MOLECULAR FLOWS

The System of Study: Let us postulate a system of study consisting of a ***p***-population of gaseous atmospheric molecules in random motion in proximity space. The surface of interest is the intangible surface of an imaginary intangible plane surrounded by the ***p***-population. The plane has a surface area of one square meter. The mean number density of the ***p***-population is $\bar{\boldsymbol{n}}$.

System Subdivisions: The postulation of randomness divides our system number density into two equal subpopulations, $\bar{\boldsymbol{n}}_{\boldsymbol{p}}$ and $\bar{\boldsymbol{n}}_{-\boldsymbol{p}}$:

$$\bar{\boldsymbol{n}}_{\boldsymbol{p}} = \bar{\boldsymbol{n}}_{-\boldsymbol{p}} = \tfrac{1}{2}\bar{\boldsymbol{n}} \qquad \text{FLW01}$$

A moment's thought will convince us that no matter where we put our plane within our system of molecules, the two subpopulations will always be present and each will always be equal to half of the total population. Under the postulation of randomness, this population division is independent of location within the system or orientation of the plane with respect to any reference system.

Moreover, that division is the same for the next second as well as this one; and—indeed—for any second of time. The probable molecular division is independent of time; as well as location in our system, and orientation within our system.

Equivalence of Flow Numbers: Thus, we see that the number of molecules flowing toward our surface of interest is the same for any similar plane, no matter what its location within our system, or its orientation within the system, or the time of measurement.

Free Paths of Interactive Molecules: This is helped by the fact that virtually all atmospheric molecular paths originate within four mean free paths of the surface of interest. At NTP and with a mean molecular radius of 1.9 x 10^{10} meters, the mean free path is on the order of a mere 1.29 x 10^{-7} meters. This is a very short distance, indeed. You should not imagine that the molecules passing through a plane or impacting upon a surface have traveled any great distance to do so. They have not. In fact, because this is a mean number, half of the molecules will have traveled even shorter distances.

The Imaginary Tunnel: Now, let us postulate an indefinite number of identical planes, parallel to our surface of interest. The central points in each plane are connected by a straight line. Finally, each plane is spaced exactly one meter from each of the two adjoining planes. What we now have is a long tunnel, composed of individual cells of one cubic meter in volume. The most probable number of molecules in each cell is $\bar{n}$.

As far as our tunnel is concerned, each plane connected by our center line has the same number of molecules moving toward it in the ***p*** direction as are moving away from it in the ***-p*** direction. Let us concentrate on only one direction, the ***p*** direction.

A moment's thought will show us that we can consider our tunnel as having a steady stream of molecules passing through it and passing through each of our imaginary parallel planes. The mean proximity speed of the total number of molecules in the tunnel is $\bar{v}_p$. Our surface of interest is one of these planes.

The Universal Molecular Flux – Keeping our tunnel image in mind, this means that the **number** passing through any of our surface of interest in one second is,

$$\bar{f}_i = \bar{n}_p \bar{v}_p \qquad \text{FLW02}$$

This is the *universal molecular flux*. It has the dimensions of number per square meter per second ($NL^{-2}T^{-1}$). The flux $\bar{f}_i$ bears the ***i***-subscript because the molecules are involved in an interaction, passage through a plane. Keep in mind that this is solely the mean **number** of passages, not the mean speed of passage. As we saw in Molecular Speeds, that mean speed of passage is $\bar{v}_i$.

Equation FLW02 is a universal equation. As we shall see in other essays, it applies to ideal gases and to real gases, under conditions of equilibrium and under non-equilibrium conditions, when the air is still and when the air is moving. It applies to stationary bodies and to moving bodies. It even applies to the total flux upon a moving body in moving air.

Molecular Flows in Moving Air: When the wind blows, the values of many atmospheric parameters change significantly. These changes will be functions of the wind speed and the wind direction relative to the surface of interest. Phenomena related to fluid flows are discussed in advanced papers in this collection.

Still Air Parameters: The essay Still Air Parameters gives the following values for still air with no net evaporation or condensation. The system temperature is 25° C, and the system pressure is 1,000 hectopascals.

$\bar{f}_i^e$ = 2.8449 x 10^{27} interactions per square meter per second

$\underset{\sim}{\bar{f}}_i^e$ = 3.5951 x 10^{25} interactions per square meter per second

$\underset{\cdot}{\bar{f}}_i^e$ = 2.8111 x 10^{25} interactions per square meter per second

REFERENCES

Internal References: References to other essays in this collection are linked in the essay text by hyperlinks. You may follow these hyperlinks or ignore them, as you choose.

External References: These are papers by other authors that contain statements or data that are specifically incorporated into this essay. This paper has no external references.

General References: These are works that I have read carefully and whose views have helped to shape the views presented in this collection. None of these authors are have any responsibility for my many unconventional views and opinions.

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