

# Chapter 17 Homework in notes.

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Ex. 8 Convert the following Kelvin temperatures  $\begin{matrix} \nearrow ^\circ\text{C} \\ \searrow ^\circ\text{F} \end{matrix}$

(a)  $400\text{ K} \rightarrow 400 - 273 = \underline{127^\circ\text{C}}$   
 $400\text{ K} \rightarrow 127^\circ\text{C} \frac{9}{5} + 32^\circ = \underline{261^\circ\text{F}}$

(b)  $95\text{ K}$       (c)  $1.55 \times 10^7\text{ K}$       Follow the same procedure.

Ex. 7

$P_{tr, \text{H}_2\text{O}} = 1.35\text{ atm.}$        $T_{tr} = 273.16^\circ\text{K}$

$p = ??$        $T = 195\text{ K}$

$$\frac{p}{T} = \frac{P_{tr}}{T_{tr}} \quad p = P_{tr} \left( \frac{T}{T_{tr}} \right) = 1.35\text{ atm} \left( \frac{195}{273} \right) = 0.964\text{ atm}$$

$p = 0.964\text{ atm}$

Ex. 14

Ensuring a Tight Fit

Hole:  $D = \text{diameter} = 4.500\text{ mm}$  ( $23^\circ\text{C}$ )      Aluminum

Rivet:  $D_{\text{rivet}} = ??$  ( $-78^\circ\text{C}$ )

$$L = L_0 (1 + \alpha \Delta T)$$

final diameter  $\rightarrow D = 4.500\text{ mm} (1 + 2.4 \times 10^{-5} (\text{C}^\circ)^{-1} (23 - (-78)) \text{C}^\circ)$

$D = 4.511\text{ mm}$

Ex. 22

A brass rod  $L_0 = 185\text{ cm}$        $D_0 = 1.60\text{ cm}$

$120^\circ\text{C} \rightarrow 10^\circ\text{C}$

$Y = 9.0 \times 10^{10}\text{ Pa}$

$$\frac{F}{A} = -Y \alpha \Delta T$$

$\alpha = 2.0 \times 10^{-5} (\text{C}^\circ)^{-1}$

$$F = -Y \alpha A \Delta T = -Y \alpha \left( \frac{\pi D^2}{4} \right) (10^\circ\text{C} - 120^\circ\text{C})$$

$$F = -9.0 \times 10^{10}\text{ Pa} (2.0 \times 10^{-5} (\text{C}^\circ)^{-1}) \pi \frac{(1.60 \times 10^{-2}\text{ m})^2}{4} (-110^\circ\text{C}) = 39800\text{ N}$$

4

$3.98 \times 10^4\text{ N}$

Other Homework Problems Chapter 17.

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17.24 a) How much heat must be added to the water

Power = 200 W      22°C → 81.5°C      m = 0.300 kg

$$Q = mc(T_f - T_i) = 0.300 \text{ kg} \left( 4190 \frac{\text{J}}{\text{kg} \cdot \text{K}} \right) (81.5^\circ\text{C} - 22^\circ\text{C})$$

$$Q = 7.48 \times 10^4 \text{ J}$$

b.) How much time is required to heat the water

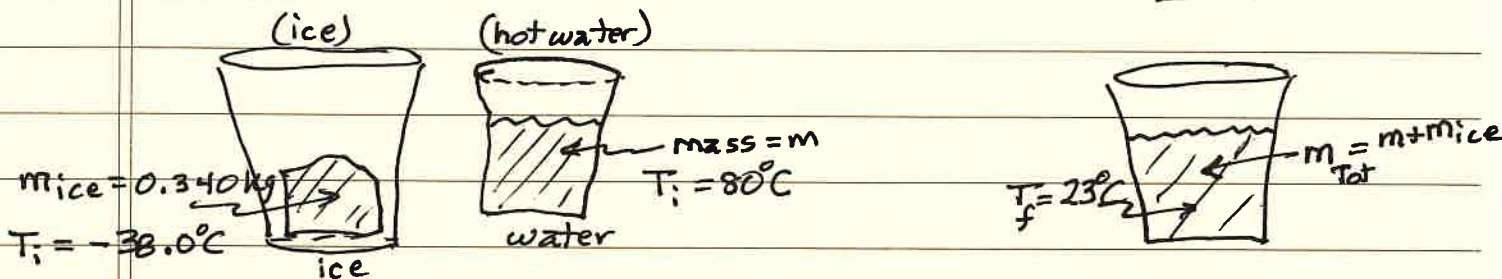
$$\text{Power} = \frac{Q}{\Delta t} \Rightarrow \text{time} = \Delta t = \frac{Q}{\text{Power}} = \frac{7.48 \times 10^4 \text{ J}}{200 \text{ J/sec}}$$

