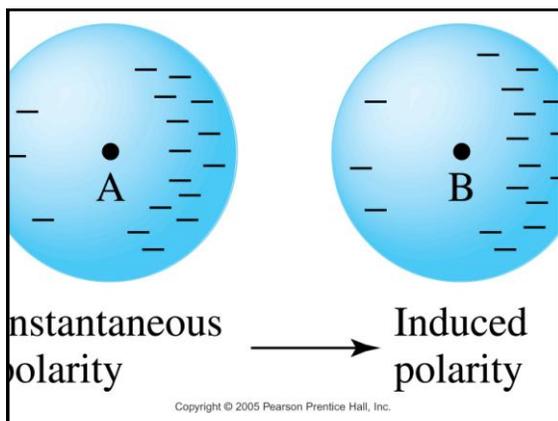


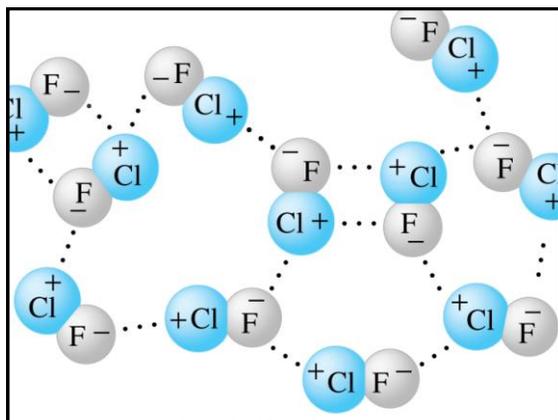
12.6 Intermolecular forces (IMF) in liquids

1. London
2. Dipole
3. Hydrogen bonding

London attractions



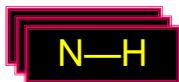
Dipole-Dipole attractions



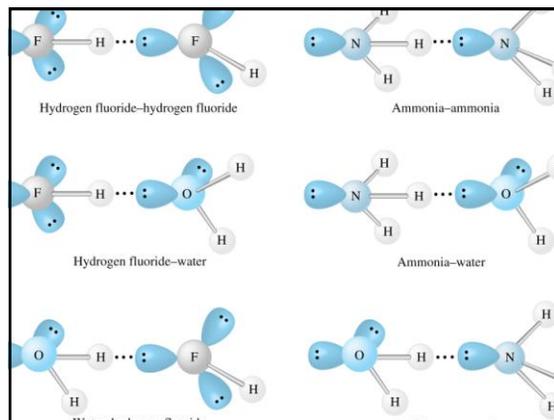
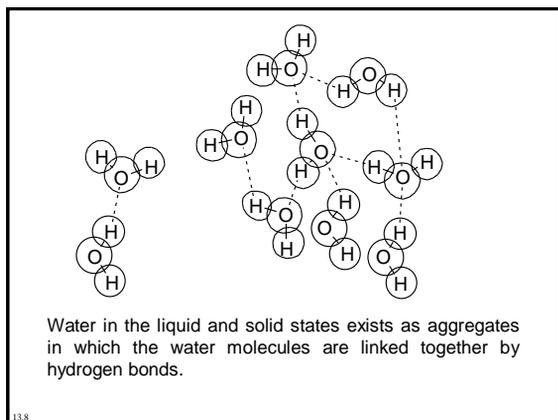
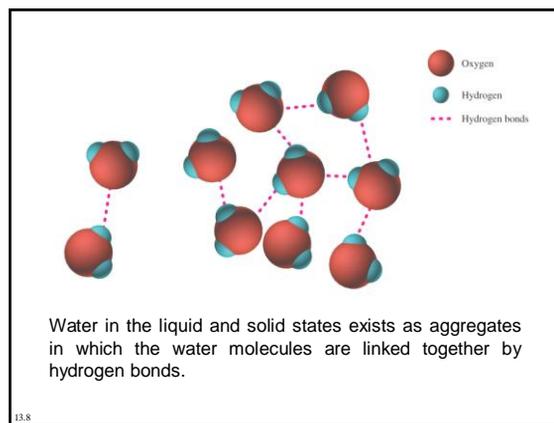
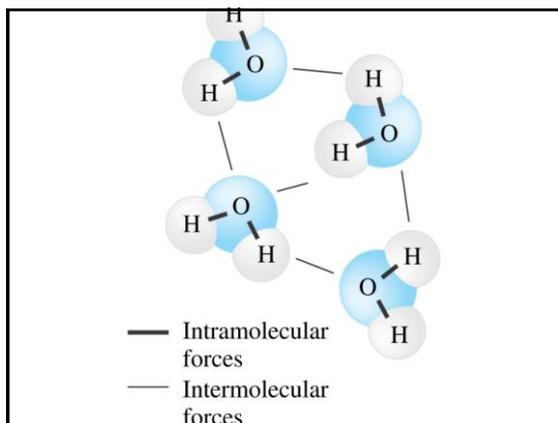
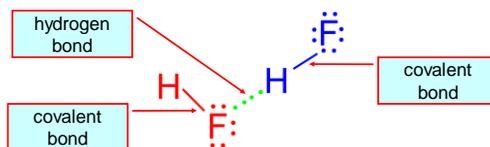
The Hydrogen Bond

