TEMPERATURE (θ)

Now we have four fundamental dimensions:

Length, Time, Mass, Temperature

L T M θ

θ is a dimension- you cannot derive it from L, T and M.

Temperature Scales: The units of θ were historically determined by reference to the properties of water at normal atmospheric pressure (~ 10^5 N/m^2)

	Celsius		Fahrenheit	
Melting pt. of ice	0 °C	100	32 °F	180
Boling pt. of water	100 °C		212 °F	

Hence a temperature difference of 5 °C is equal to 9 °F and therefore the readings on the two scales are related by the equation $\frac{F-32}{9}=\frac{C}{5}$

For example, the normal body temperature of 98.6 °F (only in the USA) is

$$\frac{5(98.6-32)}{9}=37°C\,(in\ France)$$

EFFECTS OF CHANGING θ

SOLIDS

A solid has both shape and size so the effects of changing θ appear on length (wire), Area (plate) and volume (parallelepiped).

Length: for most solids increasing the temperature causes an increase in length

$$\ell=\ell_0[1+\alpha(\theta-\theta_0)]$$

Where α is called the coefficient of linear expansion $\left|measured\ in\,[°C]^{-1}\ or\ °F^{-1}\right|$ and is typically about $10^{-5}\,[°C]^{-1}$.

Area: will involve changing two dimensions, say ℓ and b

$$\ell=\ell_0[1+\alpha(\theta-\theta_0)]$$
$$b=b_0[1+\alpha(\theta-\theta_0)]$$

so

$$A=\ell b=\ell_0 b_0[1+\alpha(\theta-\theta_0)]^2$$
$$=A_0[1+2\alpha(\theta-\theta_0)]$$

since $\alpha \ll 1$.

Volume: Now 3 dimensions are involved

$$V = V_0[1 + 3\alpha(\theta - \theta_0)]$$
$$= V_0[1 + \beta(\theta - \theta_0)]$$

With $\beta = 3\alpha$

LIQUILDS

Liquids only have size and no shape, so only volume changes occur

$$V = V_0[1 + \beta(\theta - \theta_0)]$$

and typically β is about $10^{-4}[°C]^{-1}$ or about 10 times the volume expansion coefficient of a solid.

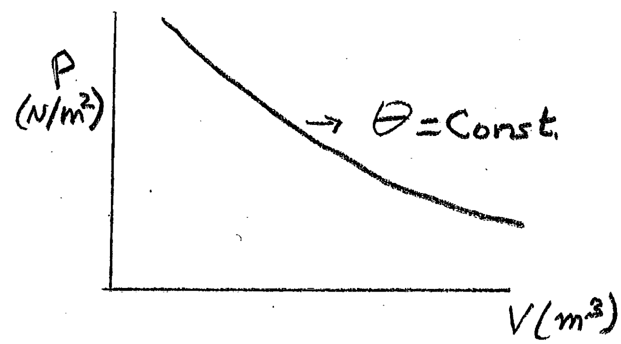
It is important to note a very important and highly unusual property of water. If you cool water it will indeed contract until the temperature reaches 4 °C. ON FURTHER COOLING WATER EXPANDS by about 1 part in 10^4 when it starts becoming ice at 0°C. During this solidification there is a further expansion of about 10 per cent.

GASES

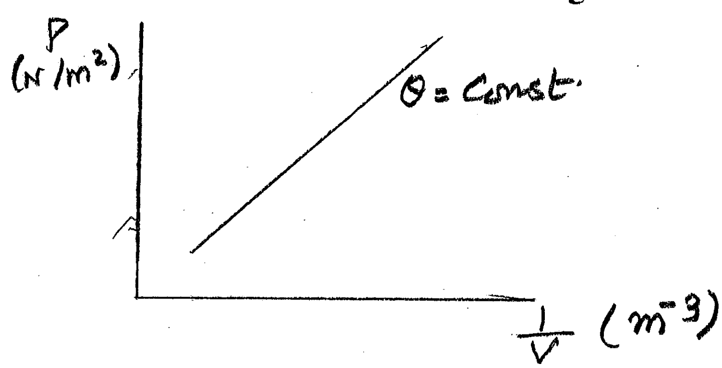
Gases have neither shape nor size and therefore have to be treated separately since Volume (V), Pressure (P), and temperature (θ) are all interrelated.

