The over-pressure  $p = P - P_{atm} = \Delta P$  required to compress a gas of initial volume V to  $V - \Delta V$  is:

$$p = P - P_{atm} = \Delta P = -B\left(\frac{\Delta V}{V}\right)$$

Fractional change in volume

Change in the pressure for a fractional change in volume

(adiabatic conditions)

(Adiabatic) bulk modulus, B of fluid (here, a gas)

*B* is the so-called <u>adiabatic bulk modulus</u>,  $B = 1/\kappa$  where  $\kappa = \underline{\text{compressibility}}$  of the fluid (liquid or gas) – *n.b. B* has same *SI* units as pressure, *p* (from dimensional analysis of above formula)!

Thus, we see that the adiabatic bulk modulus B of a fluid (liquid or gas) is the (negative) of the change in the {over-pressure} divided by the <u>fractional</u> change in the volume of the fluid due to the change in the over-pressure:

$$B = \frac{-\Delta P}{\left(\Delta V/V\right)} \quad (Pascals)$$

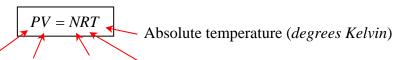
Now, for so-called adiabatic (*i.e.* slow) compression of a gas due to *e.g.* propagation of sound waves in the gas:

 $\gamma$  = "gamma" =  $C_V/C_P$  = Ratio of: <u>specific heat of gas @ constant volume</u> specific heat of gas @ constant pressure

 $\gamma = 5/3$  for monatomic gases (*e.g.* helium, neon, argon & xenon)

 $\gamma = 7/5$  for <u>diatomic</u> gases (*e.g.* oxygen & nitrogen molecules –  $O_2$  &  $N_2$ )

The Ideal Gas Law:



Pressure Volume # Moles R = universal gas constant = 8.3145 (*Joules/mole/deg.K*)  $(N/m^2)$   $(m^3)$  of gas

*e.g.* Carbon atom has 12 atomic mass units (amu's), and thus 1 *mole* (*mol*) of carbon {having Avogadro's number,  $N_A = 6.022 \times 10^{23}$  atoms/mole} weighs 12 grams.

Now air @ NTP (a mixture of oxygen & nitrogen molecules, traces of argon, *etc.*) is <u>NOT</u> a <u>perfect</u> ideal gas – but is <u>close</u> to an ideal gas.

For the so-called <u>adiabatic condition</u>:  $PV^{\gamma} = \text{constant} = K$ , thus:  $P = KV^{-\gamma}$