The Concept of Time Lost - New Equation of State

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Abstract- The new concept of time lost during molecular collisions and other physical events has been introduced. Utilizing the concept, the loss of time during molecular collisions in gaseous state was calculated. The amount of pressure decreased due to the loss of time was calculated. Based on the concept the new equation of state has been developed. A new physical state of the matter 'gasolid' was introduced and some of the properties of gasolid were discussed.

Index Terms- Time lost, physical events, gasolid, molecular attractions.

I. INTRODUCTION

In the nature every physical event takes place by spending some amount of time. For example the process of ejection of photoelectrons requires certain amount of time ($\approx 10^{-7}$sec). When the radiation with sufficiently high frequency is incident on surface of the electropositive metals the photo electrons are ejected. During the process electrons require certain time to absorb photon and escape from the metal surface. Similarly collisions between micro particles takes place by spending some amount of time (Δt).Therefore it is natural phenomenon that every event in the nature takes place by expense of certain amount of time (Δt).

According to kinetic molecular theory of gases the gas molecules are moving randomly in all directions with very high velocities and they are colloid themselves and also on the walls of the container. During the molecular collision the momentum as well as the direction will be altered. To complete collision process the molecule should have to spend certain amount of time (Δt), that is the molecule should be spent a moment of time to complete the collision process. It implies that the molecules will lost certain amount of time (Δt) without motion during each collision. Owing to this loss of time the molecule can exert the less number of collisions than expected that results the decrease in the pressure of the gas than theoretically expected. Therefore a correction is needed to calculate the decrease in pressure due to the loss of time by the molecules during collisions. This is the vital factor for the deviation of gases from ideal behavior.

So for many equations of state were developed to explain the behaviour of gases but most of the equations developed based on the property of intermolecular attraction and repulsion forces. They felt that intermolecular attraction and repulsion forces are responsible for the decrease in pressure but none of the equation was successful in explaining the behavior of gases. Inter molecular attraction and repulsion forces are operative only in the vicinity of the critical temperature or below its critical temperature where the molecular velocities are less. Above the critical temperature molecules are moving with considerably high velocities, such high velocities can't influenced by the attraction or repulsion forces exert either by neutral molecules or small charges developed on molecules or induced dipoles

developed on the molecules during molecular collisions. Even at critical temperature only a small fraction of molecules having lower molecular velocities are exerting considerable amount of intermolecular attractions due to this only small fraction of gas only liquefied at critical temperature but molecules with sufficiently high velocities are not condensed into liquid. If the intermolecular forces are really operative above critical temperature nothing is prevent the gas to liquefy at high temperatures by the application very high pressure. So far no proper explanation is available for not liquefying the gas above its critical temperature. It is clear evidence that intermolecular forces are not operative above the critical temperature, If not so the highly compressed gas can liquefy at any high temperature. Therefore it is concluded that the considerably high molecular velocities and insignificant intermolecular forces of attractions and repulsions are the main reason for not liquefying any gas above its critical temperature. If the intermolecular forces are operative above the critical temperature as expected by Vander Waal and others any gas can be liquefied above its critical temperature by applying considerably high pressure. For instance most of the gases occupy the volume equal to its volume in liquid phase as the pressure reaches to 1000 to 1500Atm. As the pressure increases the gas molecules approaches each other very closely that is the intermolecular distances are reduced as a result the intermolecular forces are increased and the gas will be liquefied but it is not practically possible and it indicates that the intermolecular forces are not operative on the high molecular velocities above the critical temperature.

Therefore a new equation of state has been developed based on the concept of time lost during the molecular collisions. As the number of collisions exert by the gas molecules are increases the amount of time lost by the gas molecules is also increases. It implies that if the collision frequency increases the pressure of the gas also increases accordingly the loss of time due to molecular collisions also increases, hence the deviation from the ideal behavior is going on increasing as the pressure increases.

Further more for the most of the gases the deviation is linearly increases with pressure. If the molecular attraction forces are responsible for the deviation the attraction forces are also increases linearly with pressure that results the liquefaction of gases even at considerably high temperature and pressure but that is not possible.

The above discussion is clearly indicates that the concept of intermolecular attractions of gases is not appropriate factor for the deviation of gases from ideal behaviour. The search for another appropriate factor the concept of time lost during molecular collisions was found to be more responsible factor for the deviation of gases from ideal behaviour.

Therefore the new equation of state is derived based on the concept of time lost during molecular collisions. The total amount of time lost by all the gas molecules in volume (V) is calculated. The total number of collisions that all the molecules

can't exert due to the loss of time and the reduced pressure due to this loss of time was calculated.

