Temperature and Heat

Thursday, January 4, 2018 6:58 PM

Temperature is empirically rooted, but can also be described on a fundamental, microscopic level.

Temperature scales:

Fahrenheit	Celsius	Kelvin	
212	100	373.15	H_2O boils
32	0	273.15	H_2O freeze
-459.67	-273.15	0	abs. 0

$T_F = \frac{9}{5} T_C + 32^\circ$

$T_C = \frac{5}{9}(T_F - 32^\circ)$

$T_K = T_C + 273.15$

Thermometers work by bringing some device into thermal contact with a body to be measured.

Zeroth Law of Thermo

If C is in thermal eq^m with A & B, then A & B are in eq^m

Some ways to measure T

- volume expansion of a liquid in a tube
- change of pressure in a gas
- change in resistivity of a wire
- differential change in length of a bi-metallic strip

Absolute temperature

Pressure is $\propto$ to T(K) at constant volume

$\frac{P_1}{P_2} = \frac{T_1}{T_2}$

let's compare pressures at 0°C (273.15 K) and 40°C (313.15 K)

$P_1 = 1\,atm$

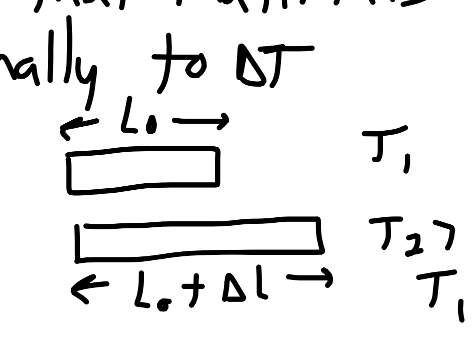
$P_2 = P_1 T_2/T_1 = 1\,atm \frac{313K}{273K} = \boxed{1.15\,atm}$

Thermal Properties of matter

Linear expansion

For moderate temp changes ΔT, experiments show that materials expand proportionally to ΔT

$\frac{\Delta L}{L_0} = \alpha \Delta T$



Same idea for volume

$\Delta V / V = \beta \Delta T \qquad V_0 + \Delta V = V_0 + V_0 \beta \Delta T$

Demo w/a bi-metallic strip

Brass $\alpha = 2.0 \cdot 10^{-5}\,K^{-1}$
Steel $\alpha = 1.2 \cdot 10^{-5}\,K^{-1}$

} Brass lengthens more → curves "away" from Brass

Problem

The Taipei 101 is 1671' tall. (at 15.5°C).
On a hot day, it is 0.471' taller.
What is T_2?
Building is made of steel

$\Delta L = \alpha L_0 \Delta T \Rightarrow T_2 = T_1 + \Delta T$

$= 15.5^\circ C + \Delta T$

$\Delta T = \frac{\Delta L}{\alpha L_0} = \frac{0.471\,ft}{1.2 \cdot 10^{-5}\,{}^\circ C^{-1}\,(1671\,ft)}$

$= 23.5\,^\circ C$

$\rightarrow T_2 = 15.5\,^\circ C + 23.5\,^\circ C = 39.0\,^\circ C$

S2.html $\boxed{A}$ imagine cutting the donut and laying it flat

S3.html $\frac{\Delta V}{V_0} = \frac{V_f - V_0}{V_0} =$

$\boxed{E}$

$= \frac{(V_0 + V_0 \beta \Delta T) - V_0}{V_0} = \beta \Delta T$

Cube: $\frac{\Delta V}{V_0} = \frac{\left[(L_0 + L_0 \alpha \Delta T)(L_0 + L_0 \alpha \Delta T)(L_0 + L_0 \alpha \Delta T) - L_0^3\right]}{L_0^3}$

$= 1 + 3\alpha \Delta T + 3\alpha^2 \Delta T^2 + \alpha^3 \Delta T^3 - 1$

$\simeq 3\alpha \Delta T$ since $\alpha \Delta T \ll 1$

$\longrightarrow \beta \simeq 3\alpha$