NAME: ……………….……………………………………………………………………..………

SCHOOL:……………………………………………………………………………………………

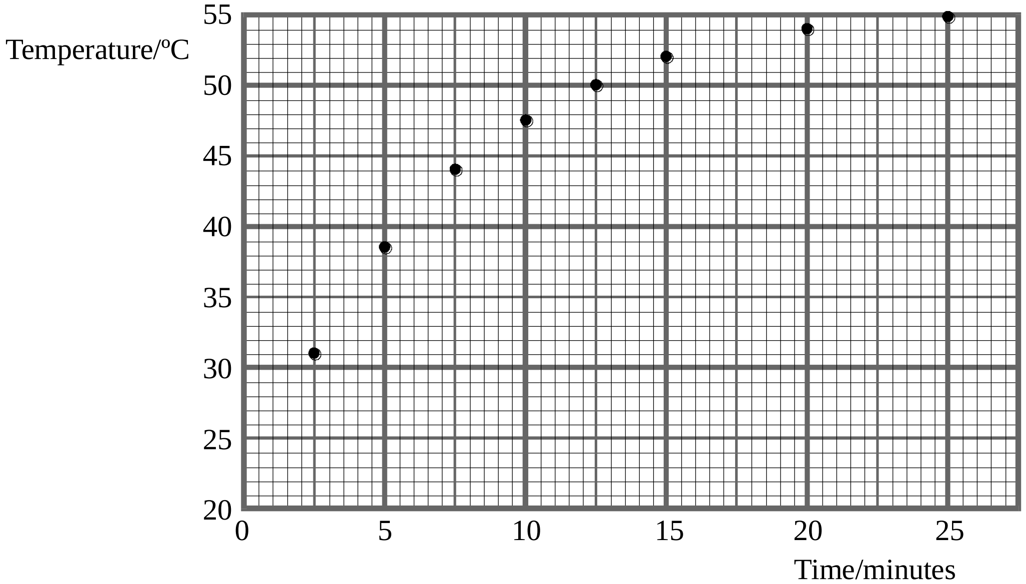
DATE: ....

HEAT ENERGY

INSTRUCTIONS TO CANDIDATES

*Answer **ALL** questions in this paper in the spaces provided.*

1. A student pours 500 g of water into an aluminium saucepan of mass 1.20 kg, heats it over a steady flame and records the temperature as it heats up. The temperatures are plotted as shown below.



Calculate the total heat capacity of the saucepan and water.

Specific heat capacity of water	=	4200 J kg^{-1} K^{-1}
Specific heat capacity of aluminium	=	900 J kg^{-1} K^{-1}

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....

....

Heat capacity = ...

(3)

Find the rate of rise of water temperature at the beginning of the heating process.

....

....

Rate of rise of temperature = ...

(2)

Hence find the rate at which energy is supplied to the saucepan and water.

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....

Rate of energy supply = ...

(2)

Explain why the rate at which the temperature rises slows down progressively as the heating process continues.

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(2)
(Total 9 marks)

2. You are asked to measure the specific heat capacity of aluminium using a cylindrical block of aluminium which has been drilled out to accept an electrical heater.

Draw a complete diagram of the apparatus you would use.

(3)

Describe how you would carry out the experiment and list the measurements you would take.

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(5)

Explain how you would calculate the specific heat capacity of aluminium from your measurements.

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(3)
(Total 11 marks)

3. A container holding 2.3 litres of milk at 15 °C is put into a freezer. Calculate the energy that must be removed from the milk to reduce its temperature to the freezer temperature of –30 °C. Assume that the milk behaves like ice and water.

Specific heat capacity of water = 4.2 kJ kg^{-1} K^{-1}
Specific heat capacity of ice 2.1 kJ kg^{-1} K^{-1}
Specific latent heat (enthalpy) of fusion of ice = 330 kJ kg^{-1}
Density of water = 1.0 kg $litre^{-1}$

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....

....

