Homework 1 – Specific Heat Capacity and Specific Latent Heat

1. Below are three statements concerning the transfer of heat energy.

   I Different substances require different quantities of heat energy to raise the temperature of 1 kg by 1 °C.
   II When a substance changes state, no heat energy is lost or gained.
   III When a substance changes state, its temperature does not change.

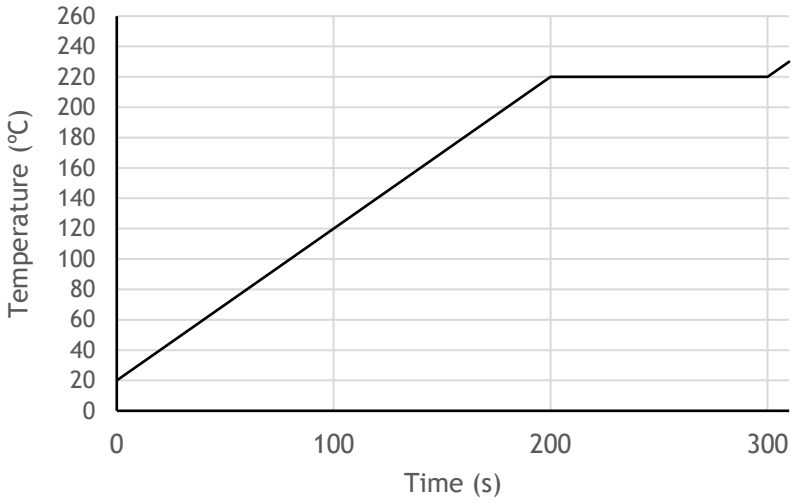
   Identify which of the statements is/are correct.

   A I only
   B I and II only
   C I, II and III
   D II and III only
   E I and III only

2. Calculate how much heat energy is required to convert 50 g of water into steam.
   You may wish to use information from your data sheet to help you.

   A $1{\cdot}67 \times 10^4$ J
   B $1{\cdot}13 \times 10^5$ J
   C $1{\cdot}67 \times 10^7$ J
   D $4{\cdot}52 \times 10^7$ J
   E $1{\cdot}13 \times 10^8$ J

3. A heater rated at 500 W is used to heat 1 kg of a substance. Initially the substance is in a solid state. The following graph of temperature against time is obtained.

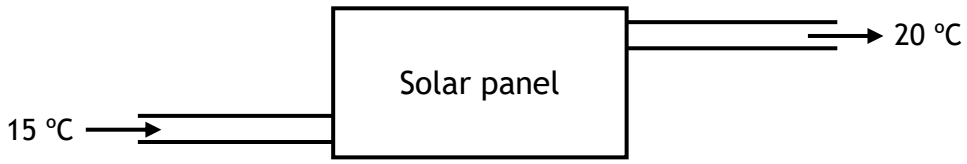


   Identify which of the following values can be obtained from the information given.

   I The melting point of the substance.
   II The specific heat capacity of the solid substance.
   III The specific latent heat of fusion of the substance.

   A I only
   B I and II only
   C I and III only
   D II and III only
   E I, II and III

4. Water enters a solar panel at 15 ºC and leaves at 20 ºC.

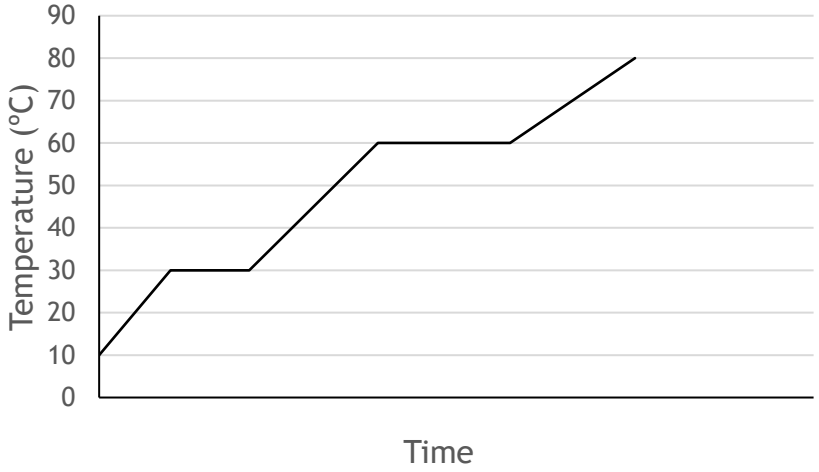


4 kg of water pass through the solar panel every minute.