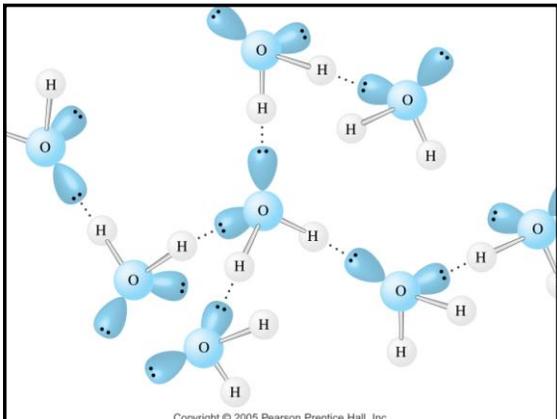


- A hydrogen bond is an **intermolecular** bond.
- A hydrogen bond is formed between polar molecules that contain hydrogen covalently bonded to a small, highly electronegative atom: **F, O, N**.

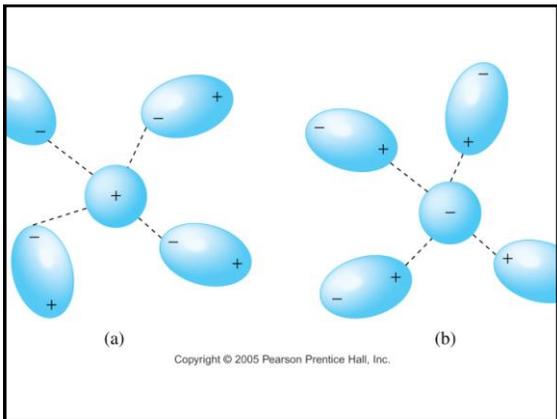


- When hydrogen is attached to one of the small electronegative atoms: **F, O, or N** it will be attracted to another **F, O, or N** on another molecule.
- A dipole-dipole bond will be formed between the two molecules which is called a **hydrogen bond**.

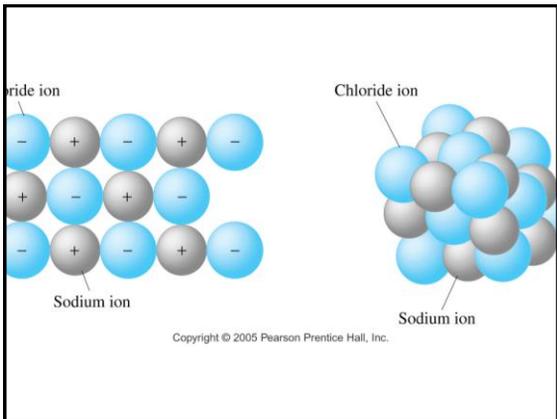




Ion-dipole attractions



Ion-Ion attractions



12.8 Water: An Unusual Molecule



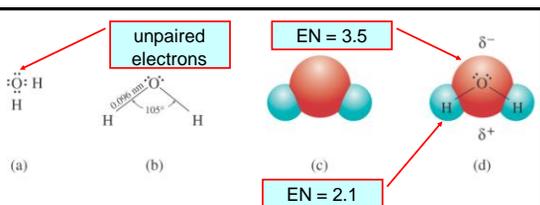
Occurrence of Water



- Water covers about 75% of the earth's surface.
- About 97% of the earth's water is in the oceans.
- About 3% of the earth's water is in the fresh water and two-thirds of this is locked up in polar ice caps and glaciers.

- 70 elements have been detected in seawater.
 - Chlorine, sodium, magnesium and bromine are commercially extracted from sea water.
- Water constitutes about 70% of human body mass.
 - 92% of blood plasma is water.
 - 80% of muscle tissue is water.
 - 60% of a red blood cell is water.

