Pure Substances

Ideal Gas Equation of State

We continue with our discussion on Pure Substances.

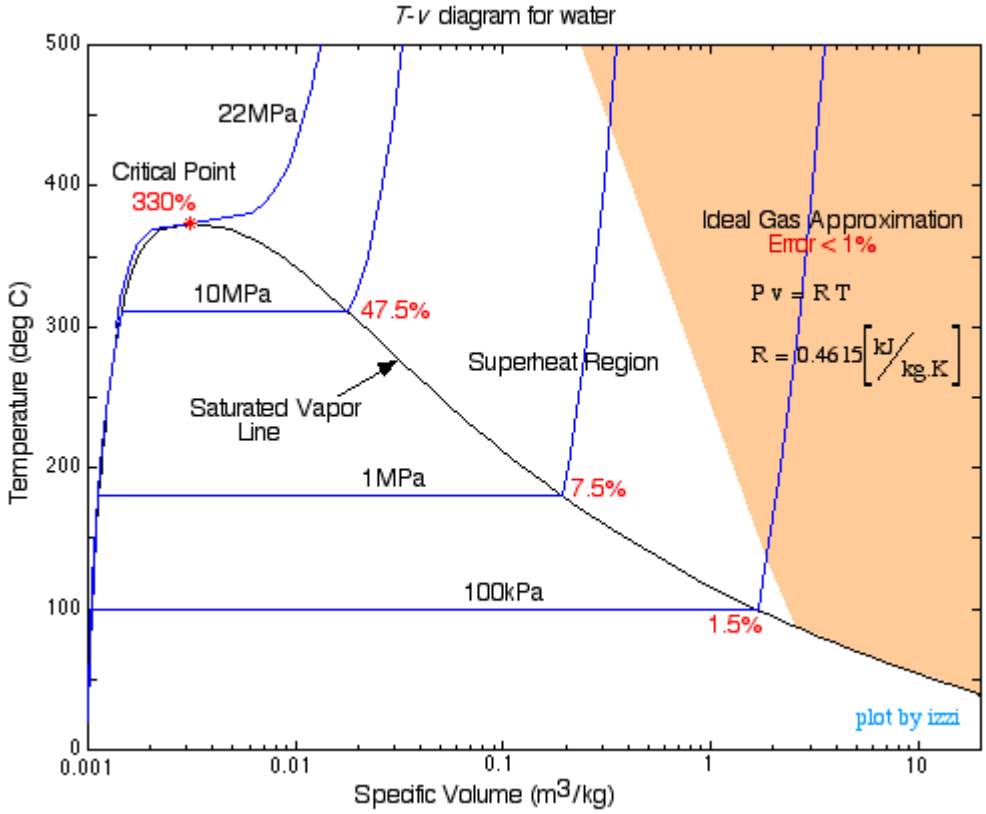
We find that for a pure substance in the superheated region, at specific volumes much higher than that at the critical point, the P-v-T relation can be conveniently expressed by the **Ideal Gas Equation of State** to a high degree of accuracy, as follows:

$P\,v = R\,T$

where: R is constant for a particular substance and is called the **Gas Constant**

Note that for the ideal gas equation both the pressure P and the temperature T must be expressed in absolute quantities.

Consider for example the *T-v* diagram for water as shown below:



The shaded zone in the diagram indicates the region that can be represented by the Ideal Gas equation to an error of less than 1%. Note that at the critical point the error is 330%.

The gas constant R can be expressed as follows:

$$R = \frac{R_u}{M}\left[\frac{kJ}{kg.K}\right] \Leftrightarrow \left[\frac{kPa.m^3}{kg.K}\right]$$

where: $R_u = 8.314\left[\frac{kJ}{kmol.K}\right]$ is the Universal Gas Constant

$M\left[\frac{kg}{kmol}\right]$ is the molar mass of the substance

For Air: $R = 0.287\left[\frac{kJ}{kg.K}\right]$

Steam: $R = 0.4615\left[\frac{kJ}{kg.K}\right]$

The three commonly used formats to express the Ideal Gas Equation of State are:

$P\,v = R\,T,$	where v = specific volume
$P = \rho\,R\,T,$	where $\rho = 1/v$ (density)
$P\,V = m\,R\,T,$	where V = volume, m = mass

Source: http://www.ohio.edu/mechanical/thermo/Intro/Chapt.1_6/Chapter2b.html