**Chapter 7 Problem 83** [†]

**Given**
$Q = 20.0\ C$
$\Delta V = 1.00 \times 10^2\ MV = 1.00 \times 10^8\ V$
$T_0 = 15\ ^\circ C$
$T_f = 100\ ^\circ C$
$c_{H2O} = 4184\ J/kg^\circ C$
$L_v = 2.26 \times 10^6\ J/kg$

**Solution**
a) Find the energy dissipated in the lightning strike.

From the potential difference, we can find the electric potential energy in the lightning strike. This energy needs to be dissipated into the object being struck.

$$\Delta U = Q\Delta V$$

$$\Delta U = (20.0\ C)(1.00 \times 10^8\ V)$$

$$\Delta U = 2.00 \times 10^9\ J$$

b) Find the mass of water heated from $15^\circ C$ and boiled by the lightning strike.

The heat required to bring the water to boiling is calculated by the formula

$$\Delta Q_S = mc\Delta T$$

where $m$ is the mass of the water, $c$ is the specifice heat of water and the $\Delta T$ is the change in temperature of the water. Once the water is at the boiling point, it goes through a phase change going from liquid to gas. This requires an additional amount of energy given by the formula

$$\Delta Q_L = mL_v$$

The total energy to heat and then boil water is

$$\Delta Q = \Delta Q_S + \Delta Q_L = mc\Delta T + mL_v$$

$$\Delta Q = m(c\Delta T + L_v)$$

Solving for $m$ gives

$$m = \frac{\Delta Q}{c\Delta T + L_v} = \frac{\Delta Q}{c(T_f - T_0) + L_v}$$

The boiling point of water is $100\ ^\circ C$, so

$$m = \frac{2.00 \times 10^9\ J}{(4184\ J/kg^\circ C)(100^\circ C - 15^\circ C) + 2.26 \times 10^6\ J/kg} = 765\ kg$$

This is 1700 $lbs$ of water.

c) Discuss the damage done to the tree.

With this much water boiling in an instant, the phase change will generate an extreme pressure inside the tree trunk. Since the wood structure cannot withstand this high pressure, it will result in either the tree splitting or part of the trunk splintering to relieve the pressure.

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[†]Problem from Univesity Physics by Ling, Sanny and Moebs (OpenStax)