Energy removed = ...

(6)

It costs 8.2 p per kWh to remove energy from the freezer. What is the cost of freezing the milk?

....

....

Cost = ...

(2)
(Total 8 marks)

4. A small house uses a tank containing 1.2 m^3 water as a thermal store. During the night its temperature rises to 98 ^oC. During the day, its temperature drops as the water is pumped round, the house radiators to keep the house warm.

The density of water is 1 000 kg m^{-3} and its specific heat capacity is 4200 J kg^{-1} K^{-1}. Calculate the energy given out by the water on a day when its temperature drops from 98 °C to 65 °C.

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Energy = ...

(3)

The six radiators in the house give out an average power of 1.5 kW each. For how long can they all operate at this power before the water temperature drops to 65°C?

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....

Time = ...

(3)

Explain why this heating system operates more effectively early in the morning than towards the evening.

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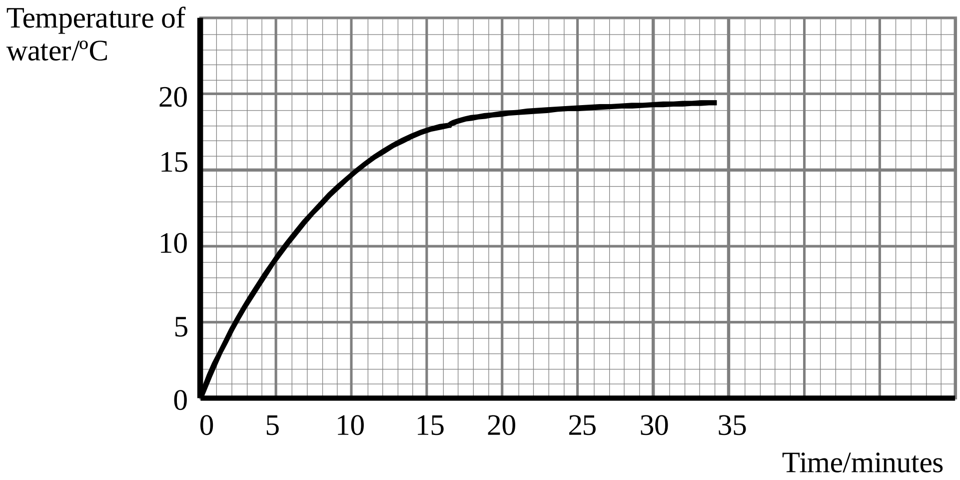
(2)
(Total 8 marks)

5. A thin beaker is filled with 400 g of water at 0°C and placed on a table in a warm room. A second identical beaker, filled with 400 g of an ice-water mixture, is placed on the same table at the same time. The contents of both beakers are stirred continuously.

The graph below shows how the temperature of the water in the *first* beaker increases with time.



Use the graph to find the initial rate of rise of water temperature. Give your answer in Ks^{-1}.

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Rate of rise = ……….........……................

(2)

The specific heat capacity of water is 4200 J kg^{-1} K^{-1}. Use your value for the rate of rise of temperature to estimate the initial rate at which this beaker of water is taking in heat from the surroundings.

