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|  | **Question** http://www.physlink.com/Images/graypix.gif Could you explain van der Waals' forces to me, and their role in why energy is needed to vaporize water? http://www.physlink.com/Images/graypix.gif   **Answer** http://www.physlink.com/Images/graypix.gif It is important to remember that van der Waals' forces are forces that exist between MOLECULES of the same substance. They are quite different from the forces that make up the molecule. For example, a water molecule is made up of hydrogen and oxygen, which are bonded together by the sharing of electrons. These electrostatic forces that keep a molecule intact are existent in covalent and ionic bonding but they are NOT van der Waals' forces.   The van der Waals' forces are the forces that exist between the millions of separate water molecules, and not between the hydrogen and oxygen atoms in the case of water.   **Dipole-Dipole forces** are one of van der Waals' three forces. Dipole Dipole forces occur in polar molecules, that is, molecules that have an unequal sharing of electrons. For example, HCl comprised of the atom Hydrogen and Chlorine is polar. The Chlorine atom has an extra electron, which came from the hydrogen atom. Because of this, the chlorine part of the molecule is negatively charged, and the hydrogen side of the molecule is positively charged.  ie. H - Cl     +    -   So in a solution where there are thousands of these molecules around that are slightly charged on each side, the molecules naturally orient themselves the accommodate the charge. The positive part of one molecule will move until it is next to the negative part of a neighboring molecule. These forces between molecules tend to make them 'stick' together.   **Dispersion forces** are another of van der Waals' three forces. They exist between nonpolar molecules. For example, chlorine gas is made up of two chlorine atoms. In this bond, the electrons are equally shared and are not dominant on one side of the molecule as is the case in HCl. The atom looks like this   Cl - Cl   no overall charge on either side but, it is important to remember that within a bond, electrons are constantly MOVING. They zoom around the atoms really quickly. As a result, there may be a tiny instant in time where the electrons happen to be dominant on one side, creating a situation like this,   Cl - Cl +    -   However, this temporary charge disappears as quickly as it appeared because the electrons are moving so fast. These temporary dipoles allow the temporarily negative side of one molecule to attract the temporarily positive side of another molecule, which is the intermolecular force.   **Hydrogen bonding** is the third type of van der Waals' forces. It is exactly the same as dipole-dipole interaction, it just gets a special name. A hydrogen bond is a dipole dipole interaction that occurs between any molecule with a bond between a hydrogen atom and any of oxygen/fluorine/nitrogen. So, Hydrogen Fluoride (HF), Water (H2O), ammonia (NH3)....any kind of substance that has a hydrogen bonded to either an oxygen, fluorine or nitrogen atom, exhibits hydrogen bonding. The hydrogen bond is just the dipole dipole force but it is extremely strong compared to either dipole dipole forces like HCl. It is extremely strong because F N and O are extremely good at attracting electrons and H is extremely good at losing them. So basically, the bond is EXTREMELY a one-sided affair, resulting in an extreme dipole situation, thus named, a hydrogen bond. The extremely positive side of the molecule will orient itself with the extremely negative side of another molecule.   The van der Waals' forces are very weak. I said the hydrogen bond is extremely strong, but that is only compared to the other van der Waals' forces. Compared to say, a covalent bond, a hydrogen bond is approximately one tenth of that strength. The dipole-dipole bond is weaker still, and the dispersion forces are the weakest of Van De Waals' forces. That is demonstrated in the fact that, take for example, Cl2. Chlorine gas exhibits dispersion forces, the weakest of van der Waals' forces. Cl2 is a GASEOUS compound, because the dispersion forces are not strong enough to pull the molecules together as a solid. The dispersion forces can only suffice to keep the substance as a gas, because the forces between molecules are so weak that they can float about all over the place and exist as a gas.   Now that we know what van der Waals' forces are we move on to the second part of the question.   When you vaporize water, you need to turn it from a liquid to a gas. To do this, you need to overcome the forces between the molecules, to allow them to float about freely by themselves. You supply the substance with energy in the form of heat. The heat makes the molecules vibrate. If the vibrations are strong enough, the molecules break free of the van der Waals' forces that hold them together. In the case of water, these forces are hydrogen bonding. So you supply the system with enough energy, and it is able to overcome the forces between the molecules.   This accounts for the fact that water has an unusually high boiling point. Because hydrogen bonds are stronger than the other van der Waals' forces, then water will take more energy to overcome these bonds than say, HCl as a liquid- which would need sufficiently less because it has weaker bonds between molecules to overcome.   So, in a sentence, the role of energy in vaporizing water is that is needed to overcome the van der Waals' forces at work between the molecules. |