

2 (a) State what is meant by two objects being in thermal equilibrium.

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.....

..... [2]

(b) A mass X of ice at 0°C is placed in a beaker containing a mass M of water at Celsius temperature t . The beaker is perfectly insulated and has negligible heat capacity. After some time, the ice that was added reaches thermal equilibrium with the original water in the beaker.

The specific latent heat of fusion of water is L . The specific heat capacity of water is c .
The final Celsius temperature of the system is θ .

Give expressions, in terms of some or all of X , M , t , θ , L and c , for the thermal energy:

(i) E_1 , gained by the ice as it melts to become water at 0°C

$E_1 =$

[1]

(ii) E_2 , lost by the water as its Celsius temperature decreases from t to θ

$E_2 =$

[1]

(iii) E_3 , gained by the melted ice as its Celsius temperature increases from 0°C to θ .

$E_3 =$

[1]

(c) Use your answers in (b) to show that the final Celsius temperature θ of the system is given by

$$\theta = \frac{Mct - XL}{c(M + X)}.$$

[2]

[Total: 7]