Van der Waals forces' is a general term used to define the attraction of intermolecular forces between molecules. There are two kinds of Van der Waals forces: weak London Dispersion Forces and stronger dipole-dipole forces.

Introduction

The chance that an electron of an atom is in a certain area in the electron cloud at a specific time is called the "electron charge density." Since there is no way of knowing exactly where the electron is located and since they do not all stay in the same area 100 percent of the time, if the electrons all go to the same area at once, a dipole is formed momentarily. Even if a molecule is nonpolar, this displacement of electrons causes a nonpolar molecule to become polar for a moment.

Since the molecule is polar, this means that all the electrons are concentrated at one end and the molecule is partially negatively charged on that end. This negative end makes the surrounding molecules have an instantaneous dipole also, attracting the surrounding molecules' positive ends. This process is known as the London Dispersion Force of attraction.

The ability of a molecule to become polar and displace its electrons is known as the molecule's "polarizability." The more electrons a molecule contains, the higher its ability to become polar. Polarizability increases in the periodic table from the top of a group to the bottom and from right to left within periods. This is because the higher the molecular mass, the more electrons an atom has. With more electrons, the outer electrons are easily displaced because the inner electrons shield the nucleus' positive charge from the outer electrons which would normally keep them close to the nucleus.

When the molecules become polar, the melting and boiling points are raised because it takes more heat and energy to break these bonds. Therefore, the greater the mass, the more electrons present, and the more electrons present, the higher the melting and boiling points of these substances.

London dispersion forces are stronger in those molecules that are not compact, but long chains of elements. This is because it is easier to displace the electrons because the forces of attraction between the electrons and protons in the nucleus are weaker. The more readily displacement of electrons means the molecule is also more "polarizable."

Dipole-Dipole Forces

These forces are similar to London Dispersion forces, but they occur in molecules that are permanently polar versus momentarily polar. In this type of intermolecular interaction, a polar molecule such as water or H$_2$O attracts the positive end of another polar molecule with its negative end of its dipole. The attraction between these two molecules is the dipole-dipole force.

Van der Waals Equation

Van der Waals equation is required for special cases, such as non-ideal (real) gases, which is used to calculate an actual value. The equation consists of:

\[
(P + \frac{n^2a}{V^2})(V - nb) = nRT \tag{1}
\]
The V in the formula refers to the volume of gas, in moles n. The intermolecular forces of attraction is incorporated into the equation with the \( \frac{n^2a}{V^2} \) term where a is a specific value of a particular gas. P represents the pressure measured, which is expected to be lower than in usual cases. The variable b expresses the eliminated volume per mole, which accounts for the volume of gas molecules and is also a value of a particular gas. R is a known constant, 0.08206 L atm mol\(^{-1}\) K\(^{-1}\), and T stands for temperature.

Unlike most equations used for the calculation of real, or ideal, gases, van der Waals equation takes into account, and corrects for, the volume of participating molecules and the intermolecular forces of attraction.

References


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