Chapter 13

13-1

$$Q/t = \frac{k A \Delta T}{L}$$

$k = 0.2\ J/s\cdot m\,°C$

$$240\ J/s = \frac{0.2 \times 1.6 \times \Delta T}{2\times10^{-3}}$$

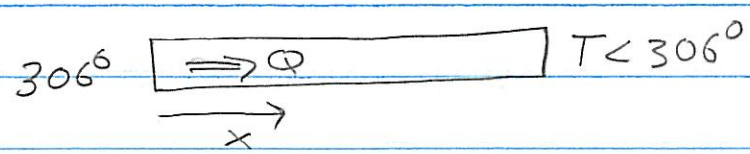
$\Delta T = 1.5°C$

13-3

$$\frac{Q}{t} = \frac{k A \Delta T}{L}$$

$$= \frac{0.04 \times 1.6 \times 25°C}{2\times10^{-3}} = 800\ J/s$$

13-9

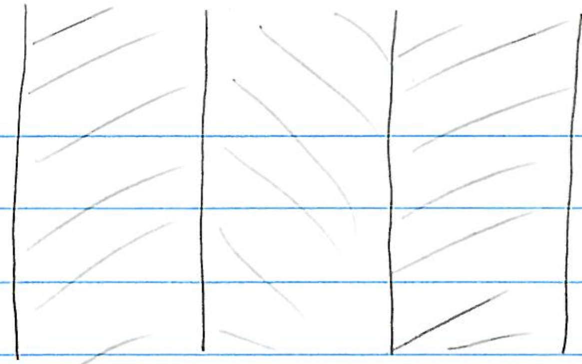


$$\frac{Q}{t} = \frac{k A \Delta T}{x} = \frac{110 \times 2.6\times10^{-4} \times (306 - T)}{0.15} = 3.6\ \frac{J}{s}$$

$0.191\,(306 - T) = 3.6$

$306 - T = 18.9 \Rightarrow T = 287°C$

13-13



$k_{plaster} = 0.3\ J/ms°C$, $k_W = 0.1\ J/s \cdot m \cdot °C$

$k_{BRICK} = 0.6\ J/ms°C$

→ Heat flow per SEC is the SAME in A 3 MATERIALS

$$Q/t = \frac{k_P A}{L}(27 - T_1) = \frac{k_B A}{L}(T_1 - T_2) = \frac{k_W A}{L}(T_2 - 0)$$

$$k_P(27 - T_1) = k_B(T_1 - T_2) = k_W T_2$$

(a) $0.3(27 - T_1) = 0.6(T_1 - T_2) = 0.1 T_2$

$$0.6T_1 - 0.6T_2 = 0.1T_2$$

$$0.6T_1 = 0.7T_2$$

$$T_2 = 6/7\, T_1$$

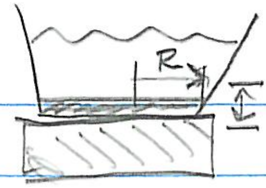
$$0.3(27 - T_1) = 0.6(T_1 - 6/7\, T_1)$$

$$27 - T_1 = 2(T_1 - 6/7\, T_1) = 2T_1 - \frac{12}{7}T_1$$

$$27 = 3T_1 - \frac{12}{7}T_1 = 1.29\, T_1 \Rightarrow T_1 \cong 21\ °C$$

(b) $T_2 = 17.9°C$

13-15



$R = 6.5\ cm$

$L = 2.0\ mm$

Heat to boil 0.45 kg of water at 100°C

$$Q = m L_v = 0.45\,kg \times 22.6 \times 10^5\ J/kg$$

then $$Q/t = \frac{0.45 \times 22.6 \times 10^5\ J}{120\,s} = 8475\ J/s$$

$$Q/t = \frac{k\,A\,\Delta T}{L}$$

$\Delta T = T_E - T_P$, when T_P is the temperature of the pot in contact with the water $= 100°C$

$$8475 = \frac{390\ J/s.m°C \times \pi (6.5 \times 10^{-2}\,m)^2}{2 \times 10^{-3}\,m} (T_E - 100°C)$$

$$8475 = 2588 (T_E - 100)$$

$$T_E - 100 = 3.3$$

$$T_E = 103.3°C$$

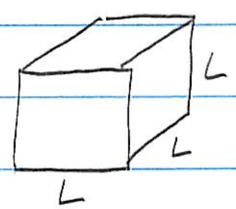
13-20

$$Q/t \propto T^4 \cdot A$$

$$T_1^4 A_1 = T_2^4 A_2$$

$$\frac{A_1}{A_2} = \left(\frac{T_2}{T_1}\right)^4 = \left(\frac{2100}{2700}\right)^4 = 0.37$$

13-21



$L = 0.01\,m$ @ $30^{\circ}C$

in one hour $(24 \times 60 \times 60\,s)$ a 100 W light bulb uses

$$E = 100\,\frac{J}{s} \times 60 \times 60$$

$$= 3.6 \times 10^5\,J$$

$$Q = \sigma e T^4 A \cdot t \quad , e = 1 \text{ (perfect)}$$

$$3.6 \times 10^5 = 5.67 \times 10^{-8}\,\frac{J}{s\,m^2 K^4}\,(273+30)^4\,6\,(0.01)^2 \cdot t$$

↑ SIDES

$$t = 1.26 \times 10^6\,s \times \frac{1\,min}{60\,s} \times \frac{1\,hr}{60\,min} \times \frac{1\,day}{24\,hrs}$$

$$= 14.5 \text{ days}$$

13-24

175°C = 448K
35°C = 308K
22°C = 295K

From example 8 on page 403, the net power radiated by an object that is at a higher temperature than its surroundings is

(13-3) $P_{net} = e\sigma A(T^4 - T_o^4)$, where

T_o is the temperature of the surroundings.

$$P_{net}(308K) = e\sigma A\left[(308)^4 - (294)^4\right] = 12W$$

$$P_{net}(448K) = e\sigma A\left[(448)^4 - (295)^4\right]$$

$$\text{so } e\sigma A = \frac{12W}{(308)^4 - (295)^4} = 8.4 \times 10^{-9}$$

$$P_{net}(448) = (8.4 \times 10^{-9})\left[(448)^4 - (295)^4\right]$$

$$= 275W$$

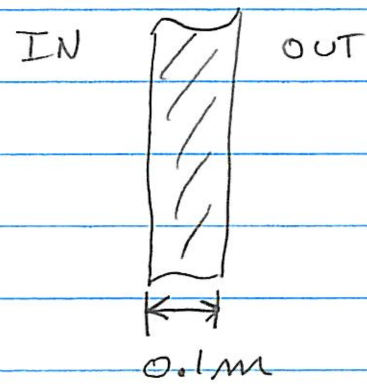
13-29

560 W per m^2

$$\frac{Q}{t \cdot A} = 560 = e\sigma T^4 \quad , e = 1$$

$$T = \left(\frac{560}{5.67\times10^{-8}}\right)^{1/4} = 315\,K$$

13-39



$$(Q/t)_{CONDUCTION} = kA\Delta T/L \quad , \Delta T = 20^\circ C = 20^\circ K$$

$$(Q/t)_{radiation} = e\sigma A T^4 \quad , \text{where } T = 273^\circ K$$

$$k = k_{concrete} = 1.1\ J/s\cdot m^\circ C$$

$$\frac{k\cancel{A}\Delta T}{L} = e\sigma \cancel{A} T^4$$

$$e = \frac{k\Delta T}{L\sigma T^4} = \frac{1.1\,(20^\circ)}{0.1\times5.67\times10^{-8}\,(273)^4}$$

$$= 0.69$$