KING FHAD UNIVERSITY OF PETROLEUM & MINERALS
DEPARTMENT OF PHYSICS

PHYSICS 102 (992)
SOLUTION (CHAPTER 19)

Q.1 At what temperature is the Fahrenheit scale reading equal to (a) twice of the Celsius and (b) half that of the Celsius?

(a) $F = \frac{9}{5}C + 32$

$2C = \frac{9}{5}C + 32, \quad (2 - \frac{9}{5})C = 32$

$\frac{C}{5} = 32, \quad C = 5 \times 32 = 160\,°C$ or $320\,°F$.

$\boxed{C = 160\,°C \text{ or } 320\,°F.}$

(b) $\frac{1}{2}C = \frac{9}{5}C + 32$

$(\frac{1}{2} - \frac{9}{5})C = 32, \quad -\frac{13}{10}C = 32, \quad C = -24.6\,°C$

or $-12.3\,°F$

$\boxed{C = -24.6\,°C \text{ or } -12.3\,°F.}$

Q.2 At what temperature do the following pairs of scales read the same: (a) Fahrenheit and Celsius, (b) Fahrenheit and Kelvin, (c) Celsius and Kelvin?

(a) $F = \frac{9}{5}C + 32$

$F = C$

$C = \frac{9}{5}C + 32, \quad \left(1 - \frac{9}{5}\right)C = 32, \quad -\frac{4}{5}C = 32.$

$\boxed{C = -40}$

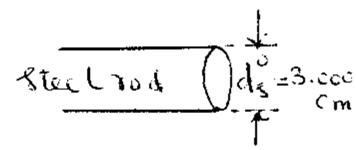
(b) $F = \frac{9}{5}(K - 273) + 32$

$F = K, \quad \left(1 - \frac{9}{5}\right)F = -\frac{9}{5}(273) + 32 = -459.4$

$\boxed{F = 574.}$

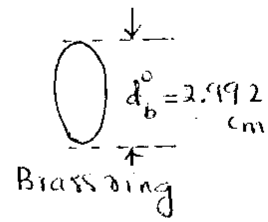
(c) $C = K - 273.$ – They are never equal.

Q.3 A steel rod is 3.000 cm in diameter at 25 °C. A brass ring has an interior diameter of 2.992 cm at 25 °C. At what common temperature will the ring just slide onto the rod?



$\alpha_b = 19 \times 10^{-6}\ °C^{-1}$ $\quad$ S ≡ Steel

$\alpha_s = 11 \times 10^{-6}\ °C^{-1}$ $\quad$ b ≡ brass



$$d_s = d_s^o + \Delta d_s \quad , \quad d_b = d_b^o + \Delta d_b$$

$$d_s = d_b$$

$$d_s^o + \alpha_s d_s^o \Delta T = d_b^o + \alpha_b d_b^o \Delta T$$

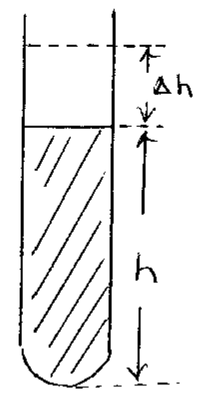
$$\Delta T = \frac{d_s^o - d_b^o}{(19 \times 10^{-6})(2.992) - (11 \times 10^{-6})(3.000)}$$

$$\Delta T = \frac{0.008}{2.38 \times 10^{-5}} = 335.5\ °C$$

$$T = T_o + \Delta T = 25 + 336 = 360\ °C$$

$$\boxed{T = 360\ °C}$$

Q.4 Show that when the temperature of a liquid in a barometer changes by ΔT, and the pressure is constant, the height h changes by $\Delta h = \beta h \Delta T$, where β is the coefficient of volume expansion. Neglect the expansion of the glass tube.



$V = Ah$, A = Cross sectional area assumed to be constant

$\Delta V = A \Delta h$

$\Delta V = \beta V \Delta T$

$$\Delta h = \frac{\Delta V}{A} = \frac{\beta (Ah) \Delta T}{A} = \beta h \Delta T$$

$$\boxed{\Delta h = \beta h \Delta T}$$

Q.5 A pendulum clock with a pendulum made of brass is designed to keep accurate time at 20 °C. What will be the error, in seconds per hour, if the clock operates at 0.0 °C?

$$T_1 = 2\pi\sqrt{\frac{L_1}{g}}$$

$$T_2 = 2\pi\sqrt{\frac{L_2}{g}} = 2\pi\sqrt{\frac{L_1(1+\alpha\Delta T)}{g}}$$

$$T_2 = 2\pi\sqrt{\frac{L_1}{g}}\sqrt{1+\alpha\Delta T}$$

$$2\pi\sqrt{\frac{L_1}{g}} = 1\ \text{sec} = T_1$$

$$T_2 = \sqrt{1+\alpha\Delta T} = \sqrt{1+19\times10^{-6}(-20)} = 0.9998\ \text{sec.}$$

$$\Delta T = T_2 - T_1 = -1.9\times10^{-4}\ \text{sec} = -0.684\ \text{S/hour}$$

The clock will gain 0.684 sec every hour.