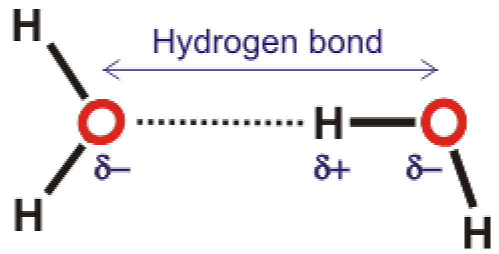
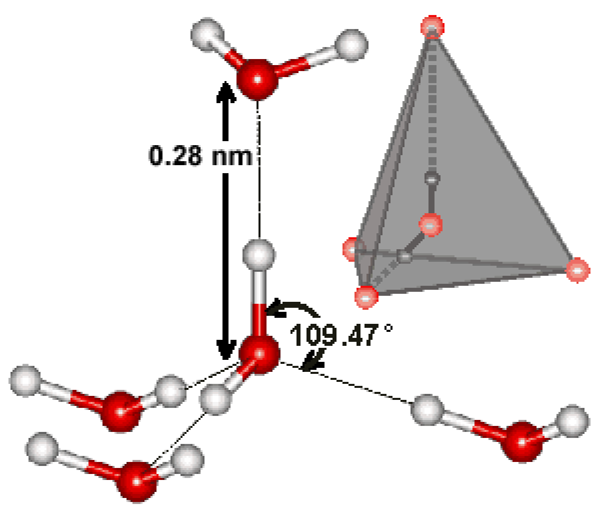
Hydrogen bonding in water: Introduction

Hydrogen bonding forms in liquid water as the hydrogen atoms of one water molecule are attracted towards the oxygen atom of a neighboring water molecule.



In a water molecule (H_2O), the oxygen nucleus with +8 charges attracts electrons better than the hydrogen nucleus with its +1 charge. Hence, the oxygen atom is partially negatively charged and the hydrogen atom is partially positively charged. The hydrogen atoms are not only covalently attached to their oxygen atoms but also attracted towards other nearby oxygen atoms. This attraction is the basis of the 'hydrogen' bonds.

The water hydrogen bond is a weak bond, never stronger than about a twentieth of the strength of the O-H covalent bond. It is strong enough, however, to be maintained during thermal fluctuations at, and below, ambient temperatures. The attraction of the O-H bonding electrons towards the oxygen atom leaves a deficiency on the far side of the hydrogen atom relative to the oxygen atom. The result is that the attractive force between the O-H hydrogen and the O-atom of a nearby water molecule is strongest when the three atoms are in a straight line (that is, O-H····O) and when the O-atoms are separated by about 0.28 nm.



Each water molecule can form two hydrogen bonds involving their hydrogen atoms plus two further hydrogen bonds utilizing the hydrogen atoms attached to neighboring water molecules. These four hydrogen bonds optimally arrange themselves tetrahedrally around each water molecule as found in ordinary ice. In liquid water, thermal energy bends and stretches and sometimes breaks these hydrogen bonds. However, the 'average' structure of a water molecule is similar to this tetrahedral arrangement. The diagram opposite shows such a typical 'average' cluster of five water molecules. In ice this tetrahedral clustering is extensive, producing its crystalline form. In liquid water, the tetrahedral clustering is only locally found and reduces with increasing temperature. However, hydrogen bonded chains still connect liquid water molecules separated by large distances.

There is a balance between the strength of the hydrogen bonds and the linearity that strong hydrogen bonds impose on the local structure. The stronger the bonds, the more ordered and static is the resultant structure. The energetic cost of the disorder is proportional to the temperature, being smaller at lower temperatures. This is why the structure of liquid water is more ordered at low temperatures. This increase in orderliness in water as the temperature is lowered is far greater than in other liquids, due to the strength and preferred direction of the hydrogen bonds, and is the primary reason for water's rather unusual properties.

Source:http://www1.lsbu.ac.uk/water/hbond-easy.html