The Snowflake

A hundred years ago little was known about a snowflake. Today we can describe it in considerable detail. It is a crystalline solid with definite molecular arrangements; over 2 dozen patterns exist. I will describe only one, the hexagonal pattern and what makes it so. It is aesthetically pleasing and the one most illustrated by artists.

The snowflake usually begins in air as water vapor (gaseous H_2O) which cools (condenses) to water (liquid H_2O) and finally freezes to snow (solid H_2O). Thus, a knowledge of the H_2O molecule is essential.

We begin, of course, with hydrogen (H), the simplest element and atom, with a nucleus of one proton (+) and one orbiting electron (-). We add oxygen (O) whose atom is a little more complex having a nucleus of 8 protons and 8 neutrons with 8 orbiting electrons. Two H atoms join (bond) with one O atom to form an H_2O molecule. This occurs in a unique way with an angle of 104° between the H atoms bonded to the O atom. The result is a molecule which is shaped like a boomerang.

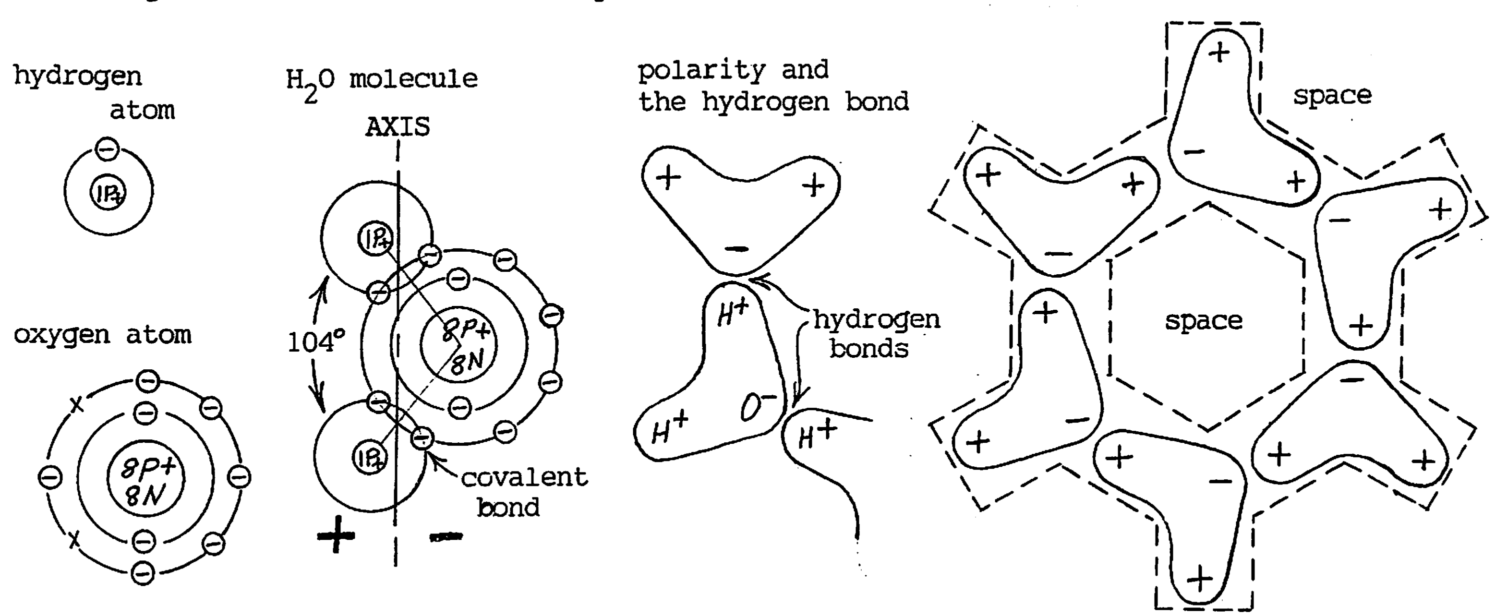
When a H atom bonds to an O atom, it shares its one electron with O which in turn shares one of its 8 electrons with H; it is called a <u>covalent</u> (sharing) bond. Of course, an H_2O molecule with two H atoms has two covalent bonds. However, the sharing of the electrons between H and O is not equal. The larger O nucleus with its 8 protons electrically dominates the 1 proton of H. The result is the O atom attracts H's electron(s) and becomes slightly negative while the "denuded" H's are left slightly positive. When combined with the unique 104° angle, this imbalance of electrical charge creates <u>polarity</u>. The H_2O molecular is a <u>polar</u> molecule that has a distinct positive and negative side along an axis. This polarity is the key to the expansion of water when it freezes and the formation of the hexagonal pattern of a snowflake.