$$\text{time} = \Delta t = 374 \text{ seconds}$$

17.40

Initial

Final



Conservation of Energy

$$Q_{\text{ice}}(-38^\circ\text{C} \rightarrow 0^\circ\text{C}) + Q_{\text{ice}}(0^\circ \xrightarrow{\text{melting}} 0^\circ\text{C}) + Q_{\text{ice}}(0^\circ \rightarrow 23^\circ) + Q_{\text{water}}(80^\circ\text{C} \rightarrow 23^\circ) = 0$$

$$0.340 \text{ kg} \cdot 2100 + 0.340 \cdot 334 \times 10^3 + 0.340 \cdot 4190 (23^\circ\text{C} - 0^\circ\text{C}) + m C_w (23^\circ\text{C} - 80^\circ\text{C}) = 0$$

$$m = m_{\text{ice}} \left[ c_{\text{ice}} (38^\circ) + L_{\text{fusion}}^{\text{ice}} + C_w (23^\circ) \right] C_w (57^\circ)$$

$$m = 0.726 \text{ kg}$$

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Ex. 31

While painting the top of an antenna 225 m in height.

1.00 L of water.

Cons. of Energy

$= \frac{1}{2}mv^2$  when it hits the ground

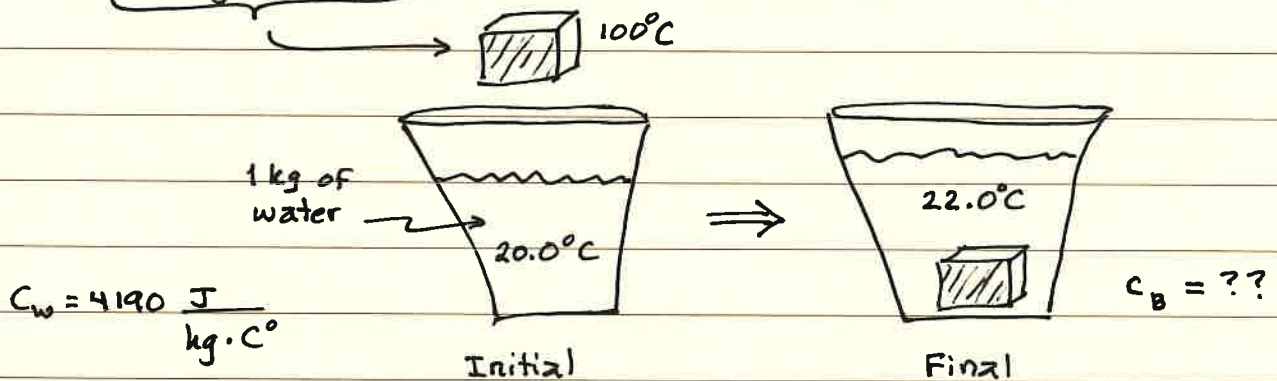
$$mgh = mc\Delta T \quad c_w = 4190 \frac{\text{J}}{\text{kg}\cdot\text{K}}$$

$$\Delta T = \frac{gh}{c} = \frac{(9.8 \text{ m/s}^2)(225 \text{ m})}{4190 \frac{\text{J}}{\text{kg}\cdot\text{K}}} = 0.526 \text{ }^\circ\text{C}$$

$\Delta T = 0.526 \text{ }^\circ\text{C}$

Ex. 35

A 500-g chunk of an unknown metal



B = block    W = water

(a)  $Q_W + Q_B = 0 \Rightarrow m_W c_W \Delta T_W + m_B c_B \Delta T_B = 0$

$$m_W c_W (2^\circ\text{C}) + m_B c_B (22 - 100) = 0$$

$$c_B = \frac{-m_W c_W (2^\circ\text{C})}{(-78^\circ\text{C}) m_B} = \frac{1.00 \text{ kg}}{0.500 \text{ kg}} \cdot \frac{2}{78} (4190 \frac{\text{J}}{\text{kg}\cdot\text{C}}) = 214.9 \frac{\text{J}}{\text{kg}\cdot\text{C}}$$