II.   DERIVATION OF AN EQUATION FOR THE PRESSURE OF GAS

Consider a cube of length '**l**' enclosed with 'n' molecules of gas of molecular weight 'm' moving with RMS velocity 'C'. The velocity component is resolved into three components along three coordinate axis 'x' , 'y' and 'z' as C_x, C_y and C_z

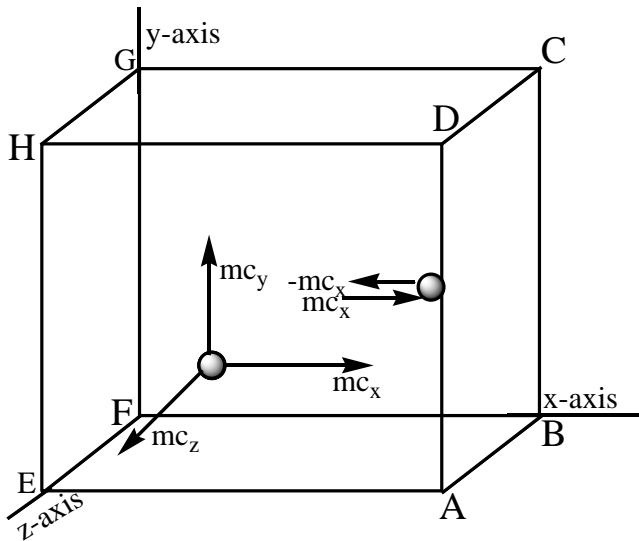$$C^2 = C_x^2 + C_y^2 + C_z^2 - - - - - - - - - - - - - (1)$$

Fig-1

Consider the molecule is moving along with 'x' axis strikes on the face ABCD of the cube communicate a momentum 'mc_x'. Further, since the collision is perfectly elastic the molecule will rebounds from the face ABCD with the same velocity, so that the change in its momentum during the collision on ABCD.

$$mc_x - [-mc_x] = 2mc_x$$

After recoil, the molecule travels to the opposite face EFGH and collides with it rebounds and travels back to the face ABCD after covering the distance '2**l**.'

The number of collisions per unit time which the molecule can makes with ABCD   = $C_x / 2l$

Therefore the time taken by the molecule for the two successive collisions on ABCD = $2l/C_x$

The loss of time during each of the collision is 'Δt'

The loss of time during the $C_x \big/ 2l$ collisions is =

$$\frac{C_x}{2l} \Delta t$$

This time is wasted by the molecule during $\dfrac{C_x}{2l}$ collisions, by taking into consideration it is possible to calculate the loss of collisions during this time.

The number of collisions per unit time   =
$$\frac{C_x}{2l}$$

In ' $\dfrac{C_x}{2l} \Delta t$ 'time the molecule will make $\dfrac{C_x}{2l} \times \dfrac{C_x}{2l} \Delta t$ collisions. But these collisions are not exerted by the molecule due to the loss of time during the collisions. By taking these collisions into account the total number of collisions exerted by the molecules   =
$$\frac{C_x}{2l} \times \frac{C_x^2}{4l^2} . \Delta t$$

The rate of change of momentum   =
$$2mC_x \left[\frac{C_x}{2l} \times \frac{C_x^2}{4l^2} . \Delta t \right] - - - - - - - - - - - - - - - - (2)$$

$$= \frac{mC_x^2}{l} \times \frac{mC_x^3}{2l^2} . \Delta t$$

According to the Newton's second law the impressed force = Rate of change of momentum

$$f_x = $$

$$\frac{mC_x^2}{l} \times \frac{mC_x^3}{2l^2} . \Delta t$$

Since pressure is force per unit area, the pressure P_x on the face ABCD.

$$P_x = \frac{f_x}{l^2} = \frac{mC_x^2}{l^3} \times \frac{mC_x^3}{2l^4} . \Delta t$$

Similarly, if P_y and P_z are representing pressure on the faces EFBA and FBCH which are perpendicular to the 'Y' and 'Z' axis respectively. Then

$$P_y = \frac{mC_y^2}{l^3} \times \frac{mC_y^3}{2l^4} . \Delta t$$

and

$$P_z = \frac{mC_z^2}{l^3} \times \frac{mC_z^3}{2l^4} . \Delta t$$

$$P = \frac{P_x + P_y + P_z}{3} = \frac{1}{3}\left[\frac{mc^2}{l^3} + \frac{mc^3}{2l^4}.\Delta t\right] - - - - - - - (3)$$

It is the pressure exerted by one molecule. Therefore the total pressure exerted by 'n' number of molecules present in the container of volume 'V'

$$P = \frac{1}{3}\left[\frac{mnc^2}{V} + \frac{mnc^2}{V}.\frac{C}{l}.\Delta t\right] \quad \because l^3 = v \; volume$$

$$P = \frac{1}{3V}mnC^2\left[1+.\frac{C}{l}.\Delta t\right] - - - - - - - (4)$$

$$P = P^1 + P^1 \frac{C}{l}\Delta t \quad - - - - - - (5)$$

P^1 is the observed pressure

$\frac{C}{l}$ is the number of collisions made by the molecule in unit time.