In liquid form, the H_2O molecules can move freely while contracting until the temp. is lowered to 39° F. At this point, the polarity's electrical forces kick in, and the simple electrical rules of like charges repel and unlike charges attract dictate what takes place. The molecules begin to fall into a distinct pattern of <u>hydrogen bonds</u>. The pattern increases the <u>spacing</u> between the H_2O molecules; thus, we have the well-known expansion that occurs when water freezes. In air, this process creates the snowflake.

In its simplest form, the hexagonal pattern of a few molecules would be invisible. However, it is a "seed" that other molecules attach (bond) to and thus "grows" in size until, millions of molecules later, it becomes visible. This, of course, is what all crystals do, like salt, quartz, rubies, ice, etc. They start as a "seed" and "grow" (add layers of molecules).

The hydrogen bond between the molecules in the pattern is one of the strongest in nature and why ice's expansion can break open so many "strong" objects like rock, water-cooled motor blocks, water pipes, etc.

Obviously, there is a lot of good science in the study of the H_2O molecule and its place in the snowflake. My story is simplified, of course, but it's a start, a plausible scenario. With effort (rereading), you can learn it. The snowflake is another one of nature's most beautiful gifts, even if it's not always welcome.



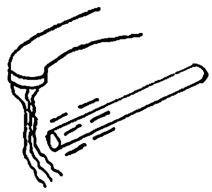
Addendum: The H_2O molecule is electrically neutral with its equal number (10) of protons (+) and electrons (-). However, it takes on an electrical (charged) nature because of the unequal distribution of the 10 electrons, the polarity that results. Fortunately, several simple demonstrations can be performed to show water's polarity, that it has these distinct positive and negative sides, and that the molecule can rotate.

(a) Using a thin stream of water (from a tap?), bring a charged rod, + or –, near it. The stream will always be attracted (deflected) toward the rod. The water molecules will rotate so the unlike charges can attract.

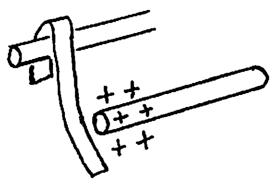
(b) Using a narrow strip of paper, folded and hanging down, bring a charged rod, + or –, near it. Again, the strip will be attracted to the rod. Paper always retains moisture (water vapor); the polarity is always present.

(c) On a much larger scale, a pine stick, 2' long, suspended and balanced on a nylon thread, can easily be deflected by a charged rod, + or –, placed near one of its ends. Once again, wood always retains some moisture which makes the stick "polar".

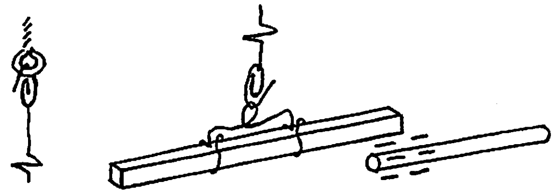
(a)



(b)



(c)

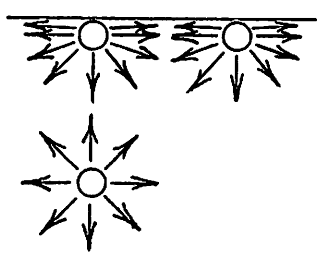


The hydrogen bond also exists between H_2O molecules in the liquid state (water) but is much weaker than in the solid state (ice). It shows up best in surface tension, usually the boundary between water and air. The water molecules exhibit a "pulling together," a "film" effect, a strengthen barrier. This effect is due to a redistribution of forces between the molecules at the surface compared to those beneath the surface. See (d). Surface tension demonstrations are many; here are two of the most popular.

(e) Carefully "float" steel needles on water via surface tension. Also, show that point down a steel needle will go straight to the bottom of the container.

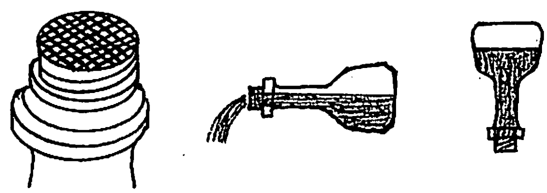
(f) Epoxy a piece of window screening on the top of a medium-sized (qt. or l.) bottle. Fill the bottle under a water tap. Start by pouring water from the tipped bottle. Then suddenly turn the bottle totally upside down; the stream ceases. An air pressure gradient has developed, but the hydrogen bond (surface tension) is now strong enough to seal off the screened opening. If you rub (disturb) the screening (break the surface tension), some water will briefly escape. However, the surface tension quickly restores itself, and the stream ceases.

(d)



(e)

(f)



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