The energy of the gas

- The energy of the gas U is the sum of the kinetic and potential energies

$$U = U(T, V; N)$$

- As before we will regard N as being fixed, And the dependence on volume simply reflects the change in density. Specifically the energy per volume takes the form:

$$\frac{U}{V} = e_V(T, n) \qquad e_V = \text{some function of temperature + density.}$$

$\uparrow$ energy per volume

- If I double the system size, double the number of particles, at fixed temperature, the density remains the same and, energy per volume is the same. At small density, we expand in density

$$\frac{U}{V} = n\, e_0(T) + n^2 e_1(T) + n^3 e_2(T) + \ldots$$

- So the low density (ideal gas) expansion takes the form with $n = N/V$

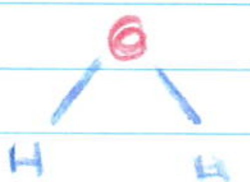
$$U(T,V) = N\left(e_0(T) + \frac{N}{V} e_1(T) + \ldots\ldots\right)$$

- If we only include the first term, $e_0(T)$ this is an ideal gas

$$\boxed{U = N e_0(T)} \qquad \text{Ideal Gas}$$

Then $\boxed{\left(\frac{\partial U}{\partial V}\right)_T = 0}$. This is oly for an ideal gas

- Complex molecules such as H_2O, can vibrate in a large number of ways, and this leads to a rich $e_0(T)$. Since $C_V = (\partial U/\partial T)_V$, measurements of specific heats can determine $e_0(T)$.



- The interactions between the molecules lead to a non-zero result

$$\left(\frac{\partial U}{\partial V}\right)_T = -\left(\frac{N}{V}\right)^2 e_1(T) \qquad \text{Non ideal}$$

This involves pairs of particles and their interactions. Derivatives such as this can be determined from specific heats, β_p and K_T. Maybe on homework you will show

$$\left(\frac{\partial U}{\partial V}\right)_T = \frac{C_p - C_V}{V \beta_p} - p$$