Calculate the heat energy gained by the water in 1 minute.
You may wish to use information from your data sheet to help you.

A 16 700 J
B 83 600 J
C 251 000 J
D 334 000 J
E 1 003 000 J

5. A block of wax, initially in the solid state, is heated. The graph below shows how the temperature of the wax changes with time.



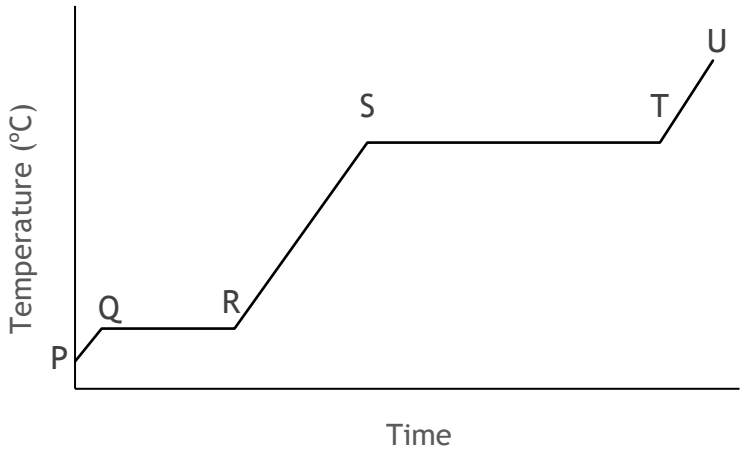
Identify the temperature at which the wax melted.

A 0 ºC
B 10 ºC
C 30 ºC
D 60 ºC
E 80 ºC

6. Identify the definition of specific latent heat of fusion of a substance.

A The energy required to melt 1 kg of the substance at its melting point.
B The energy required to evaporate 1 kg of the substance at its boiling point.
C The energy required to change the state of the substance without changing its temperature.
D The energy required to change the temperature of the substance without changing its state.
E The energy required to change the temperature of 1 kg of the substance by 1 °C.

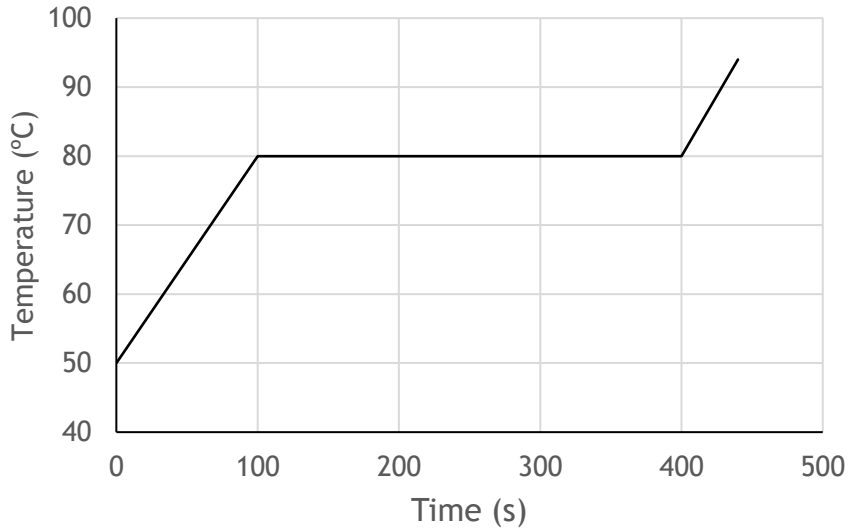
7. A solid substance is placed in an insulated container and heated. The following graph shows how the temperature of the substance varies with time.



Identify which time period would be used to calculate the specific latent heat of vaporisation of the substance.

A PQ
B RS
C TU
D QR
E ST

8. 100 g of a solid material is heated by a 50 W heater.
The graph of the temperature of the substance against time is shown below.