(b) Which is more useful for storing heat? Water → it has a higher heat capacity →  $4190 \frac{\text{J}}{\text{kg}\cdot\text{K}}$  compared to  $215 \frac{\text{J}}{\text{kg}\cdot\text{K}}$

(c)  $Q_W + Q_B + Q_{\text{sty}} = 0$

$$Q_W + (m_B c_B \Delta T_B) + Q_{\text{sty}} = 0$$

$Q_1$        $Q_2$

In part (a),  $m_B c_B \Delta T$  had to provide  $Q_1$  alone. In part (c),  $m_B c_B \Delta T$  must provide  $Q_1$  &  $Q_2$ , so its heat capacity ( $c_B$ ) must be larger than it was in part (a).



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Ex. 45

What must the initial speed of a lead bullet...

$$C_{pb} = 130 \frac{\text{J}}{\text{kg} \cdot \text{K}}$$

$$L_f^{Pb} = 24.5 \times 10^3 \frac{\text{J}}{\text{kg}}$$

↑ fusion

$m$  = mass of the bullet

$$\begin{aligned}
 & \underbrace{Q_{\text{bullet}}}_{(K_f - K_i)} + \underbrace{m C_{pb} (T_f - T_i)}_{327.3^\circ\text{C} \rightarrow 25^\circ\text{C}} + \underbrace{m L_f^{Pb}}_{\text{required to melt it completely}} = 0 \\
 & - \left( \frac{1}{2} m v_i^2 \right)
 \end{aligned}$$

$Q$  required to raise it to the melting point temp.

$$- \frac{1}{2} v_i^2 + C_{pb} (302.3^\circ\text{C}) + 24.5 \times 10^3 \frac{\text{J}}{\text{kg}} = 0$$

$$v_i = \sqrt{2 \left[ 130 (302.3) + 24.5 \times 10^3 \right]} = \boxed{357.2 \text{ m/s}}$$

Ex. 52

A 4.00 kg silver ingot  $T_i = 750^\circ\text{C}$

Block of ice @  $0^\circ\text{C}$

How much ice is melted.

$m_{Ag}$  = mass of silver

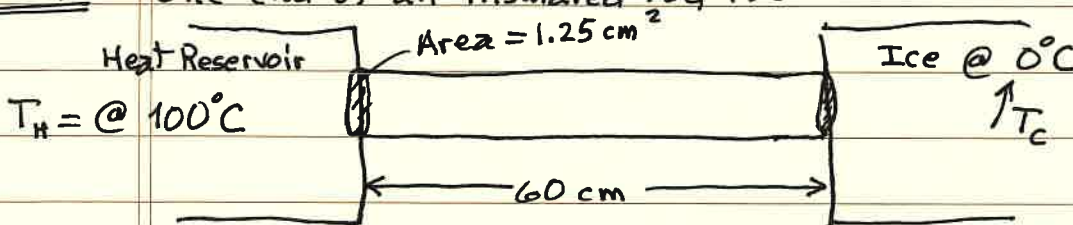
$m$  = mass of ice that is melted.

$$Q_{Ag} + Q_{ice} = 0 \quad m_{Ag} \underbrace{C_{Ag}}_{234 \frac{\text{J}}{\text{kg} \cdot \text{K}}} (0^\circ\text{C} - 750^\circ\text{C}) + m \underbrace{L_f^{ice}}_{334 \times 10^3} = 0$$

$$m = - \frac{m_{Ag} C_{Ag} (-750^\circ\text{C})}{L_f^{ice}} = + 4.00 \text{ kg} \frac{234 \frac{\text{J}}{\text{kg} \cdot \text{K}} (750 \text{ K})}{334 \times 10^3 \frac{\text{J}}{\text{kg}}} = \boxed{2.10 \text{ kg}}$$

Ex. 56

One end of an insulated rod ...



$$\frac{m}{\Delta t} = \frac{0.0085 \text{ kg}}{(60 \text{ s}) \frac{10 \text{ min}}{\text{min}}}$$

$$\frac{m}{\Delta t} = 1.417 \times 10^{-5} \frac{\text{kg}}{\text{sec}}$$

$$H = \frac{kA (T_H - T_C)}{\text{Length}} \quad k = \frac{H(\text{Length})}{A (T_H - T_C)} = \left( \frac{m L^{fus}}{\Delta t} \right) (\text{Length})$$

