

Problem :

A cup has 15 grams of ice chips at 0 deg. C.

How much heat is required to convert all the ice to steam at 100 deg. C ?

How much time will it take your 600-watt microwave to do the job (assume 100%efficiency) ?

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Solution :

We first have to add heat to change the phase (melt) of the ice to water, *at the same temperature* :

$$Q_1 = H_{FUSION} \cdot Mass$$

$$Q_1 = \left(3.33 \times 10^5 \frac{J}{kg} \right) \cdot (0.015kg) \rightarrow 4995J$$

Now we've got water at 0 deg. C, and must heat it up to 100 deg. C *while maintaining its liquid phase.*

$$Q_2 = (mass) \cdot (SpecificHeatWater) \cdot (TemperatureChange)$$

$$Q_2 = (0.015kg) \cdot \left(4190 \frac{J}{kg \cdot C^\circ} \right) \cdot (100 - 0) \rightarrow 6285J$$

At this point we have hot water at 100 C. We must add heat to change the phase of the water from liquid to steam, with temperature maintained at 100 C.

$$Q_3 = H_{VAPORIZATION} \cdot Mass$$

$$Q_3 = \left(2.26 \times 10^6 \frac{J}{kg} \right) \cdot (0.015kg) \rightarrow 33900J$$

The total amount of heat needed to change the ice to steam, is...

$$Q_{TOTAL} = Q_1 + Q_2 + Q_3$$

$$Q_{TOTAL} = 4995 + 6285 + 33900 \rightarrow 45180J$$

This heat output is related to the required power, according to...

$$Power = \frac{Energy}{Time} \rightarrow Time = \frac{Energy}{Power}$$

When energy is obtained in *Joules* and power is in *Watts*, then time comes out in *seconds*.

$$Time = \frac{45180}{600} \rightarrow 75 \text{ sec.}$$

Time required is 1 min. 15 sec.