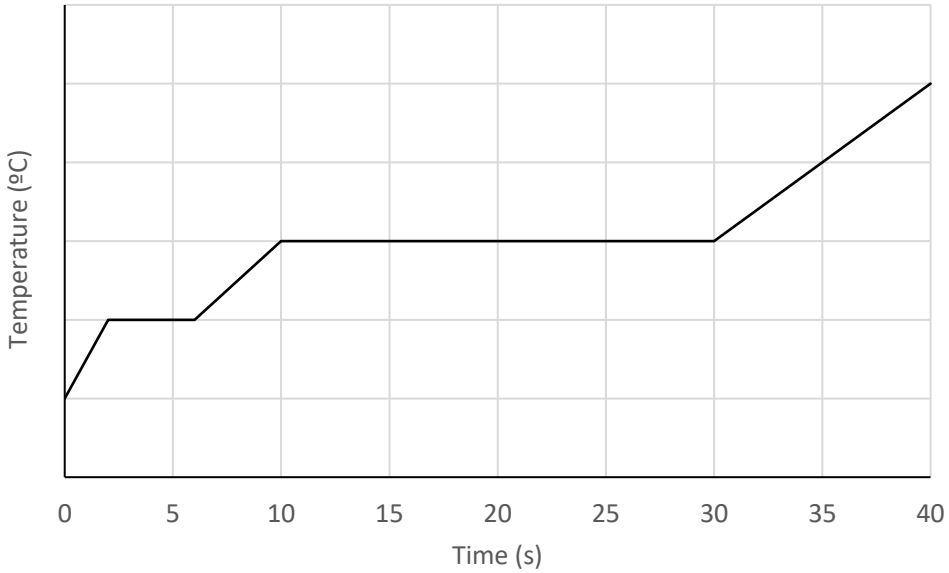
Calculate the specific latent heat of fusion of the substance.

A $1{\cdot}3 \times 10^3$ Jkg^{-1}
B $1{\cdot}5 \times 10^3$ Jkg^{-1}
C $3{\cdot}0 \times 10^3$ Jkg^{-1}
D $1{\cdot}5 \times 10^5$ Jkg^{-1}
E $1{\cdot}9 \times 10^5$ Jkg^{-1}

9. A block of ice of mass 1·50 kg is placed in a room.
The temperature of the block is 0 °C and the temperature of the room is 20 °C.
Calculate the minimum heat energy required to melt the ice.

A $0{\cdot}63 \times 10^5$ J
B $1{\cdot}25 \times 10^5$ J
C $1{\cdot}88 \times 10^5$ J
D $5{\cdot}01 \times 10^5$ J
E $6{\cdot}26 \times 10^5$ J

10. A solid substance is placed in an insulated flask and heated continuously with an immersion heater. The graph shows how the temperature of the substance in the flask varies with time.



Determine the state of the substance after a period of 5 minutes.

A Solid
B Mixture of solid and liquid
C Liquid
D Mixture of liquid and gas
E Gas

11. A blacksmith cools a hot, iron horse-shoe of mass 0·75 kg by dropping it into water. The mass of water is 15 kg and its initial temperature is 17 °C. Heat energy from the iron warms the water until both the horse-shoe and the water are at 23 °C.

You may wish to refer to data from the data sheet for the following questions.

(a) Calculate the heat energy absorbed by the water.

(b) Calculate the initial temperature of the horse-shoe.

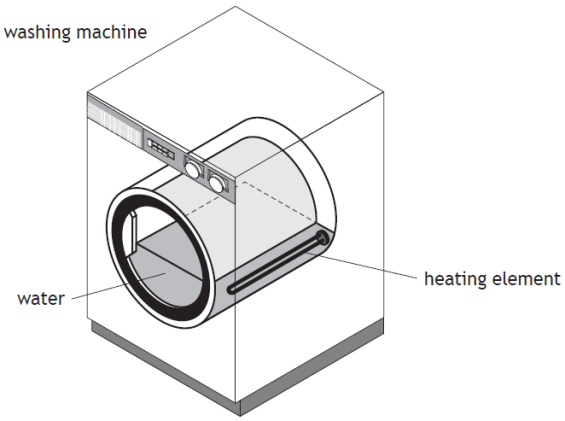
(c) State **one** assumption required for the calculation in part (b).

