Kinetic theory of matter shows the comparison of how macroscopic properties of gas are related to the microscopic properties of a gas.

Examples of microscopic properties of gas are;

- speed
- mass

NB: Macroscopic Properties of gas are

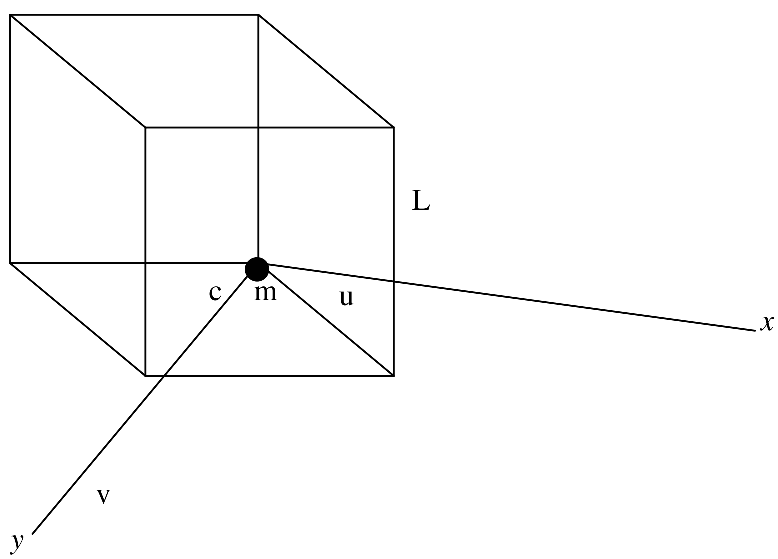
- Pressure
- Volume
- Temperature

ASSUMPTION OF KINETIC THEORY OF MATTER

1. The volume of the molecules is negligible compared to the volume of the container

NB: In ideal gas, the volume of the molecule of a gas is negligible compared to the containers while in real gas both the volume of the gas and the container are considered

2. The molecules of the gas moves in random motion still obeying Newton's law of motion
3. The intermolecular force of attraction between the gas molecules is negligible
4. The molecules are the solid

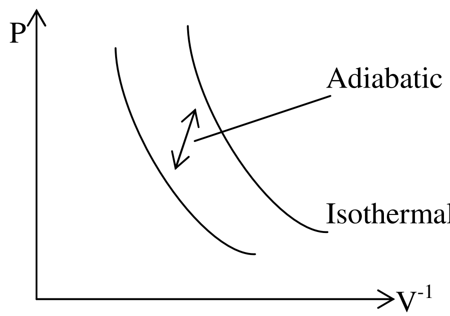


5. The collision between the molecules of a gas and the wall of the container is perfectly elastic

(iii) Root Mean Square Speed (C_{rms}) = $\sqrt{\bar{C}^2} = \sqrt{4.56} = 2.1 m/s$

NB: This example shows clearly how to compute $\bar{C}^2$, $\bar{C}^2$ and C_{rms}

ADIABATIC EXPANSION



An adiabatic system is an isolated system in which no heat leaves the system or enters the system
NB: dq = du + PdV
When dq = 0, then
0 = du + PdV
du = -PdV

When there is increase in thermal energy by the system it means work is been done on the system. But when there is decrease in thermal energy of the system, it means work is been done by the system.

EXAMPLES OF ADIABATIC PROCESS

i. Expansion of steel in the cylinder of steel engine
ii. Expansion of hot gases in an internal combustion engine
iii. Compression of air in a diesel engine/in air compressor

NB: To do something adiabatically is to do something quickly for example, in a calorimeter, in other to avoid heat loss or heat gain by the solution in the calorimeter. The calorimeter is lagged with cotton wool or silk.

