Water, water, everywhere

"Water, water, every where,

And all the boards did shrink;

Water, water, every where,

Nor any drop to drink."

The Rime of the Ancient Mariner
Samuel Taylor Coleridge

Earth: the Blue Planet

Unique properties of water

- Ice (solid water) is less dense than liquid water
- usually high boiling and freezing point
- High heat of vaporization
- high specific heat capacity
- high surface tension
- water is a universal solvent

Life as we know it would not exist without water

<u>If ice were denser than liquid water</u>, what would happen to a pond when it is below freezing in winter?

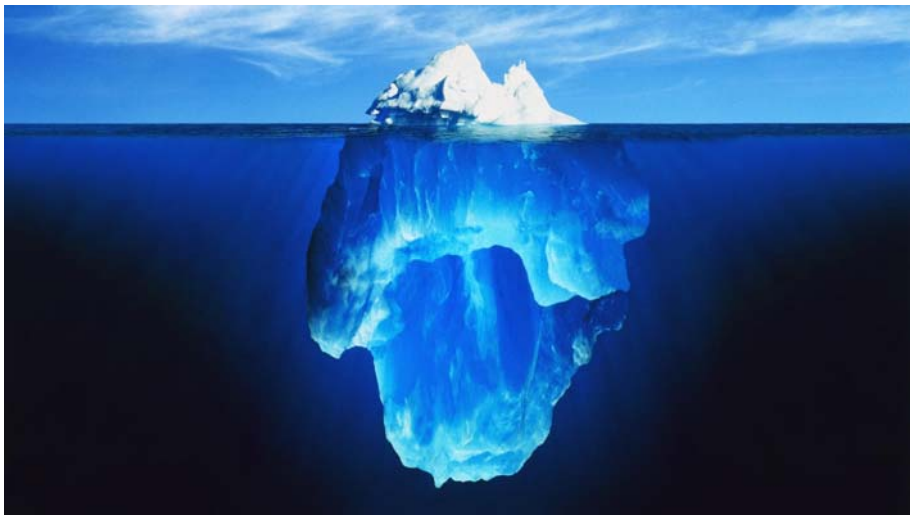
A. The top of the pond will be frozen solid but not the bottom.

B. The bottom of the pond will be frozen solid but not the top.

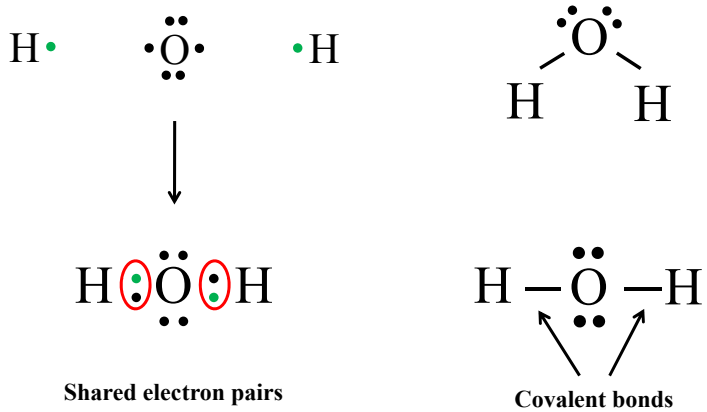
C. The whole pond will be frozen solid.

D. The pond will not freeze at all.

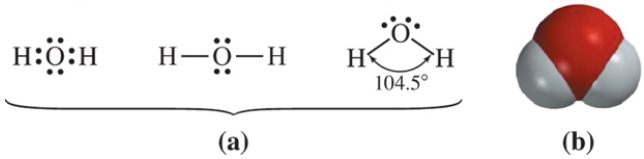
Iceberg

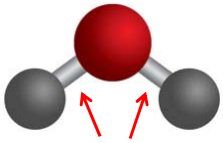


Bonds in Water Molecule



Water Molecule





Covalent bonds

In water molecules, electrons are <u>NOT shared equally</u> between O and H atoms. So the bond between O and H is a _____