Structure of the Water Molecule



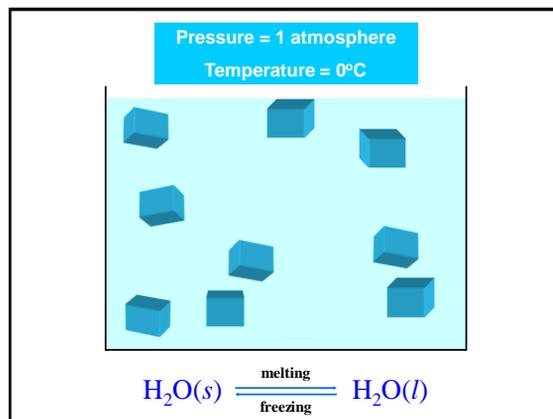
- (a) Lewis structure of water showing electron distribution.
- (b) Bond angle and bond length.
- (c) Molecular orbital structure.
- (d) Dipole representation.

13.7

Physical Properties of Water



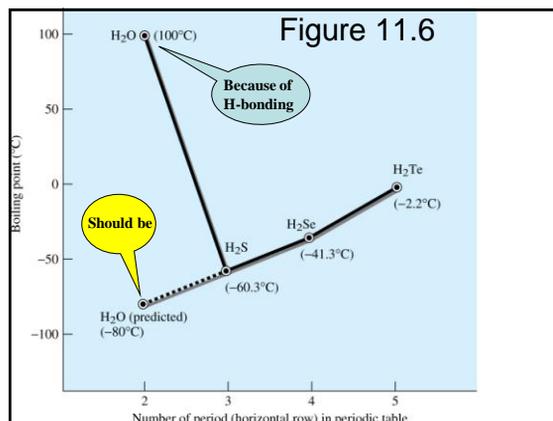
Ice and water exist together in equilibrium at 0°C.



The melting point, boiling point, and heat of vaporization of water are unusual trends of properties for Group VIA. Water has the lowest melting point, the highest boiling point, and the highest heat of vaporization in the group.

Table 13.3 Physical Properties of Water and Other Hydrogen Compounds of Group VIA Elements

Formula	Color	Molar mass (g/mol)	Melting point (°C)	Boiling point, 1 atm (°C)	Heat of fusion J/g (cal/g)	Heat of vaporization J/g (cal/g)
H ₂ O	Colorless	18.02	0.00	100.0	333 (80.0)	2.26 × 10 ³ (540)
H ₂ S	Colorless	34.09	-85.5	-60.3	69.9 (16.7)	548 (131)
H ₂ Se	Colorless	80.98	-65.7	-41.3	31 (7.4)	238 (57.0)
H ₂ Te	Colorless	129.6	-49	-2	—	179 (42.8)



Water exhibits these unusual properties because of hydrogen bonding between water molecules.

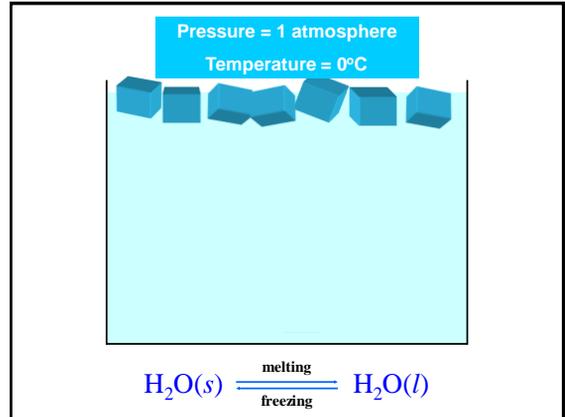
Density of Water

When liquids change to solids:

1. Most liquids contract (get smaller) as they are cooled.
2. They get more dense.
3. When they change to solid, they are more dense than the liquid.

Solid metals sink in liquid metal.

- But, ice floats in water.
- Why?



- The density of water reaches a maximum at 4°C.
- When it is cooled from 4°C to 0°C it expands in volume and decreases in density
- It's volume expands by 9%. The density of ice at 0°C is less than the density of water at 0°C.

Ice

- As the molecules slow down, they arrange themselves into honeycomb shaped crystals to maximize hydrogen bonding.
- The molecules have to spread out, so the density of solid water decreases relative to liquid water.
- This is why ice floats in water.