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Ex. 56 continued

$$k = \frac{(1.417 \times 10^{-5} \frac{\text{kg}}{\text{s}} \times 334 \times 10^3 \frac{\text{J}}{\text{kg}}) (0.60 \text{ m})}{1.25 \text{ cm}^2 \left( \frac{1 \text{ m}^2}{10^4 \text{ cm}^2} \right) (100 \text{ C}^\circ)} = \boxed{227.2 \frac{\text{W}}{\text{m} \cdot \text{K}}}$$

↑  
Conversion to SI

Ex. 106

The rate of radiant energy from the sun reaching the upper atmosphere of the earth is  $\sim 1.50 \text{ kW/m}^2$

$$I_{\text{Earth}} = 1.50 \text{ kW/m}^2$$

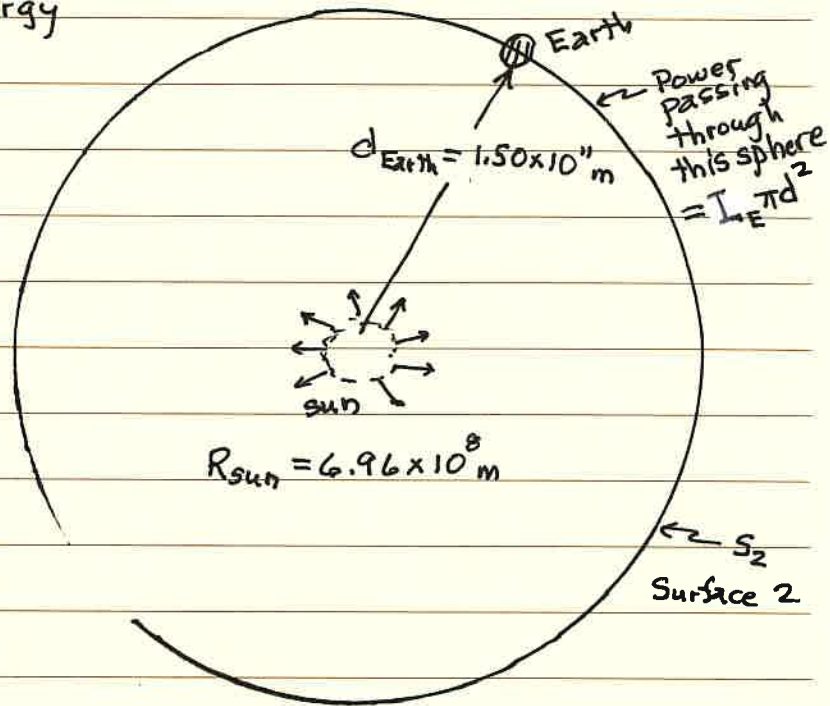
On the surface of the sun:

$$P_{\text{sun}} = I_s A_{\text{sun}} = I_s (\pi R_{\text{sun}}^2)$$

$\frac{\text{W}}{\text{m}^2}$  ↑      $\frac{\text{W}}{\text{m}^2}$  ↑      $\text{m}^2$  ↑

The power passing through the surface  $S_2$ :

$$P_{S_2} = I_E \pi (d_{\text{earth}})^2$$



Power through the surface of sun must equal the power through  $S_2$ .

$$I = \text{intensity} \quad I_{\text{sun}} (\pi R_{\text{sun}}^2) = I_E (\pi d_{\text{earth}}^2) \quad I_{\text{sun}} = I_E \left( \frac{d_{\text{earth}}}{R_{\text{sun}}} \right)^2$$

$\left[ \frac{\text{W}}{\text{m}^2} \right]$

$$I_{\text{sun}} = 1.50 \overset{10^3 \text{ W}}{\text{ kW}} \left( \frac{1.50 \times 10^{11} \text{ m}}{6.96 \times 10^8 \text{ m}} \right)^2 = \boxed{6.967 \times 10^7 \frac{\text{W}}{\text{m}^2}}$$

b.) Temperature of the Sun

$$I_{\text{sun}} = \frac{H_{\text{sun}}}{A} = (e=1) \sigma T^4 \quad T^4 = \frac{I_{\text{sun}}}{\sigma}$$

$$T = \sqrt[4]{\frac{6.967 \times 10^7 \frac{\text{W}}{\text{m}^2}}{5.67 \times 10^{-8} \frac{\text{W}}{\text{m}^2 \text{ K}^4}}} = \boxed{5920 \text{ K}}$$