Answers to Questions

5. $B > A = C$

12. $H = kA \frac{T_H - T_C}{L}$

$\Rightarrow \quad A = B = C > D = 0$

13. at the temperature of your finger.

Exercises & Problems

4P. (T_L, P_L) = (temperature, pressure) of the left-hand thermometer
(T_R, P_R) = (temp., pressure) of the right-hand thermometer

$$\Rightarrow \frac{T_L}{273.16K} = \frac{P_L}{P_3} \quad \& \quad \frac{T_R}{273.16K} = \frac{P_R}{P_3}$$

where P_3 = pressure of the gas at the triple point of water (=273.16K)

Subtract the second eqn. from the first.

$$T_L - T_R = (273.16K) \cdot \left(\frac{P_L - R_R}{P_3} \right)$$

Take $T_L = 373.125\,k$ (the boiling point of water) and
$T_R = 273.16\,k$ (the triple point of water)
then $P_L - P_R = 120$ mm of mercury.

$$\Rightarrow 373.125K - 273.16\,K = (273.16K) \left(\frac{120\,mm}{P_3} \right)$$

$\therefore \quad P_3 = 328$ mm

Now let $T_L = 273.16\text{ K}$ and T_R = unknown.
then $P_L - P_R = 90\text{ mm}$

$$\Rightarrow \quad 273.16\text{K} - T_R = (273.16\text{K})\left(\frac{90\text{ mm}}{328\text{ mm}}\right)$$

$$\therefore \quad T_R = 348\text{ K}.$$

26E. $\Delta V = \beta V \Delta T$ and $\beta = 3\alpha$

For aluminum $\beta = 3 \times (23 \times 10^{-6}/C^\circ)$
$= 69 \times 10^{-6}/{}^\circ C$

$$\Delta V = \Delta V_{glycerin} - \Delta V_{aluminum}$$

$$= \beta_{gly} V \Delta T - \beta_{alum} V \Delta T \qquad \left(V = 100\text{ cm}^3,\ \Delta T = 6^\circ C \right)$$

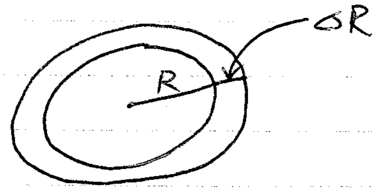
$$= (\beta_{gly} - \beta_{alum}) V \Delta T$$

$$= (5.1 \times 10^{-4}/C^\circ - 0.69 \times 10^{-4}/{}^\circ C)(100\text{ cm}^3)(6^\circ C)$$

$$= 26.5 \times 10^{-2}\text{ cm}^3$$ will spill out of the cup.

$$= 0.26\text{ cm}^3$$

34P. (a) D : diameter



$$\frac{\Delta D}{D} = 0.18 \times 10^{-2}$$

$$\frac{\Delta A}{A} = \frac{2\pi R \cdot \Delta R}{\pi R^2} = 2 \cdot \frac{\Delta R}{R} = 2 \cdot \frac{\Delta D/2}{D/2} = 2 \cdot \frac{\Delta D}{D}$$

$$\therefore \quad \frac{\Delta A}{A} = 2 \cdot \frac{\Delta D}{D} = 0.36 \times 10^{-2}$$

0.36 % area increase.

(b) $\Delta L = \alpha L \Delta T$ applies to every dimension of the object.

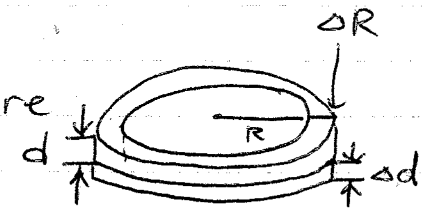
Therefore, thickness increases by 0.18 %.

(c) You might notice that from (a), Volume increases by $3 \times \frac{\Delta D}{D}$.

This is true actually.

$$\frac{\Delta V}{V} = 3 \times \frac{\Delta D}{D} = 0.54 \ (\%)$$

To prove this, consider the figure



$$\Delta V = \pi (R + \Delta R)^2 \cdot (d + \Delta d) - \pi R^2 d$$

$$= \pi \left(R^2 \Delta d + 2R\Delta R d + \underbrace{2R\Delta R \Delta d}_{2^{nd}} + \underbrace{\Delta R^2 d}_{2^{nd}} + \underbrace{\Delta R^2 \Delta d}_{2^{nd}} \right)$$

Ignore the second order differentials.

Then $\Delta V = \pi (R^2 \Delta d + 2R\Delta R d)$

$$\frac{\Delta V}{V} = \frac{\pi R^2 \Delta d}{\pi R^2 d} + \frac{2\pi R \Delta R d}{\pi R^2 d} = \frac{\Delta d}{d} + 2 \cdot \frac{\Delta R}{R} = 3 \frac{\Delta D}{D} \quad \left(\because \frac{\Delta d}{d} = \frac{\Delta D}{D} \right)$$

42E. The heat needed is

$$Q = \rho V L_F = m L_F$$

$$= (0.1)\cdot(1\times10^3\ kg/m^3)\cdot(333\ kJ/kg)$$

$$= 6.7\times10^{12}\ J$$

82E. (a) The rate of heat flow is

$$H = \frac{kA(T_H - T_C)}{L}$$

$$= \frac{(0.040\ W/mk)\cdot(1.8m^2)\cdot(33°C - 1.0°C)}{1.0\times10^{-2}\ m}$$

$$= 2.3\times10^2\ J/s$$

(b) The new rate of heat flow is

$$H' = \frac{k'H}{k} = \frac{(0.60\ W/mk)(230J/s)}{0.040\ W/mK} = 3.5\times10^3\ J/s$$

$$\left(\because \frac{H'}{k'} = \frac{H}{k} = \frac{A(T_H - T_C)}{L}\right)$$

which is about 15 times as fast as the original heat flow.

92P. (a) surface area of the sphere $= 4\pi r^2$

$$P_r = \sigma \epsilon A T^4$$
$$= (5.6703 \times 10^{-8}\ W/m^2 K^4)(0.850)\cdot(4\pi)(0.5\ m^2)(300\ K)^4$$
$$= 1.23 \times 10^3\ W$$

(b) $P_a = \sigma \epsilon A T_{environment}^4$

$$= (5.6703 \times 10^{-8}\ W/m^2 \cdot K^4)(0.850)(4\pi)(0.5\ m^2)(350\ K)^4$$
$$= 2.27 \times 10^3\ W$$

(c) $P_n = P_a - P_r = 2.27 \times 10^3\ W - 1.23 \times 10^3\ W$

$$= 1.04 \times 10^3\ W$$