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12 - Van der Waals forces

The Power of Polarity: Decoding Electrostatic Interactions

Video 12 - Transcript

Hi everyone, welcome to video number 12. Today we are going to be continuing our discussion of intermolecular forces, of attraction, which occur between and amongst molecules. Today we're going to be looking at Van der Waals forces. Now there are three main types of Van der Waals forces and these are listed here: We have ion-dipole interactions, dipole-dipole interactions, and instantaneous dipole induced-dipole forces, otherwise known as London dispersion forces. Now these are all electrostatic in nature. Although these intermolecular forces are relatively weak compared to intramolecular bonds, they collectively play a major role in determining the physical properties of substances, especially organic compounds. Now, van der Waals forces are caused by correlations in the fluctuating polarizations of nearby particles, which is due to the dynamic nature of atomic and molecular orbitals. The electrons in orbitals are not stagnant, but rather they're constantly moving in their defined space with opposite spins to one another because they're both negatively charged and negative charges repel. Let's take each of these in turn and look at the conditions under which each of these types of Van der Waals forces will develop. First of all, let's look at ion-dipole interactions. These are an important force in solutions of ions. For example, when we have an ionic substance - Let's take NaCl, for example. When NaCl dissolves in a polar solvent, such as water, ion- dipole interactions come into play. We have an interaction between a charged ion. Here I've shown you for example, this can be Na+, the interaction between the charged ion and the polar molecule. We have cations being attracted to the negative portions of our polar molecule, vice versa, of course - we can have the Cl- component of our ionic compound being attracted to the positive ends of our polar molecule. Now, a dipole - dipole interaction is going to occur between neutral polar molecules. The polar molecules attract one another, when the partial positive charge on one molecule is near to the partial negative charge on another molecule. The polar molecules must be in close proximity to each other for the dipole - dipole forces to be significant. Now, dipole-dipole forces are characteristically weaker than ion-dipole forces, and they tend to increase with an increase in the polarity of the molecule. The more polar the molecule, the higher is its boiling point. Note that polarity simply refers to a separation of negative and positive charges in a molecule due to the differences in electronegativity of the atoms or the groups of atoms. If you recall, electronegativity is the ability of a species to draw negative charge towards itself. Finally, let's look at London dispersion forces. Now one might think that non polar molecules would not seem to have any basis for attractive interactions. However, in non polar substances such as helium and iodine, the motion of electrons within these molecules results in what we call a transient, which just means temporary - a transient dipole moment. As we said before, due to the particulate nature of electrons, it is usual for the average distribution of electrons around each nucleus in a non-polar bond to be spherically symmetrical. The atoms are non-polar and possess no dipole moments - the distribution of electrons around an individual atom at any given instant in time may not be perfectly symmetrical. Both electrons may be on one side of the nucleus, causing the atom to have an apparent dipole moment at that instant in time, which is called a transient dipole moment. In that case, we can have a slightly positive charge being present on one atom of the molecule at any given time, which allows the other atom of the molecule to develop a slightly negative charge. What would happen is, if this iodine molecule comes into contact with another iodine molecule, we can then induce this separation of charge. So due to electron repulsion, a temporary dipole on one atom can induce a similar dipole on a neighboring atom. This will cause the neighboring atoms to be attracted to one another, and it is significant, again, just like with dipole - dipole interactions, when the atoms are close together. London dispersion forces are present in all molecules, whether they are polar or non-polar. The tendency of an electron cloud to distort in this way is called polarizability. The strength of dispersion forces tend to increase with increasing molecular weight. Larger atoms have larger electron clouds, which are easier to polarize. Generally speaking, the larger a molecule, the bigger the molecular weight of the molecule, the higher the magnitude and amount of London dispersion forces will be observed. In closing, we can say that intermolecular forces of attraction, which include hydrogen bonding, which we covered previously, and our various Van der Walls forces of attraction are responsible for the properties of molecules or substances such as viscosity, surface tension, melting and boiling points, solubility and volatility. That's all for now. I'll see you in the next video.