(d) The blacksmith replaces the 15 kg of water with 15 kg of oil.

State how the temperature rise of the oil compares to the temperature rise of the water. You **must justify** your answer.

12. A science technician removes two metal blocks from an oven.
Immediately after the blocks are removed from the oven the technician measures the temperature of each block, using an infrared thermometer.
The temperature of each block is 230 °C.
After several minutes the temperature of each block is measured again. One block is now at a temperature of 123 °C and the other block is at a temperature of 187 °C.
Using your knowledge of physics, comment on possible explanations for this difference in temperature.

13. A washing machine is filled with water at a temperature of 15·0 °C.
The water is heated by a heating element.



(a) The mass of water in the washing machine is 6·00 kg.

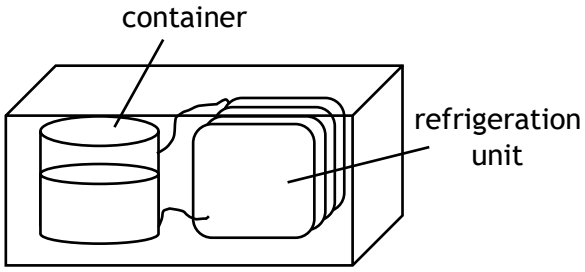
Show that the minimum energy required to increase the temperature of the water from 15·0 °C to 40·0 °C is 627 000 J.

(b) The heating element has a power rating of 1800 W.

(i) Calculate the time taken for the heating element to supply the energy calculated in part (a).

(ii) Explain why, in practice, it takes longer to heat the water from 15·0 °C to 40·0 °C than is calculated in (b)(i).

14. An ice cream maker has a refrigeration unit which can remove heat at a rate of 120 Js^{-1}.
Liquid ice cream, of mass 0·6 kg at a temperature of 20 °C, is added to the container.



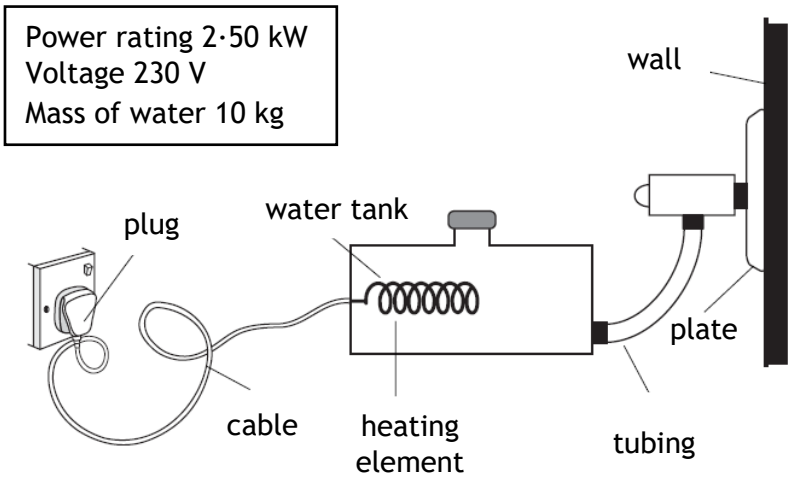
The specific heat capacity of ice cream is 2100 J kg^{-1} $°C^{-1}$.
The specific latent heat of fusion of the ice cream is 2·34 x 10^5 J kg^{-1}.

(a) Calculate how much heat energy must be removed from the mixture to cool it to its freezing point of -16 °C.

(b) Calculate how much heat energy must be removed to freeze the ice cream at this temperature.

(c) (i) Calculate the time taken to freeze the ice cream.
(ii) State the assumption you made in carrying out this calculation.

15. A steam wallpaper stripper is used on the walls of a room.
Water is heated until it boils and produces steam. The plate is held against the wall and steam is released from the plate.



(a) The tank is filled with water. The water has an initial temperature of 20 °C.

(i) Calculate the energy required to bring the water to its boiling point.

(ii) Calculate the time taken for this to happen.

(iii) The actual time taken for this to happen was found to be longer than the time calculated in part (ii). Explain why this is the case.

(b) After using the wallpaper stripper for some time, 1·2 kg of water is converted into steam. Calculate the heat energy required to do this.