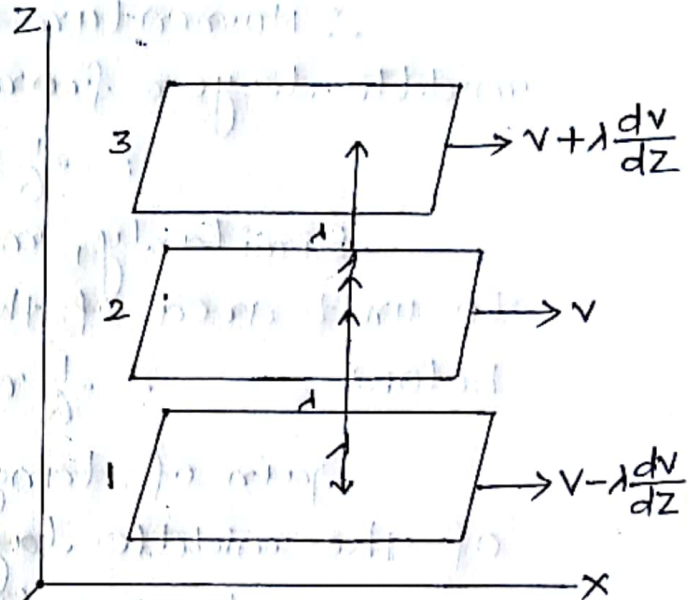


Calculation of viscosity on Kinetic theory of gas.

Consider three parallel layers in a gas at distance λ apart, where λ is the mean free path of the gas. Let these layers be parallel to xy plane and the middle layer has a velocity v . If the velocity gradient be along z-axis, the



velocity at the upper layer is $v + \lambda \frac{dv}{dz}$ and that at the layer lower to the middle one is $v - \lambda \frac{dv}{dz}$. If n is the density of the molecules of the gas, then $\frac{n}{3}$ molecules per unit volume will be moving along any of the axes. So in the z-direction $\frac{n}{3}$ molecules per unit volume will be moving. As they move both in the positive and negative direction of z, their number moving in either direction is $\frac{n}{6}$ per unit volume. To find the number of molecules moving downward through unit area in unit time, consider a cylinder of

length \bar{c} and standing parallel to z-axis on unit area of the middle layer. Here \bar{c} is the mean velocity of the gas. The number of molecules contained in this cylinder will pass downward through its base in 1 second. The number of molecules contained in the cylinder is $\frac{1}{6} n \bar{c}$.

\therefore Momentum Carried to unit area of the middle layer from the layer below.

$$= \frac{1}{6} n \bar{c} \times m \left(v + \lambda \frac{dv}{dz} \right)$$

Similarly, momentum Carried in unit time to unit area of the middle layer from the layer below

$$= \frac{1}{6} n \bar{c} \times m \left(v - \lambda \frac{dv}{dz} \right)$$

Gain of tangential momentum by unit area of the middle layer

$$= \frac{1}{6} n \bar{c} m \left(v + \lambda \frac{dv}{dz} \right) - \frac{1}{6} n \bar{c} m \left(v - \lambda \frac{dv}{dz} \right)$$

$$= \frac{1}{6} n \bar{c} m \left(v + \lambda \frac{dv}{dz} - v + \lambda \frac{dv}{dz} \right)$$

$$= \frac{1}{6} n \bar{c} m \times 2 \lambda \frac{dv}{dz}$$

$$= \frac{1}{3} m n \bar{c} \lambda \frac{dv}{dz} = \frac{1}{3} \rho \bar{c} \lambda \frac{dv}{dz}$$

By Newton's law this is the viscous force per unit area of the layer which is given by

$$F = \eta \frac{dv}{dz} \quad \therefore \eta = \frac{1}{3} \rho \bar{c} \lambda$$

Since $\bar{c} \propto \sqrt{T}$, viscosity of gases should vary as the square root of absolute temperature of the gas. Actually It is found to vary more rapidly. This is due to deviation of real gases from the behaviour of ideal gases.