399.

Problem 32.59 (RHK)

A 420-W *immersion heater is placed in a pot containing* 2.10 *litres of water at* 18.5^0 C. *We have to find* (a) *the time required for bringing the water to boiling temperature, assuming that* 77.0% *of the available energy is absorbed by the water. We will calculate how much longer will it take for half the water to boil away.*

Solution:

(a)

Specific heat capacity of water is

$c = 4190 \text{ J kg}^{-1} \text{ K}^{-1}$.

Therefore, the amount of heat required for boiling 2.10 litres of water from 18.5^0 C will be

$Q = 2.10 \times 4190 \times (100 - 18.5) \text{ J} = 7.17 \times 10^5 \text{ J}$.

Power of the immersion heater is given as

$P = 420 \text{ W}$.

As only 77% of the available energy is absorbed by the water, the Joule heat absorbed by the water per second will be

$$P' = 420 \times \frac{77}{100} \text{ J s}^{-1} = 323.4 \text{ J s}^{-1}.$$

Therefore, the amount of time required for boiling the given amount of water using the immersion heater will be

$$t = \frac{7.17 \times 10^5}{323.4} \text{ s ; } 37 \text{ minutes.}$$

(b)

For answering the next part of the problem, we note that the heat of vaporisation of water is

$$L_v = 2256 \times 10^3 \text{ J kg}^{-1}.$$

Therefore, the amount of heat required for vaporisation of 1.05 litres of water will be

$$Q' = 1.05 \times 2256 \times 10^3 \text{ J}.$$

The additional time required for boiling away half the quantity of water will be

$$t' = \frac{1.05 \times 2256 \times 10^3}{323.4} \text{ s} = 122 \text{ minutes.}$$