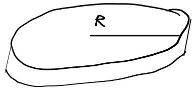
(1)

11-01-82

Estimate the energy released by a small thunder shower due to the condensation of the evapoured steam into liquid water



$\} \; h = 1{,}0\,cm \qquad V = \pi R^2 h, \quad M = V\rho = \pi R^2 h \rho$

$R = 10^3\,m \qquad L_v^{H_2O} \sim 2256\ kJ/kg$

the energy released is

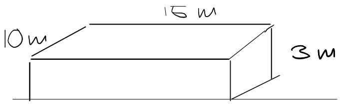
$$E = M L_v^{H_2O} = \pi R^2 \underbrace{h\rho} L_v^{H_2O}$$

$$\simeq \pi (10^3)^2 \cdot 0{,}01 \cdot 1000 \cdot 2256 = 7 \cdot 10^{10}\ kJ = \underline{70\,TJ}$$

Compare to an earthquake of magnitude 6.0 Richter releases 63 TJ

(2)

11-01-100



A home owner adds $\Delta d = 8{,}0$ cm to the insulation layer of the attic with $d = 15$ cm. How much does this improve the insulation of the house

Fiber glass: $k = 0{,}042 \dfrac{W}{(m \cdot {}^\circ C)}$

we have for the power dissipating from the house

$$P = P_{sides} + \frac{kA(T_h - T_c)}{(d + \Delta d)}$$

At the moment we do not worry about P_{sides}, but we know it is also proportional to $(T_h - T_c)$, $P_{sides} = \beta (T_h - T_c)$

we notice that $\Delta d/d$ is by no means small!

(3)

$$P = P_{sides} + \frac{kA(T_h - T_c)}{d\left(1 + \frac{\Delta d}{d}\right)}$$

$$= P_{sides} + \frac{kA(T_h - T_c)}{d}\left\{1 + \frac{\Delta d}{d} + \left(\frac{\Delta d}{d}\right)^2 - \left(\frac{\Delta d}{d}\right)^3 + \left(\frac{\Delta d}{d}\right)^4 + \dots\right\}$$

$$\rightarrow P - P_0 = \frac{kA(T_h - T_c)}{d} \sum_{k=1}^{\infty} \left(-\frac{\Delta d}{d}\right)^k$$

where P_0 is the original power dissipation of the house

$$\rightarrow P - P_0 = \Delta P = \frac{kA(T_h - T_c)}{d} \sum_{k=1}^{\infty} \left(-\frac{\Delta d}{d}\right)^k$$

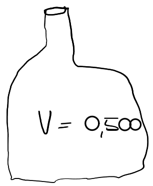
$$= \frac{kA(T_h - T_c)}{d} \left\{\frac{1}{1 + \frac{\Delta d}{d}} - 1\right\}$$

$$= -\frac{kA(T_h - T_c)}{d} \cdot 0{,}35$$

This not a small reduction and without going to further calculations we know that the area of roof is the largest surface of this house

(4)

11-02-30



$T_c = 25\,^\circ C$

$T_H = 80\,^\circ C$

$\left.\begin{array}{l} pV = N k_B T \\ N = N_A n \end{array}\right\} pV = nRT$

a) Find n at T_H, open bottle

$$n = \frac{pV}{RT} = \frac{1\,atm \cdot 0{,}5\,L}{0{,}0821 \frac{L \cdot atm}{mol \cdot K} \cdot (273 + 80)}$$

$$= \underline{0{,}0173\ mol}$$

b) Find p_c if the bottle is closed at T_H

$$\frac{p_c V}{T_c} = \frac{p_H V}{T_H} \longrightarrow p_c = p_H \frac{T_c}{T_H}$$

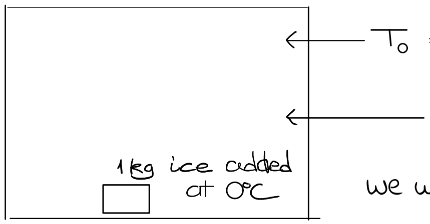
$$= 1{,}0\,atm \frac{(273 + 25)\,K}{(273 + 80)\,K}$$

$$= \underline{0{,}844\ atm}$$

11-02-62

(5)

Sealed room, initially at 24°C



$T_0 = 24°C$, $P_0 = 9{,}83 \cdot 10^4$ Pa

$V = 24\ m^3$

we want to find the final T_f

Closed system, the energy is conserved

The melting heat of ice $\quad L_f^{H_2O} = 334 \frac{kJ}{kg}$

Heat capacity of air: $\quad C_V^{air} = \frac{d}{2} R, \quad d = 3 + 1 + 1 = 5$ (translations, rotation, vibrations)

$= 2{,}5 R$

The energy of the air wil be lowered

$$\Delta Q^{air} = n C_V^{air} \Delta T, \quad \Delta T = T_i - T_f$$

(6)

The water absorbs energy

$$m_{H_2O} \cdot L_f^{H_2O} + \Delta Q^{H_2O}, \qquad \Delta Q^{H_2O} = n^{H_2O} \cdot (T_f - T_i), \quad T_i = 273\ K$$

Conservation of energy

$$n^{air} \cdot C_V^{air} \cdot (T_0 - T_f) = m_{H_2O} L_f^{H_2O} + n^{H_2O} C_V^{H_2O} \cdot (T_f - T_i)$$

$$1\,kg\ H_2O \rightarrow n^{H_2O} = \frac{1000\,g}{18\,g} = 55{,}6\ mol$$

$$24\ m^3\ air \rightarrow n^{air} = \frac{P_0 V}{RT} = \frac{0{,}97\ atm \cdot 24 \cdot 10^3\ L}{0{,}0821 \frac{L \cdot atm}{K} (273 + 24)}$$

$$= 955\ mol$$

$1\ atm = 1.013 \cdot 10^5$ Pa

$$P_0 = 9{,}83 \cdot 10^4\ Pa = \frac{9{,}83 \cdot 10^4}{1.013 \cdot 10^5}\ atm = 0{,}97\ atm$$

(7)

$$T_f = \frac{n^{air} \cdot C_V^{air} T_i - m_{H_2O} L_f^{H_2O} + C_V^{H_2O} T_i}{n^{air} C_V^{air} + n^{H_2O} C_V^{H_2O}}$$

$$= \frac{955 \cdot (2{,}50 \cdot 8{,}31)(273+24) - (1 \cdot 334 \cdot 10^3) + 4179 \cdot 273}{955 \cdot 2{,}50 \cdot 8{,}31 + 1 \cdot 4179}$$

$$= 279\ K = 6°C$$

Here I do not use
but in stead the heat capacity of
water with respect to mass, I just
have to make sure to use the
same energy units