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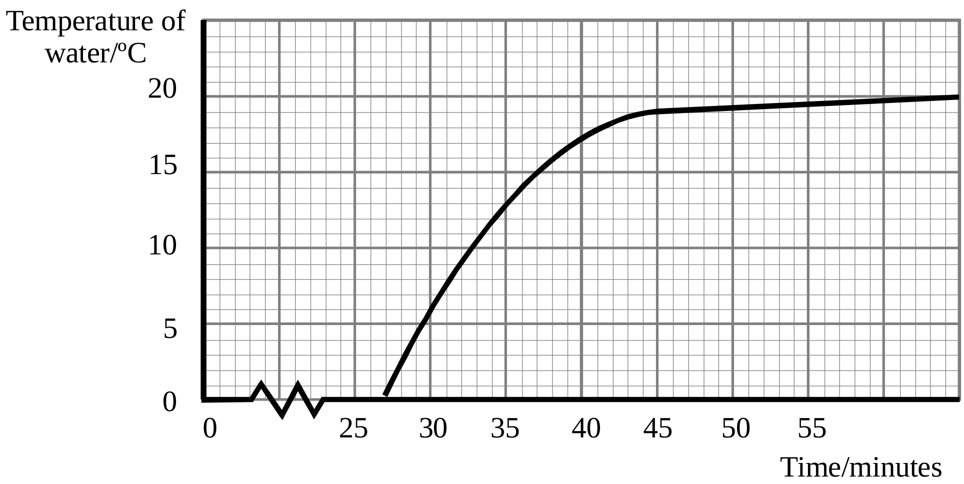
Rate of heat input = ……….........……................

(3)

The graph below shows the temperature of the water in the second beaker from the moment it is placed on the table.



How do you explain the delay of twenty-seven minutes before the ice-water mixture starts to warm up?

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(2)

The specific latent heat (enthalpy) of ice is 2.27 MJ kg^{-1}. Estimate the mass of ice initially present in the ice-water mixture.

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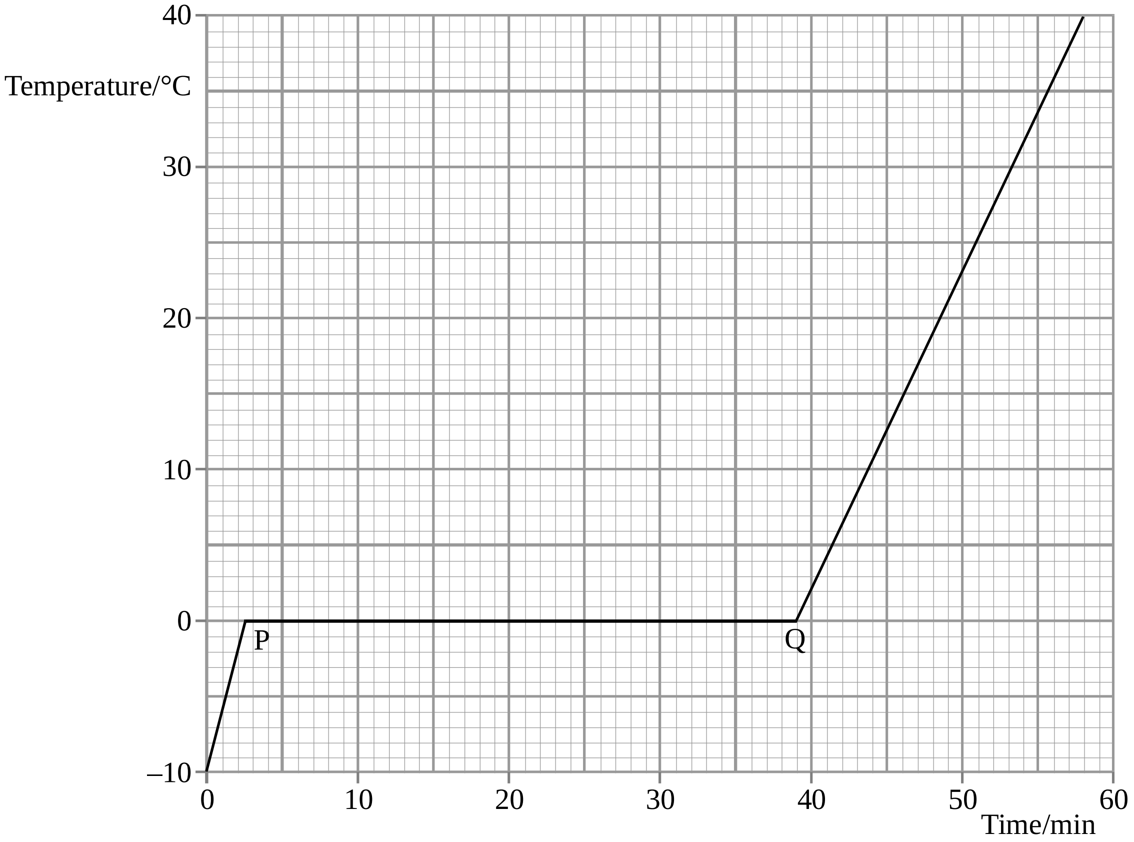
Mass =……….........……................

