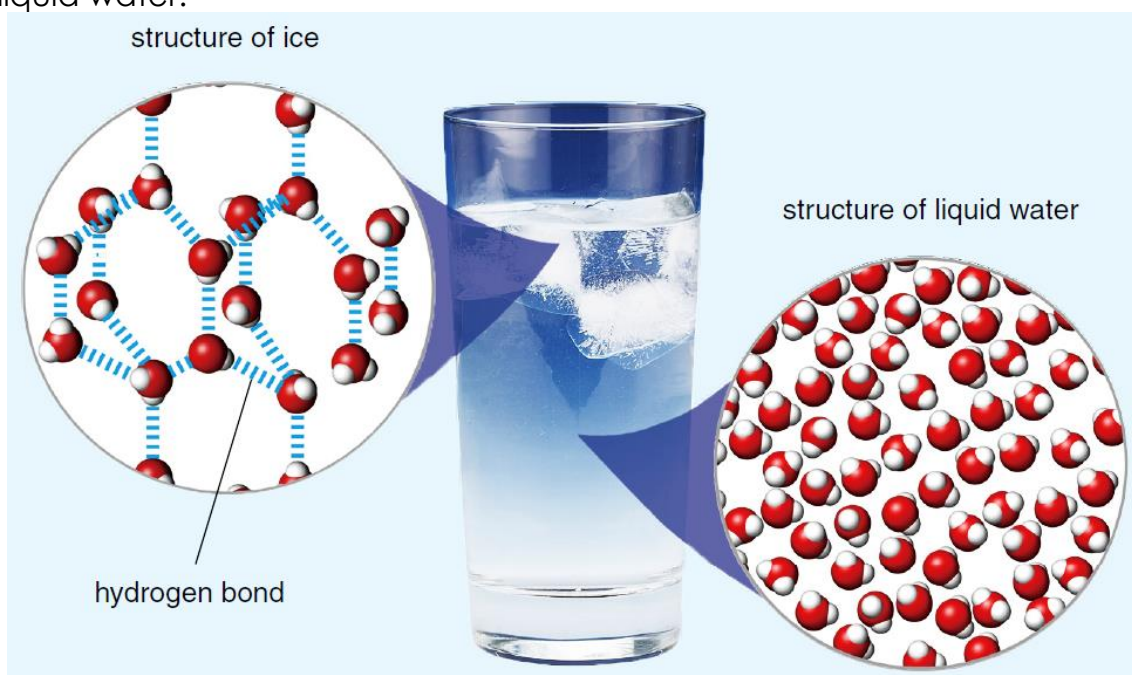


Quiz (Structure of Ice)

- With the aid of a diagram, describe briefly the arrangement of water molecules in ice.
 - Explain, in terms of structure and bonding, why ice is less dense than liquid water.
- The following diagram shows the arrangement of water molecules in ice and liquid water.



Answer the following questions.

