(a) A student investigates how different surfaces radiate energy as they cool.

Figure 9 shows some of the apparatus used in a part of the investigation.

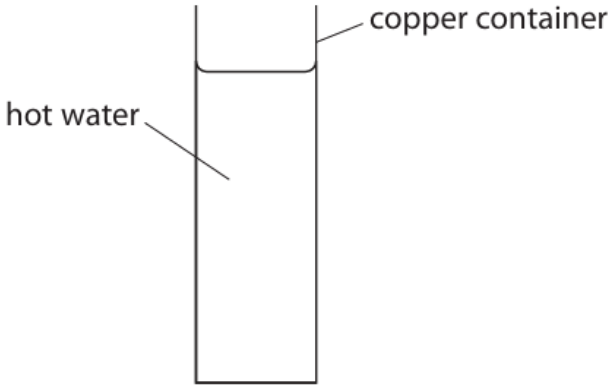

Figure 9

Describe how the student could collect data to show how the rate of cooling of the container and water change with time.

(2)

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(b) Figure 10 is a graph of intensity against wavelength for the electromagnetic radiation emitted by a halogen lamp.

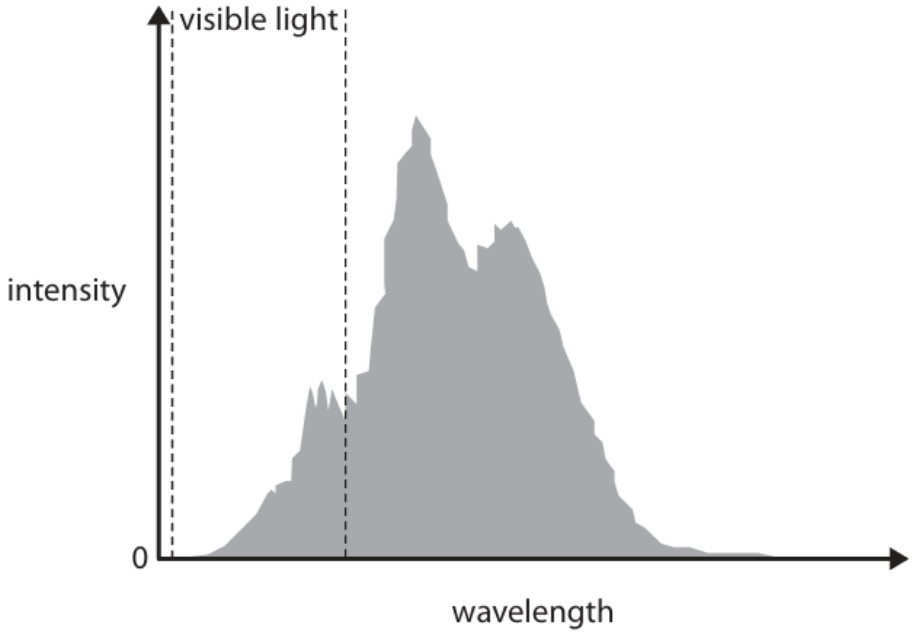

Figure 10

Describe how the intensity of the radiation varies with wavelength in Figure 10.

(2)

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(c) Figure 11 is a graph of temperature against time for a halogen lamp for the first 120 ms after it has been switched on.

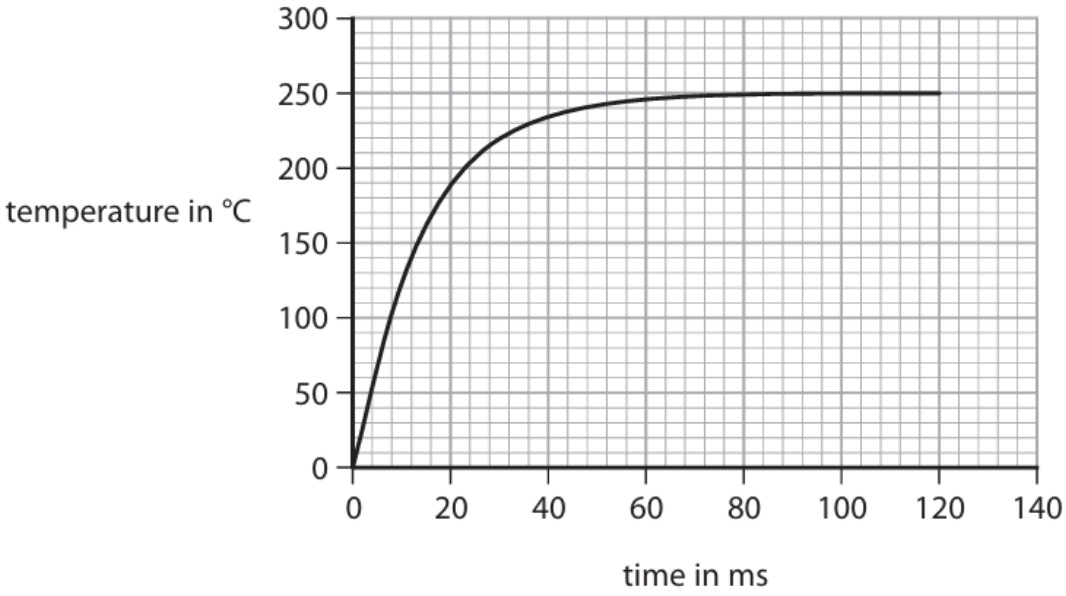

Figure 11

(i) Calculate the gradient of the graph at a time of 30 ms.