(4)
(Total 11 marks)

6. A well-insulated vessel contains 0.20 kg of ice at –10 °C. The graph shows how the temperature of the ice would change with time if it were heated at a steady rate of 30 W and the contents were in thermal equilibrium at every stage.



Describe in terms of molecules the change which occurs between points P and Q.

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....

(2)

Use the graph to determine the specific latent heat of fusion of water.

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....

Specific latent heat of fusion ....

(3)

A student tries to plot this graph experimentally. He places crushed ice at –10 °C in a well-insulated beaker containing a small electric heater. What additional equipment would he need, and how should he use it, to obtain the data for his graph?

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(2)

Suggest one precaution he should take to try to get an accurate graph.

....

....

(1)

Gallium is a metal with a melting point of 29 °C. Its specific heat capacity, in both the solid and liquid state, and its specific latent heat of fusion, are all smaller than those of water. Add to the graph above a second line showing the results you would expect if 0.20 kg of gallium, initially at –10 °C, was heated at the same rate of 30 W.

(3)
(Total 11 marks)

7. You are asked to measure the specific heat capacity of aluminium using a cylindrical block of aluminium which has been drilled out to accept an electrical heater and a thermometer.

Draw a complete diagram of the apparatus you would use.

(3)

List the measurements you would take and explain how you would calculate the specific heat capacity of aluminium from your measurements.

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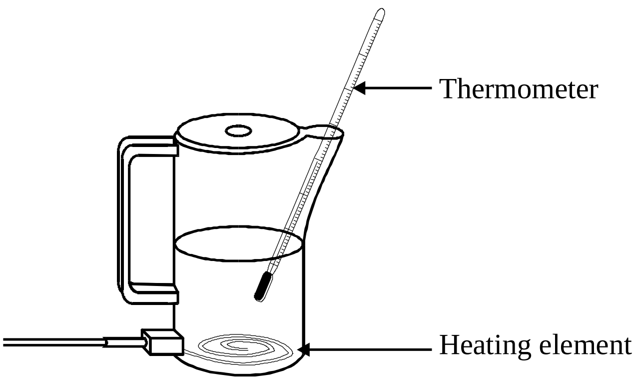
(6)
(Total 9 marks)

8. Water in a plastic kettle is heated by an electric element near the bottom of the kettle. The temperature of the water near its surface can be recorded on a thermometer.



A kettle contains 0.70 kg of water at an initial temperature of 20°C. It is calculated that about 250 kJ of thermal energy is needed to heat the water from 20°C to 100°C. Show how this value is calculated.

(The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.)

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....

....

(2)

Calculate the time it should take for an element rated at 2.2 kW to supply this energy.

....

