

## 1.1 WATER

### Learning outcomes:

At the end of this topic, students should be able to:

- Illustrate the structure of water molecule.
- State the properties of water.

### a) Illustrate the structure and state the properties of water molecules

**Exercise 1.1 (a):** Draw the structure of water molecules. Use the information given to label and complete the structure of a water molecule.

**Exercise 1.1 (b):** Fill in the blanks below to complete the explanation of water structure.



**Key:**  
Covalent bond  
104.5 °  
 $\delta^+$   
 $\delta^+$   
 $\delta^-$   
Oxygen atom  
Hydrogen atom

### STRUCTURE OF WATER

Consists of \_\_\_\_\_ oxygen atom and two hydrogen atoms. The three atoms of water molecule form wide \_\_\_\_\_ shaped structure. Two hydrogen atoms joined to the oxygen atom by \_\_\_\_\_ bond. Thus, one water molecule, has two covalent bonds. The bond angle in water molecule between two covalent bonds is 104.5 °. Water is **polar molecule**.

### Universal Solvent

- Defined as a molecule that carry an \_\_\_\_\_ distribution of electrical charge such as the opposite ends of the molecule have opposite charge.
- The oxygen region of molecule has a \_\_\_\_\_ ( $\delta^-$ ) and each hydrogen has a partial positive charge ( $\delta^+$ ).
- This unequal sharing of electrons occurs where oxygen atom is more electronegative than hydrogen.
- The polarity of the water molecule can attract other \_\_\_\_\_ molecules (hydrophilic or water-loving substances e.g. sugar, salt) but it \_\_\_\_\_ non-polar molecules (hydrophobic or water-hating substances) e.g. oil.
- Polarity of water molecule allows it to form hydrogen bonds with each other. One water molecule able to form \_\_\_\_\_ hydrogen bonds with another four water molecules.

b) State the properties of water.

# Properties of Water

1. \_\_\_\_\_

2. LOW viscosity

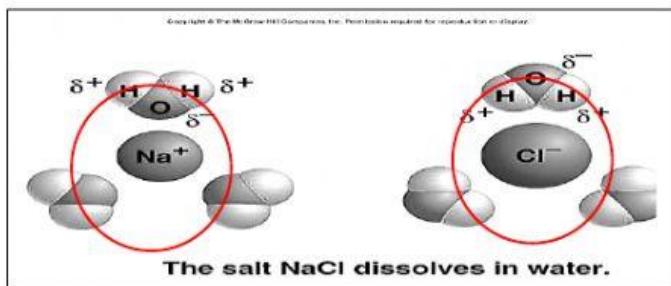
3. High specific HEAT CAPACITY

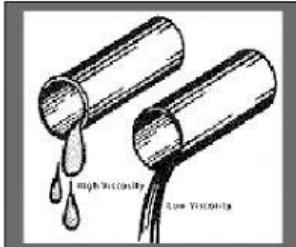
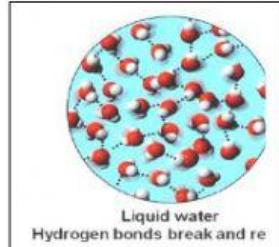
4. \_\_\_\_\_

5. High SURFACE TENSION

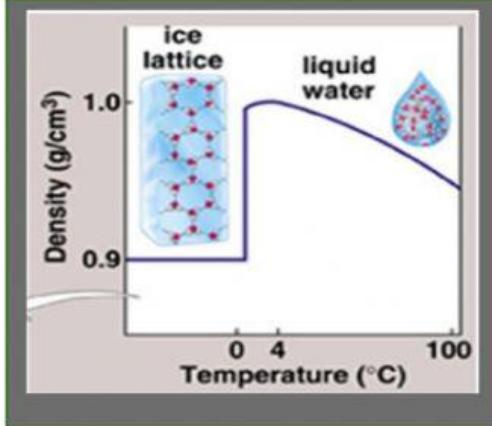
6. Maximum density at 4°C

➤ Describe the properties of water and its importance.

No.	Properties of Water	Description
1.	_____	<ul style="list-style-type: none"><li>➤ Solvent is dissolving agent of a solution.</li><li>➤ Water is a _____ molecule; that makes it suitable as universal solvent for ions (e.g. <math>\text{Na}^+</math> and <math>\text{Cl}^-</math>) and polar molecules.</li><li>➤ <b>Example : NaCl can dissolve in water</b></li><li>➤ Oxygen atoms of water are attracted to the positively charged _____ ions while,</li><li>➤ Hydrogen atoms of water are attracted to the negatively charged chloride ions.</li></ul> <div style="text-align: center;"><p>The salt NaCl dissolves in water.</p></div> <ul style="list-style-type: none"><li>➤ Water molecules gather around the <math>\text{Na}^+</math> and <math>\text{Cl}^-</math> to form _____ separating them from one another.</li><li>➤ Pulling these ions away from the salt crystal</li><li>➤ Causes these ions to separate &amp; dissolve.</li></ul>

