heated?

Students should explain this using the particle model – the particles gain kinetic energy, they vibrate more so pushing their neighbours further apart and the whole solid increases in volume.

The sensitivity of an expanding air based temperature sensor can be calibrated to be triggered through a range of different temperatures because the volume of air is proportional to the temperature.

In which of the following situations might the expanding air based sensor be applicable:

The amount of expansion up to 20°C would be too negligible for a reliable system. It should be applicable in the drying room and gas boiler.

Situation	Normal temperature range	Threshold temperature to trigger alarm	Applicable (Y/N)
An outside garage	0°C - 15°C	Above 20°C	N
Bedroom	18°C - 25°C	Above 20°C	N
Drying room	30°C - 50°C	Above 80°C	Y
Gas boiler	100°C - 150°C	Above 200°C	Y