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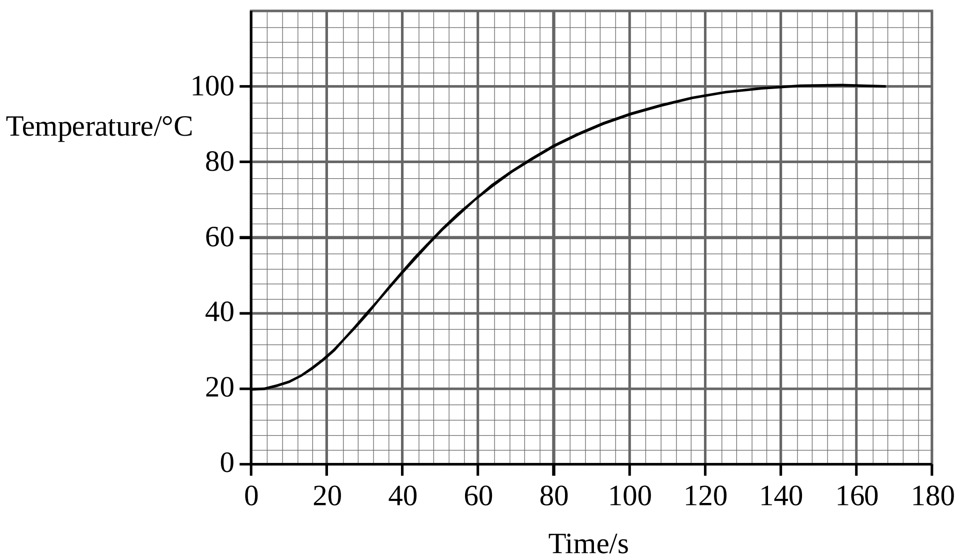
Time = ...

(3)

To check this calculation, the kettle is switched on at t = 0 s and temperature readings are taken as the water is heated. The graph shows how the temperature varies with time.



Use the graph to fully describe qualitatively how the temperature of the water changes during the first 160 s.

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....

(3)

Estimate the efficiency of the electric heating element in bringing the water to the boil.

....

....

....

Efficiency = ...

(2)

(Total 10 marks)

9. Define the term **specific latent heat of fusion**.

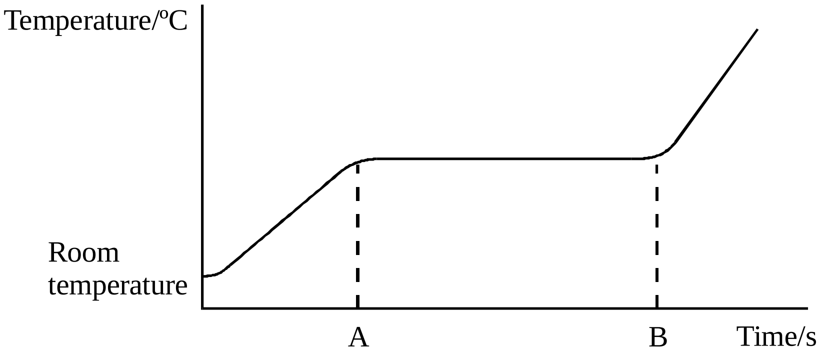
....

....

....

(3)

The graph shows how the temperature of a heated metal sample varies with time.



During the time interval AB, the metal changes from a solid to a liquid whilst still being heated. Explain, in molecular terms, what is happening to the energy being supplied during this time.

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(1)

Describe, in molecular terms, the main differences between the solid and liquid states. You may illustrate your answer with simple diagrams.

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....

(2)

(Total 6 marks)

10. Define the term **specific heat capacity**.

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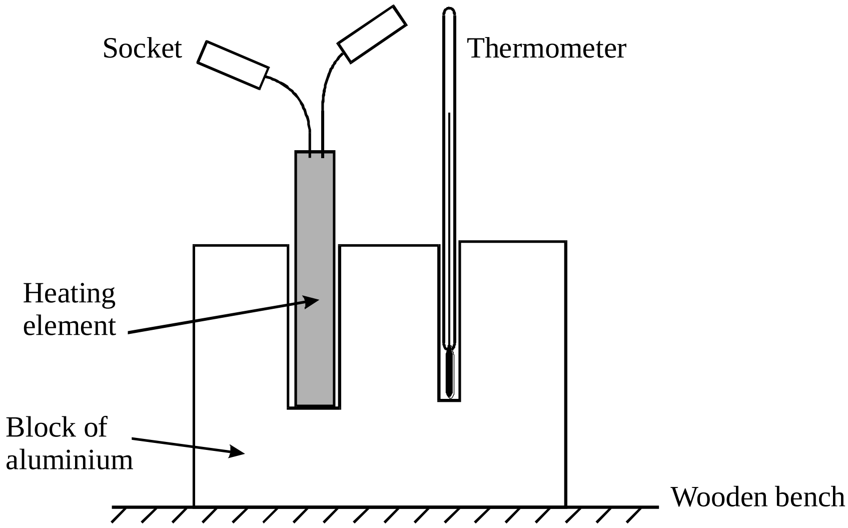
(2)