	<p><b>Importance of universal solvent:</b></p> <ol style="list-style-type: none"> <li>_____ for most solutes</li> <li>Provides an aqueous medium for biochemical reactions.</li> <li>Serves as the body's major transport medium e.g. in blood capillaries and xylem.</li> </ol>
2.	<p>_____</p> <ul style="list-style-type: none"> <li>Viscosity is a measure of _____ to flow.</li> <li>Water has low viscosity because hydrogen bonds between water molecules are being continually broken &amp; reformed.</li> <li>The less viscous of the fluid the greater its movement (fluidity).</li> </ul> <div style="display: flex; justify-content: space-around; align-items: center;">   </div> <p><b>Importance of low viscosity:</b></p> <ul style="list-style-type: none"> <li>_____</li> <li>Foods could move easily down the alimentary canal.</li> <li>Synovial fluid within the joints reduces _____ between bone surfaces, thus enables free easy movement.</li> <li>Blood and lymph flow easily in the circulatory system.</li> </ul>
3.	<p>_____</p> <p>_____</p> <p>The amount of heat must be _____, to raise the temperature of 1g of water, by 1°C, per calorie (cal) or 1 cal/g/°C.</p>

	<ul style="list-style-type: none"> <li>➤ Large amount of _____ is needed to increase the temperature of 1g of water by <math>1^{\circ}\text{C}</math>.</li> </ul> <div data-bbox="647 271 1246 557" style="border: 1px solid black; padding: 10px;"> <p><b>Definition</b></p> <ul style="list-style-type: none"> <li>• <b>Specific Heat Capacity</b> is the amount of heat energy needed to raise the temperature of one kilogram of any material by 1 degree Celsius (or 1 Kelvin – doesn't matter – thank you metric system!).</li> <li>• For example it takes 4180 J of heat energy to raise the temperature of 1 kg of water by <math>1^{\circ}\text{C}</math>.</li> </ul>  </div> <ul style="list-style-type: none"> <li>➤ As water absorb heat, _____ bonds between water molecules are broken.</li> <li>➤ Only after hydrogen bonds are broken does heat absorption increase the motion of water molecules, thus the temperature of water increase.</li> </ul> <p><b>Importance of high specific heat capacity:</b></p> <ul style="list-style-type: none"> <li>• Acts as _____ buffer to prevent sudden body temperature changes in cells of organisms.</li> <li>• Allow ocean to _____ relatively constant temperature.</li> </ul>
4.	<p><b>Definition:</b></p> <p>Quantity of heat must be _____ for 1g of water to vaporize liquid to _____.</p> <ul style="list-style-type: none"> <li>➤ Large amount of heat/energy is used to _____ the hydrogen bonds that link individual water molecule.</li> </ul> <p><b>Importance of high latent heat of vaporization:</b></p> <p>▢ _____ effect;</p> <p>✓ _____ of water in sweat on skin or in transpiration from green leaves or panting in animals e.g. dog.</p>
5.	<p><b>Definition:</b></p> <p>A measure of how _____ it is to break the surface of a liquid.</p> <ul style="list-style-type: none"> <li>➤ The stronger the bonds between the molecules in liquid, the _____ the surface tension.</li> <li>➤ Surface tension is related to _____ forces between water molecules.</li> <li>➤ In the body of water, water molecules within are attracted _____ by cohesion.</li> </ul>

		<ul style="list-style-type: none"> <li>At the air-water interface, cohesive force only from interior.</li> <li>Thus, the _____ attraction causes the <b>inwardly forces</b> that cause <b>high surface tension</b> at the surface of water.</li> </ul> <p><b>Importance of high surface tension:</b></p> <ul style="list-style-type: none"> <li>Many small organisms rely on surface tension to settle on water. E.g.: _____</li> <li>Helps in _____ of water in plants.</li> </ul>
6.	<p>_____</p> <p>_____</p> <div style="border: 1px solid black; padding: 5px; width: fit-content;"> <p><i>How do aquatic organisms in ponds and lakes can survive in liquid water during the winter</i></p> </div> <ul style="list-style-type: none"> <li>Water achieves <b>its highest density at _____.</b></li> <li>Therefore, <b>ice (0°C) is less dense</b> than water and floats on top of water.</li> <li>Water _____ on top of lakes and <b>insulates the layers below from further cooling and freezing.</b></li> <li>Thus allowing life forms to thrive in the water beneath the ice.</li> </ul>	<ul style="list-style-type: none"> <li>Water achieves its highest density at 4°C.</li> </ul>  <ul style="list-style-type: none"> <li>Therefore, ice (0°C) is _____ than water and floats on top of water.</li> <li>Water is the only substance whose <b>solid form is less dense than its liquid form</b>.</li> </ul> 