State the unit.

(4)

gradient = ... unit .....

(ii) Explain why the temperature of the lamp rises and then remains at a constant value.

(3)

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(Total for Question 8 = 11 marks)

WWW	EBI…	DIRT Task
You can describe how the student could collect data to show how the rate of cooling of the container and water change with time.	… you could describe how the student could collect data to show how the rate of cooling of the container and water change with time.	What equipment would the student need? How should the student prepare the water and container? How should the student take measurements? For how long should the student collect data? What should the student do with the data?
You can describe how the intensity of the radiation varies with wavelength.	… you could describe how the intensity of the radiation varies with wavelength.	Have another attempt at the question b.
You can calculate the gradient of the graph.	… you could calculate the gradient of the graph.	Define gradient. Memorise definition. Have another attempt at the question c (i).
You can explain why the temperature of the lamp rises and then remains at a constant value.	… you could explain why the temperature of the lamp rises and then remains at a constant value.	What causes the temperature of the lamp to increase at the start? What kind of energy transfer is happening inside the lamp? Why does the temperature stop rising after a while? What does it mean when the lamp reaches a constant temperature?
	Extension:	*Explain how greenhouse gases cause the Earth's temperature to rise.*

Question Number	Answer	Additional guidance	Mark
8(a)	a description to include: use a thermometer (1) measure temperature at regular intervals (1)	 temp. sensor datalogger it must be clear that it is a number of readings – not just 2 eg measure temperature over time	**(2)** AO 1 2

Question Number:	Answer	Additional guidance	Mark
8(b)	a description to include: intensity reaches a peak value (1) additional information (1)	 other peaks irregular curve non-linear most of radiation outside visible spectrum	**(2)** AO 3 1a AO 3 1b

Question Number	Answer	Additional guidance	Mark
8(c)(i)	tangent drawn between 20 and 40 ms (1) selection of suitable values and substitution from their tangent (1) e.g. 130 ÷ 60 evaluation (1) 2.0 unit (1) °C/ms	 range 1.8-2.5 2000 °C/s award full marks for correct answer with no working	**(4)** AO 1 1 AO 2 1

Question Number	Answer	Additional guidance	Mark
8(c)(ii)	an explanation linking: the temp rises because the (rate of) energy supplied is greater than the (rate of) energy being radiated. (1) at constant temperature the lamp radiates energy at the same **rate** at which it is being supplied (2)	 accept 'absorbed/in' for supplied. energy in greater than energy out lamp radiates more as temperature increases lamp radiates at the same **power** at which it is being supplied for 2 marks **power** out = **power** in award 1 mark for at constant temperature the energy supplied = energy radiated	**(3)** AO 3 2a AO 3 2b

Answers for DIRT task questions:

1. **Describe how the student could collect data to show how the rate of cooling of the container and water change with time.**

- The student should gather equipment including a thermometer, stopwatch, measuring cylinder, insulated container (e.g. beaker or cup), and hot water.
- First, they should measure a fixed volume of hot water (e.g. 200 mL) using a measuring cylinder and pour it into the container.
- They should record the starting temperature of the water using the thermometer.
- Then, using a stopwatch, they should record the temperature at regular time intervals, for example, every minute for 20 minutes.
- To make it a fair test, the experiment should be carried out in a room with stable temperature and without touching or disturbing the container.
- After collecting the data, the student should plot a graph of temperature (°C) on the y-axis and time (minutes) on the x-axis.
- From the graph, they can see how the rate of cooling (i.e. the change in temperature per unit of time) slows down over time.

2.

3.

4. **Explain why the temperature of the lamp rises and then remains at a constant value.**

- When the lamp is switched on, electrical energy is supplied to it.
- This energy is partly converted into light and partly into thermal energy, which causes the temperature of the lamp to rise.
- As the lamp gets hotter, it begins to lose heat to the surroundings through conduction, convection, and radiation.
- Eventually, the rate of energy being transferred to the lamp (from the electricity supply) becomes equal to the rate of energy being lost to the surroundings.
- At this point, the lamp reaches thermal equilibrium, and its temperature stays constant.

Extension

Explain how greenhouse gases cause the Earth's temperature to rise.

Model Answer:

- The Sun emits shortwave radiation that passes through the Earth's atmosphere and warms the surface.
- The Earth's surface then emits longwave (infrared) radiation back toward space.
- Greenhouse gases in the atmosphere (such as carbon dioxide, methane, and water vapour) absorb some of this infrared radiation.
- These gases then re-radiate the energy in all directions, including back toward the Earth's surface.
- This causes additional warming of the Earth’s surface and lower atmosphere.
- This process is known as the greenhouse effect, and it leads to a gradual increase in global temperature.