A student decides to measure the specific heat capacity of aluminium by an electrical method. He selects his apparatus and then assembles the aluminium block, the thermometer and the heating element as shown.



The student intends to substitute his results into the relationship

$$mc\Delta T = VIt$$

Draw a diagram of the electrical circuit he would need to set up in order to be able to carry out the experiment.

(3)

What other pieces of apparatus would he need?

....

....

(2)

He carries out the experiment and then calculates his value for the specific heat capacity of aluminium. He discovers that his value is higher than the accepted value of 900 J kg^{-1} K^{-1}.

Suggest why his result is higher than 900 J kg^{-1} K^{-1}.

....

....

(1)

With reference to the apparatus shown in the diagram, state two modifications that he should make in order to minimise the discrepancy.

1. ....

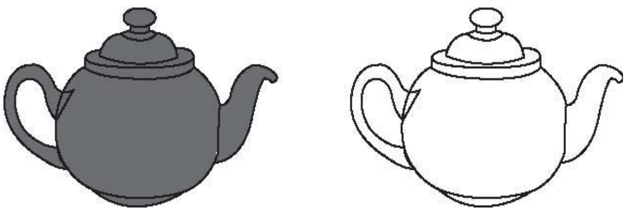
....

2. ....

....

(2)
(Total 10 marks)

11. Two metal teapots are identical except that one is black on the outside and the other is white on the outside, as shown below.



The teapots each contain the same amount of hot water.

State and explain which teapot will cool down more quickly.

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.... [3]

[Total]

12. Fig. 3.1 shows a thermometer.

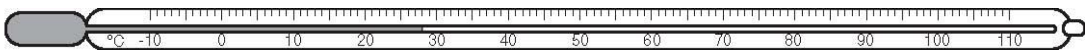

Fig. 3.1

(a) Explain how to calibrate a thermometer.

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....

....

.... [3]

(b) **(i)** State the range of the thermometer in Fig. 3.1.

.... [1]

(ii) State how you know that the scale of the thermometer in Fig. 3.1 is linear. ....

....

.... [1]

(c) Fig. 3.2 shows a thermometer which is more sensitive than the thermometer in Fig. 3.1. Only 0 °C is marked on this new thermometer.

On Fig. 3.2, draw the temperature markings for 10 °C and 20 °C. [1]

13 **(a)** State two differences between evaporation of water and boiling of water.

1...

2. ....[2]

(b) The specific latent heat of vaporisation of water is 2260 kJ / kg. Explain why this energy is needed to boil water and why the temperature of the water does not change during the boiling.

....

....

....

....[3]

(c) A laboratory determination of the specific latent heat of vaporisation of water uses a 120 W heater to keep water boiling at its boiling point. Water is turned into steam at the rate of 0.050 g / s. Calculate the value of the specific latent heat of vaporisation obtained from this experiment. Show your working.