Temperature Const.

For a given amount of gas, pressure and volume are inversely related (Boyle's Law).
–If you double the pressure, volume becomes one half as large and vice verse.
In other words, P V = Constant

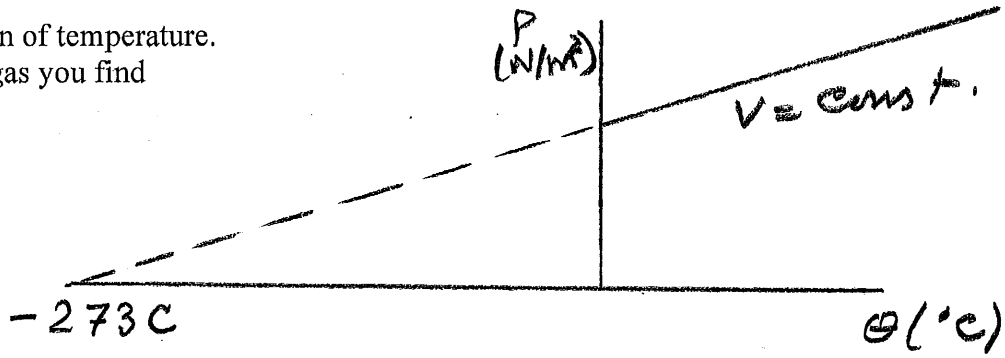


$$P = \frac{Constant}{V}$$



Volume (Const.)
Study P as a function of temperature.
For a low pressure gas you find
$P = P_0 (1 + c\theta)$

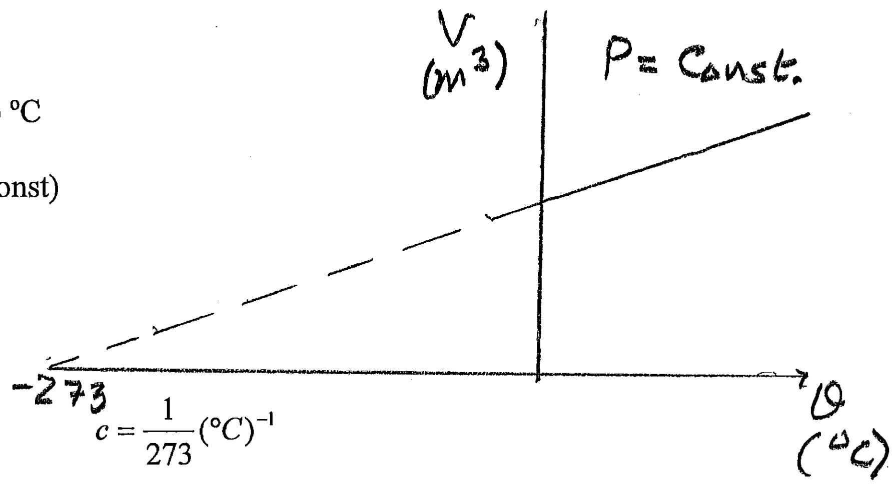
$$c = \frac{1}{273}(°C)^{-1}$$



Redefine Temperature T = (θ + 273) °C

P α T   New Scale   (Vol. Const)
Kelvin scale or Ideal gas scale

<u>Pressure Constant</u>



Now V varies as

$$V = V_0[1 + c\theta] \qquad c = \frac{1}{273}(°C)^{-1}$$

so one can write

$$V \,\alpha\, T \qquad [P\ Constant]$$

If we combine all three we can write

$$P\,V = N\,k_B\,T$$

where N = No. of gas particles in container
k_B is Boltzmann's Constant
1.38×10^{-23} Joules/Kelvin
T is in Kelvin scale   T = $[273 + \theta°C]$

Chemists write this equation as

$$P\,V = nRT$$

$$R = N_A k_B$$

N_A = Avogadro's No. = 6.02×10^{23}
Number of particles in one mole.