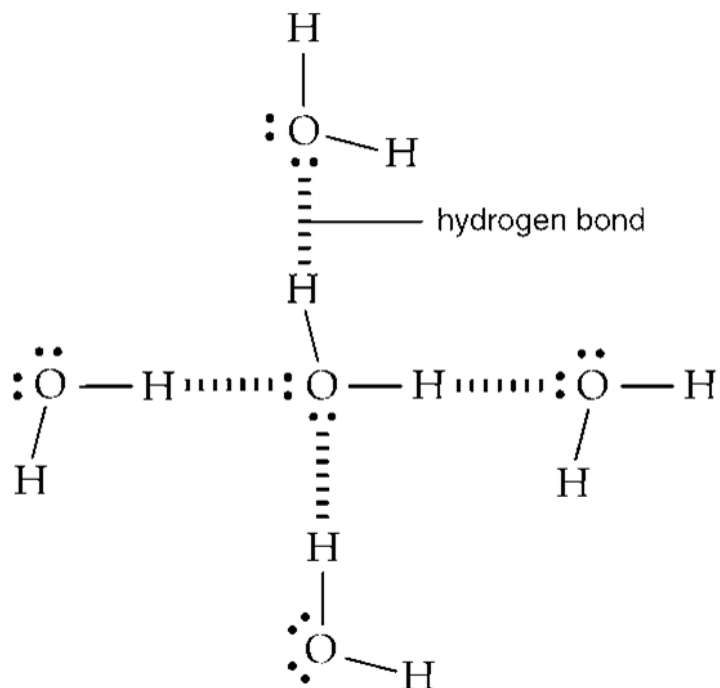
- Which substance, ice or liquid water, has a higher density?
 - Why are the molecules arranged regularly in the structure of ice?
 - During the melting of ice, energy is absorbed. What is the energy used for?
 - Explain why more energy is required to boil liquid water than to melt ice of the same amount.
- In an X-ray study of ice crystals, it was found that the oxygen atoms of water molecules are arranged in a hexagonal shape. Besides, there are two different bond distances, a and b , between the oxygen atom and the hydrogen atom in the crystal structure, where a is shorter than b .

 - Draw a diagram to show the arrangement of six water molecules in ice. In your diagram, label any one bond with bond distance a and one bond with bond distance b .
 - Explain why bond distance a is shorter than bond distance b .
 - Are all bonds with bond distances a and b broken when ice melts? Explain your answer.

4. Ice is a naturally occurring crystalline solid and it is also considered to be a mineral consisting of hydrogen and oxygen. The unusual property of ice makes it possible as a natural barrier for aquatic life.
- (a) Give an unusual property of ice that makes it work as a natural barrier for aquatic life.
 - (b) Explain why ice has the property you mentioned in (a).
 - (c) Describe the way that ice protects aquatic life.

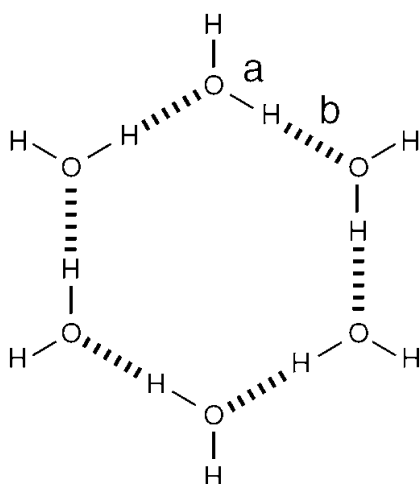
Suggested Answer

1. (a) Each H_2O molecule is tetrahedrally surrounded by four neighbouring H_2O molecules and they are held together by hydrogen bonds.



- (b) The water molecules in ice are arranged tetrahedrally to form an open structure. When ice melts, this open structure collapses and the water molecules pack more closely together. Therefore, ice is less dense than liquid water.
2. (a) Liquid water
- (b) The regular network structure of ice allows the formation of maximum number of hydrogen bonds (four for each water molecule).
- (c) To overcome a certain amount of hydrogen bonds and separate the water molecules.
- (d) During boiling, all hydrogen bonds have to be broken before the water molecules can escape as steam.

3. (a)



(b) Bond distance a corresponds to the distance of the covalent bond formed between the H atom and the O atom. Bond distance b corresponds to the distance of the hydrogen bond formed between the H atom of a water molecule and the O atom of its neighbouring molecule. As covalent bond is stronger than hydrogen bond, bond distance a is shorter than bond distance b .

(c) No. Only some bonds with bond distances b are broken because only some intermolecular forces between water molecules have to be overcome when ice melts.

4. (a) Ice has a lower density than liquid water.

(b) Water molecules in ice are held together mainly by hydrogen bonds. In ice, each water molecule is tetrahedrally arranged, resulting in an open structure.

(c) Ice floats on water. This prevents heat loss from water and helps maintain the water temperature.