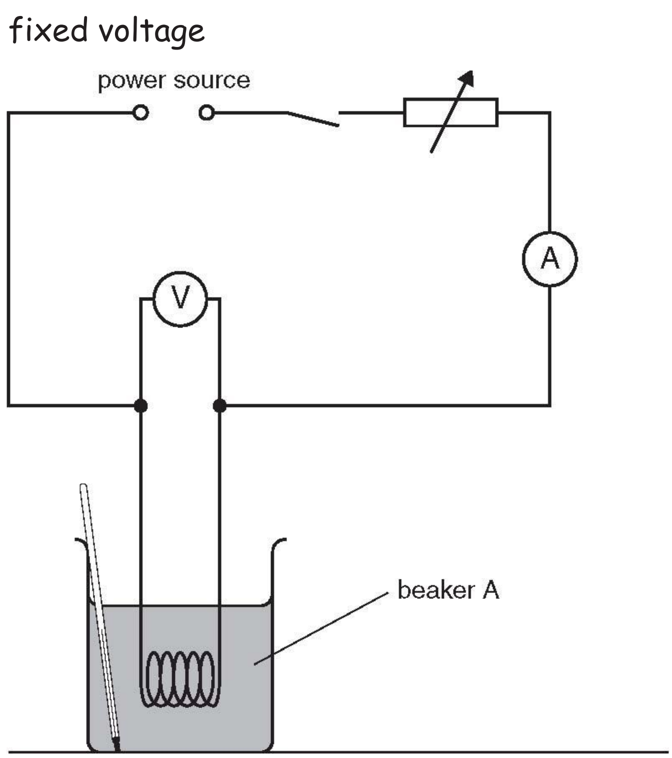
………

………

………………………………………………………………………………………………………

specific latent heat of vaporisation = ...[3]

14.A form IV student is investigating the temperature rise of water in beakers heated by different methods. The apparatus is shown in Fig. 4.1. Beaker A is heated electrically and beaker B is heated with a Bunsen burner.



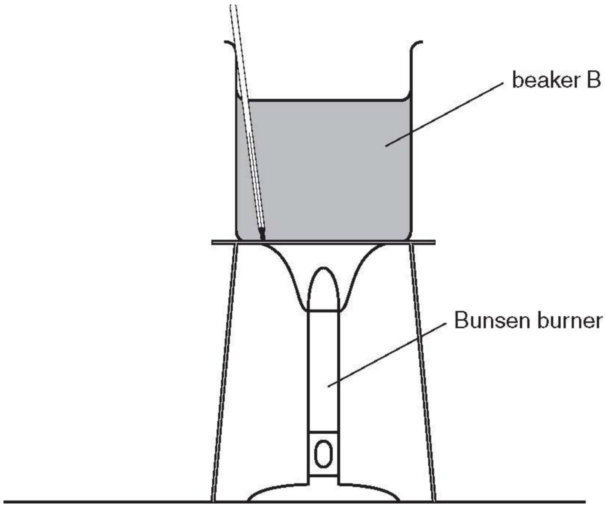


Fig. 4.1

The student first records room temperature.

(a) Fig. 4.2 shows the thermometer at room temperature.

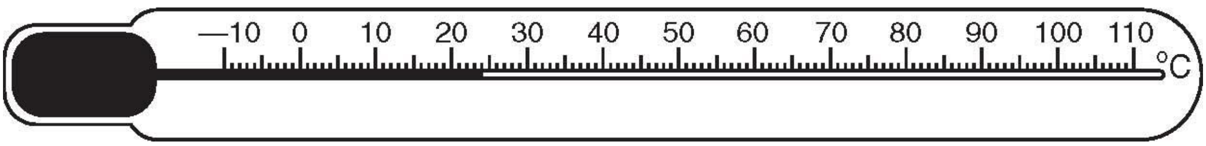


Fig. 4.2

(i) Write down the value of room temperature. room temperature =
.... [1]

(ii) The two beakers are heated from room temperature for the same length of time. The new water temperature for beaker A is 30 °C and for beaker B is 28 °C. Calculate the temperature rise of the water in each beaker.

temperature rise in beaker A = ...

temperature rise in beaker B =

.... [1]

(b) The electrical heater and the Bunsen burner both have the same power and both beakers were heated from room temperature for the same length of time. Suggest why there is a difference in temperature rise between beaker A and beaker B.

……

……

…… [2]

(c) In order to keep the heating effect of the electrical heater constant throughout the heating period, the student adjusts the current. Name the component in the circuit that the student uses for this purpose.

……… [1]