Physics 151 Class Exercise: Temperature - KEY

1. Temperature Systems.

(a) Complete the following temperature reference chart using

$$F^\circ = \frac{9}{5}C^\circ + 32 \qquad K = C^\circ + 273 \qquad F^\circ = \frac{9}{5}K - 460$$

Description	Fahrenheit	Celsius	Kelvin	Rankine
Intersection of Fº and K Scales	574	301	574	1034
Boiling Temperature of Water	212	100	373	672
Body Temperature	98.6	37	310	559
Freezing Point of Water	32	0	273	492
Intersection of Fº and Cº Scales	-40	-40	233	420
Freezing Point of CO_2	-109	-78	195	351
Boiling Point of Nitrogen	-321	-196	77	139
Absolute Zero	-460	-273	0	0

(b) The Rankine temperature scale is based on the same degree size as the Fahrenheit scale yet starts (has zero) at absolute zero. Find a conversion formula from Celsius to Rankine.

$$F^\circ = \frac{9}{5}C^\circ + 32 \qquad F^\circ = R^\circ - 460$$

$$C^\circ = \frac{5}{9}\left(F^\circ - 32\right) = \frac{5}{9}\left(R^\circ - 460 - 32\right) = \frac{5}{9}\left(R^\circ - 492\right)$$

2. At 12.25 °C a brass sleeve has an inside diameter of 2.196 cm and a steel shaft has a diameter of 2.199 cm. It is desired to shrink-fit the sleeve over the steel shaft. (a) To what temperature must the sleeve be heated in order for it to slip over the shaft? (b) Alternatively, to what temperature must the shaft be cooled before it is able to slip through the sleeve?

Note that it makes no difference whether you think about the circumference or the diameter of the shaft changing size since they only differ by the constant pi.

(a) $L = C = \pi d$

$\Delta L = \Delta C = \pi \Delta d$

$\pi \Delta d = \alpha(\pi d_0)\Delta T$

$$T = T_0 + \frac{\Delta d}{\alpha d_0} = 12.25\ ^\circ\text{C} + \frac{2.199\ \text{cm} - 2.196\ \text{cm}}{(1.9\times10^{-5}\ \text{K}^{-1})(2.196\ \text{cm})} = \boxed{80\,^\circ\text{C}}$$

(b) $$T = T_0 + \frac{\Delta d}{\alpha d_0} = 12.25\,^\circ\text{C} + \frac{(2.196\ \text{cm} - 2.199\ \text{cm})}{(12\times10^{-6}\text{K}^{-1})(2.199\ \text{cm})} = \boxed{-100\,^\circ\text{C}}$$