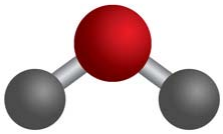
A. nonpolar covalent bond

B. polar covalent bond

C. ionic bond

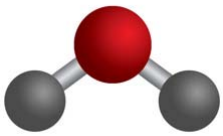
D. hydrogen bond

As a result of the polar covalent bonds,

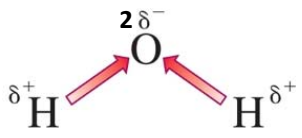


A. O atom has a slightly negative charge; H atoms have a slightly positive charge.
B. O atom has a slightly positive charge; H atoms have a slightly negative charge.
C. Both O atom and H atoms have a slightly negative charge.
D. Both O atom and H atoms have a slightly positive charge.

As a result of the polar covalent bonds,

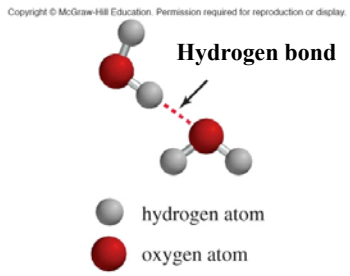


A. A water molecule has a net positive charge.
B. A water molecule has a net negative charge.
C. A water molecule is neutral overall.



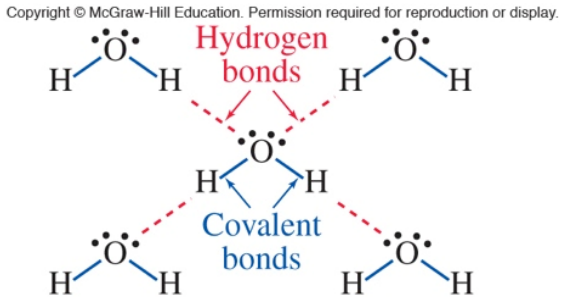
- **Partial negative charge on the O atom**
- **Partial positive charge on the H atoms**
- **Overall, the water molecule is neutral.**

Hydrogen Bond



- A **hydrogen bond** is between a **H atom in one molecule** and an **O, N, or F atom in a neighboring molecule**.
- A **hydrogen bond** is an electrostatic attraction between
  - H atom (partial positive charge, δ^+) and
  - O, N or F atom (partial negative charge, δ^-).
- A **hydrogen bond** is a force between molecules, or an *inter*molecular force.

Hydrogen bond *Vs.* Covalent bond



- **Hydrogen bonds are bonds <u>between neighboring molecules</u>.**
- **Covalent bonds are bonds between atoms <u>within the same molecule</u>.**
- **A hydrogen bond is only about 1/15 as strong as a covalent bond.**

