## Atomic Theory

ατομος - indivisible

- smallest particle of matter which cannot be divided

Law of definite proportions - when two or more elements form a compound, it is always in the same proportion by weight.

e.g. water - 1 g of hydrogen to 8 g of oxygen

$H_2O$ O 16 g/mol
H 1 g/mol

methanol - 1 g of hydrogen: 3 g of carbon: 4 g of oxygen

$CH_4O$ C 12 g/mol

CO $CO_2$
carbon monoxide vs. carbon dioxide.

C:O C:O
3g:4g 3g:8g

Comparing many elements/compounds we can determine the relative masses of atoms and composition of compounds.

## Temperature

Temperature is the measure of how hot or cold something is

Both Fahrenheit and Celsius are units of temperature. The celsius scale is based on the boiling and freezing points of water. There are several stories surrounding the Fahrenheit scale - see http://en.wikipedia.org/wiki/Fahrenheit

The end result is that water freezes at 32 °F and 0°C, while it boils at 212 °F and 100°C. Since both are linear scales

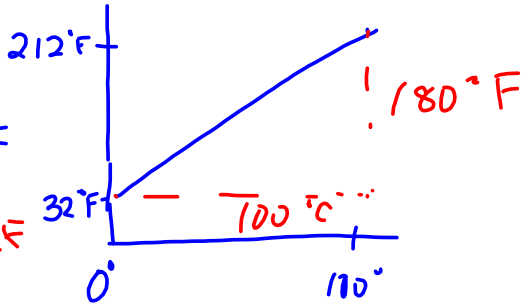
$y = mx + b$

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

$T(°F) = \frac{9F°}{5C°}(50°C) + 32°F$

$= 90°F + 32°F$

$= 122°F$




$T(°F) - 32°F = \frac{9F°}{5C°} T(C°)$

$\frac{5}{9}(T(°F) - 32) = T(C°)$

$T(°F) = \frac{9}{5} T(°C) + 32$

## Thermal Expansion

Most substances will increase in length as heated. To good approximation, the change in length, ΔL, is proportional to the length of the material, $L_0$ and to the change in temperature, ΔT.

$\Delta L \propto L_0 \cdot \Delta T$ (proportional)

$\Delta L \propto L_0 \cdot \Delta T + a_1 L_0 (\Delta T)^2 + a_2 L_0 (\Delta T)^3 + \ldots$ (negligible if ΔT "small")

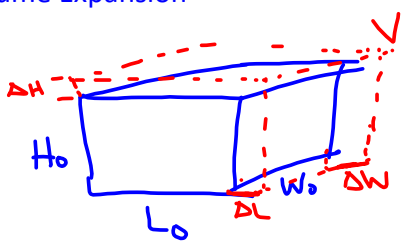
$L = L_0 (1 + \alpha \Delta T)$

$L - L_0 = \Delta L = L_0 \alpha \Delta T$

α: Thermal expansion coefficient

See Table 13-1 for lists of α (p. 388)

Volume Expansion




Isotropic (expands the same in all directions)

$V_0 = H_0 L_0 W_0$

$V = (H_0 + \Delta H)(L_0 + \Delta L)(W_0 + \Delta W)$

$= H_0 L_0 W_0 + \Delta H L_0 W_0 + \Delta L H_0 W_0 + \Delta W H_0 L_0$
$+ \Delta H \Delta L W_0 + \Delta H \Delta W L_0 + \Delta L \Delta W H_0$
$+ \Delta H \Delta L \Delta W$ negl.

Higher order 2nd / 3rd

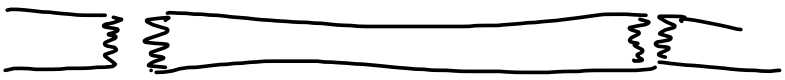
$V \approx V_0 + (H_0 \alpha \Delta T)(L_0 W_0) + (L_0 \alpha \Delta T) H_0 W_0 + (W_0 \alpha \Delta T) H_0 L_0$

$\approx V_0 + \alpha \Delta V_0 + \alpha \Delta T V_0 + \alpha \Delta T V_0$

$V \approx V_0 (1 + 3\alpha \Delta T)$

How big would an expansion joint need to be on an iron bridge with a 100 m span (in Fredericton)?

$\alpha = 12 \times 10^{-6}\ C^{\circ -1}$



$T_{min} \simeq -40^{\circ} C$

$T_{max} \simeq 80^{\circ} C$

$\Delta L = L_0 \alpha \Delta T$

$\Delta L = (100\ m)(12 \times 10^{-6} C^{\circ -1})(80 - (-40)^{\circ} C)$

$= 14.4\ cm$