REPRESSIBLE ISOTHERMAL EXPANSION

dW = PdV - - - - (i)
recall also that
PV = RT - - - - (ii)
From equation (ii) we have that

$P = \frac{RT}{V}$ - - - (iii)

Substitute (iii) in (i) therefore we have that

$dW = \frac{RT}{V} dV$ - - - - (iv)

Dividing through by C_v (NB: $\gamma = \frac{Cp}{Cv}$) then

$$\frac{dVCp}{V} \times \frac{1}{Cv} + \frac{dVCv}{P} \times \frac{1}{Cv} = 0$$

(Because du + PdV = 0)

$$\frac{dV}{V} \times \frac{Cp}{Cv} + \frac{dV}{P} = 0$$

$$\boxed{\frac{dV}{V}\gamma + \frac{dV}{P} = 0}$$ (NB: $\gamma = \frac{Cp}{Cv}$)

Similarly,

$$\boxed{\frac{dP}{P} + \gamma \frac{dV}{V} = 0}$$

Furthermore

$\ln P + \gamma \ln V = 0$

$\ln PV^{\gamma} = 0$

$$\boxed{\ln P_1 V_1^{\gamma} = \ln P_2 V_2^{\gamma}}$$

This equation is for adiabatic process at constant temperature

$P_1V_1 = P_2V_2$ - - - - - (i)

$\frac{P1V1}{T1} = \frac{P2V2}{T2}$ - - - - - (ii)

NB: PV = RT

Dividing equation (i) by (ii)

$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$

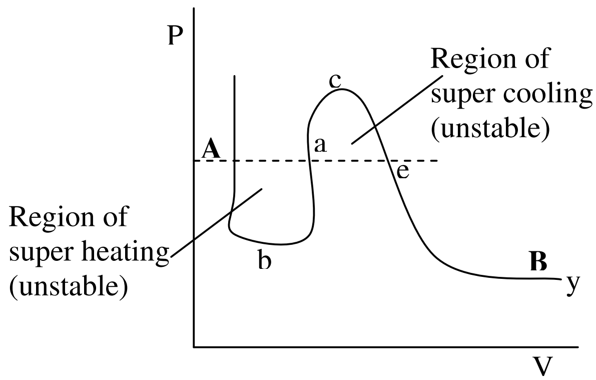
($TV^{\gamma-1}$ = constant)

Similarly,

$$\frac{P_1^{\gamma-1}}{T_1^{\gamma}} = \frac{P_2^{\gamma-1}}{T_2^{\gamma}}$$

($\frac{P^{\gamma-1}}{T^{\gamma}}$ is constant)

REAL GAS; VAN DER WAAL EQUATION



$$\left(P+\frac{a}{V^2}\right)(V-b)=RT$$

$\left(\frac{a}{V^2}\right)$ This is the value that is not negligible

Lets consider a typical isotherm *x*, A, b, a, c, e, y above consider the behaviour at "a", suppose we started with a homogeneous phase along the phase, the slope dP/dV is positive. This means that a small increase in volume is accompanied by increase in pressure, hence there is a spontaneous expansion towards C, that also implies that a small decrease in volume will lead to a spontaneous contracti8on towards "b"

dW = RT . linV ===> $W = RT\ lin\left(\frac{V2}{V1}\right)$ ==>$W = RT\ lin\left(\frac{P1}{P2}\right)$	- - 5

NB: we use $\frac{V2}{V1}$ and $\frac{P1}{P2}$ because $P_1V_1 = P_2V_2$.

In reversible adiabatic process, we move the piston extremely slowly from an ideal gas, an adiabatic expansion gives a temperature drop while the ratio $\frac{T2}{T1}=\left(\frac{V1}{V2}\right)^{\gamma-1}$

NB $\gamma=\frac{Cp}{Cv}$.

But for a real gas, the temperature drop is greater because of the energy expended in overcoming lthe intermolecular forces of attraction from dq = du + dW
NB: dW = PdV
Hence, dq = du + PdV- - - - - (i)
When dq = 0 then,

$$PV + \frac{a}{V} - Pb - ab = RT \qquad - \qquad - \qquad 3$$

$$P + V\left(\frac{dP}{dV}\right)T - \frac{a}{v} - b\left(\frac{dP}{dV}\right)T + \frac{2ab}{V^2} = 0 \qquad - \qquad - \qquad 4$$

$$\left(\frac{dP}{dV}\right)T = 0$$

$$P = \frac{a}{V^2} - \frac{2ab}{V^3} \qquad - \qquad - \qquad - \qquad - \qquad - \qquad 5$$

$$\frac{dP}{dV} = -\frac{2a}{V^3} + \frac{6ab}{V^4} = 0$$

$V_c = 3b$, $\quad P_c = \frac{a}{27h^2}$

$$T_c = \frac{8a}{27Rb}$$

for a single gas; $\frac{RT_c}{P_cV_c}$ - - (critical coefficient)

Coefficient lies between 3 – 3.5