Hydrogen bonds exist between

I. molecules in the solid state

II. molecules in the liquid state

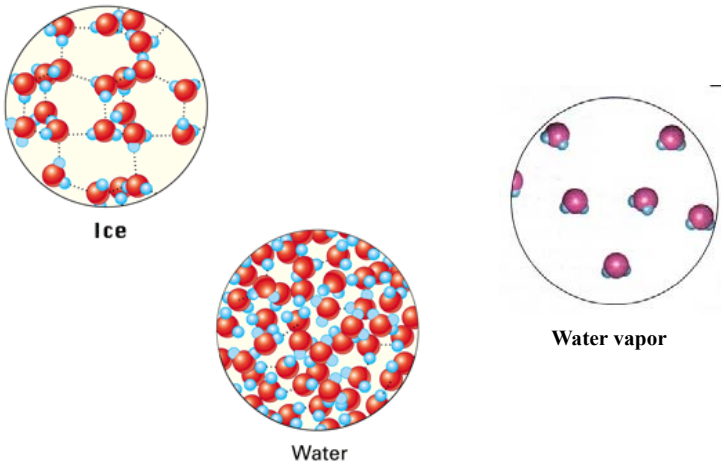
III. molecules in the gas state

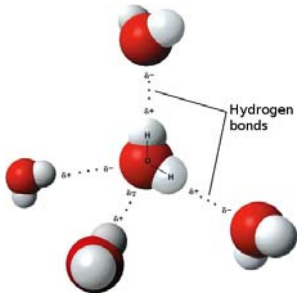
A. I only

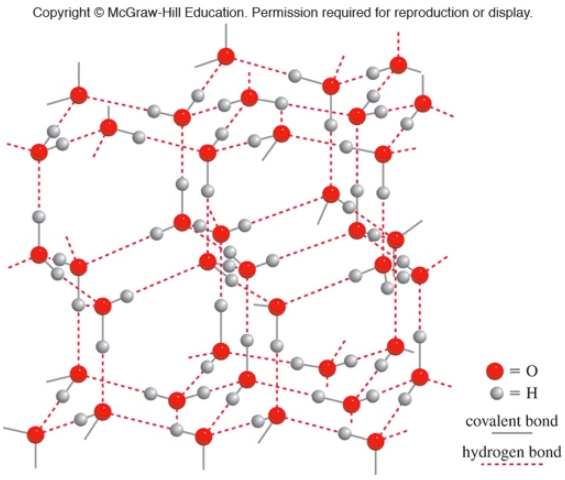
B. II only

C. I and II only

D. I, II and III


Ice
Water
Water vapor


Hydrogen bonds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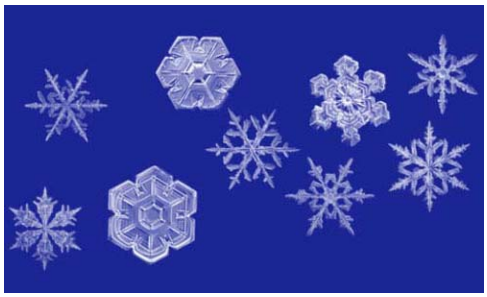
= O
= H
covalent bond
hydrogen bond

Snowflakes



"The Science of Snowflakes, and Why No Two Are Alike."

Substance	Molecular weight (amu)	Boiling point
CO_2	44	−78.5 °C
O_2	32	−183°C
N_2	28	−195.8 °C
H_2O	18	

If the trend observed in this table continues, water would have a boiling point _____.

A. lower than −195.8 °C

B. higher than −195.8 °C

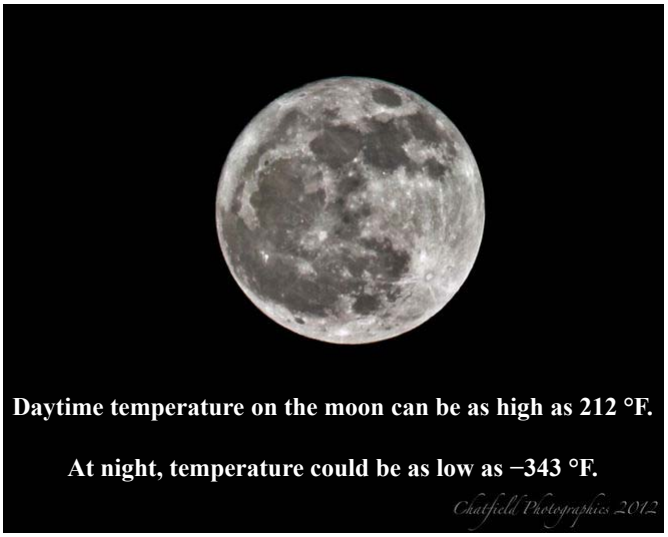
C. equals −195.8 °C

D. higher than −78.5 °C

Water has a <u>high specific heat capacity:</u> take more energy to heat up water

Summer time temperatures are lower at the waterfront than downtown.

What if there is no water on earth?



Liquid Water has very high surface tension

Water is a Universal Solvent

- Water dissolves more substances than any other liquid.
- Water dissolves both ionic compounds (such as NaCl) and molecular compounds (such as sucrose or sugar).