Actually the number of collisions made by the molecule in unit time is called collision frequency (η) and is equal to $\eta = \frac{C}{\lambda}$

C = RMS velocity of molecule; λ = mean free path; P = Actual pressure; P^l = Observed pressure; d = density of the gas; R = Universal gas constant; T = Absolute Temperature; γ = Viscosity of the gas; The value of 'η' is the collision frequency and calculated with the equation $\eta = \frac{4dRT}{3\pi m\gamma}$

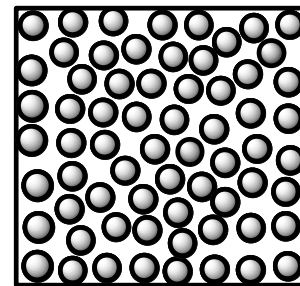The value of 'Δt', from collision theory is approximately 10^{-18}sec

Therefore the equation of state for the gases above the critical temperature is

$$P^1 (1+ \eta \Delta t) V = RT - - - - - - - - - - - - - - - - - - (6)$$

In the above equation the loss of time 'Δt during the collisions depends on the velocity of the molecules, hence it is temperature dependent and the number of collisions 'η' is both pressure and temperature dependent.

The maximum number of collisions made by the molecule η does not exceed $1/\Delta t$. It implies that '$\eta \Delta t$' is never equals to '1'. As the product of the number of collisions executed by the molecule and the loss of time during each collision approaches near to unity the gases behaves like a solid. The translatory motion is almost seized. Since each molecule is closely surrounded by number of highly populated gas molecules. Such closely surrounded molecules do not allow the molecule to move away from its position so easily. At such instance gas molecules are only vibrating among the surrounded molecules and making collisions with them like the particles in the solid. Most of the kinetic energy of the molecules is converted into vibrational energy. When 'η Δt' value tends to reach unity gases differs widely from behavior of gases and gas laws. As the pressure of the gases increased to 1000 to 1500Atm they occupy the volume almost equal to its volume in liquid phase. The difference between gases and liquid is that the intermolecular forces of attractions and repulsions are present in liquid state but intermolecular forces of repulsions are only present among the electron clouds of the surrounded molecules in gaseous state. At that instance gas can be compressed to the insignificant extent. Further compression of gas requires very high extent of force. Therefore at such conditions the compressibility of gases is nearly equal to the liquids and solids. Such state of the gas is named as *'Gasolid'.* In the state of gasolid gas do not obey gas laws and having insignificant compressibility like solids. In the state of gasolid as the value of 'η Δt' tends to unity most of the kinetic energy of the gas molecules is converted into the vibrational energy of molecules. Hence the molecules are vibrating among the surrounding molecules. Since molecules are closely packed in gasolid state they experienced very strong repulsive forces due to electron clouds of the molecules. The difference between supercritical liquid and gasolid is that the former one is an equilibrium state between liquid and gaseous states of gas in the vicinity of critical temperature where as the gasolid is the purely gaseous state in which the translatory motion is almost seized and the gas can't be compressed further.

$$\therefore P = \frac{1}{3V}mnC^2$$

Highly Compressed
state Of Gases
Called Gasolid

III. EXPLANATION FOR THE BEHAVIOUR OF GASES AT DIFFERENT TEMPERATURES AND PRESSURE

a) At high temperature and low pressure:

At high temperature the molecular velocities are high therefore the loss of time during each collision Δt is very low hence the loss of pressure is also very low. But at low pressure

the number of collisions made by the gas molecules (η) is relatively low. Hence loss of time (η Δt) is also low. Therefore the decrease in the pressure is also very low and can be negligible at high temperature and low pressure. Then the gas equation at these conditions is $PV = nRT$

b) At high pressure and low temperature:

At high pressure the number of collisions made by each of the gas molecules is (η) very high, Therefore the loss of time during the molecular collisions is very high. At low temperature the molecular velocities are very low, therefore the loss of time (Δt) during each collision is relatively high. Hence considerable amount of time (η Δt) was lost by the gas molecules as a result the pressure is decreased significantly than expected. Therefore the deviation is more from ideal behaviour of the gases.

c) At high pressure and high temperature:

At high pressure the number of collisions made by the gas molecules(η) is very high, Therefore the loss of time during the molecular collisions is very high moreover at high temperature the molecular velocities are very high as a result the loss of time during each collision (Δt) is very low. Therefore due to very large number of collisions the overall time lost (η Δt) is high and cannot be neglected. Due to this the deviation from gas laws is high. Therefore at the conditions of (b) and (c) the equation of state is $P^1 (1+ \eta^\Delta t) V = RT$

IV. EXPLANATION FOR THE BEHAVIOUR OF GASES LIKE HYDROGEN AND HELIUM

Hydrogen and Helium are the gases are known to be the permanent gases. These gases always show a positive deviation from ideal behaviour, this is due to reason that they execute large number of collisions even at low pressure because of their very low molecular weight and relatively high molecular velocities. As a result the time lost by the molecule during collision is high even at low pressure. Therefore at the conditions these gases obey the equation

$P^1 (1+ \eta^\Delta t) V = RT$

V. CONCLUSIONS

The concept of time lost was introduced. It is utilized to explain the behaviour of gases and deviation of the gases from the gas laws and ideal gas equation. It is providing the proper explanation for the linear increase of compressibility factor with pressure of all gases especially for permanent gases like Hydrogen and Helium. This concept leads to explain the basic behaviour gas at extremely high pressures and above the critical temperature.

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