3d molecular designs
Transforming Science Learning

It All Begins with Water

Ruth Hutson, MSSE

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Workshop Outcomes

- Use models to compare the structure of water at the macroscopic level to infer the strength of electrical forces between particles.
- Understand and apply factors that influence the behavior of solutions using models.
- Model pH and predict the products in acid-base reactions that form water.
- Have fun!

What's going on in this picture?

Describe five details that you see.

How does this differ from how water normally runs out of a faucet?

I notice	I wonder

Remove four molecules of water from your Water Kit and observe how they interact with each other.

Record your observations in your lab notebook.

What occurs as you add more molecules of water until you have added all twelve molecules?

Let's take a closer look at the water molecule. Very carefully separate a hydrogen from an oxygen.

What do you see?

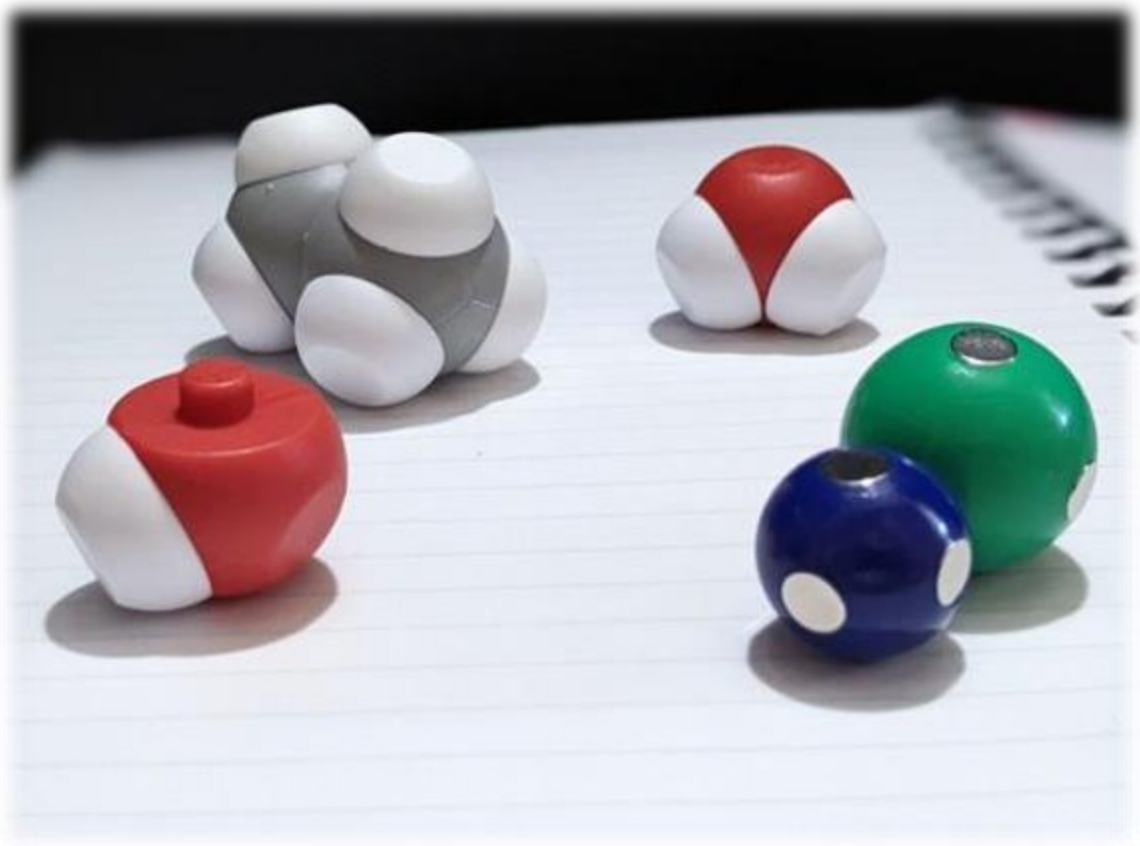
Do both hydrogens connect to the oxygen in a similar fashion?

Compare the difficulty in separating a hydrogen from an oxygen within a water molecule to separating two water molecules from each other.

Look at the other contents of the Water Kit.

What other substances contain posts that would represent covalent bonding?

How many separate covalent bonds can you find?



Modify the ethane molecule to make an ethanol molecule.

What is the chemical formula of ethanol?

How does ethanol interact with water?

How does that compare to how ethane interacts with water?

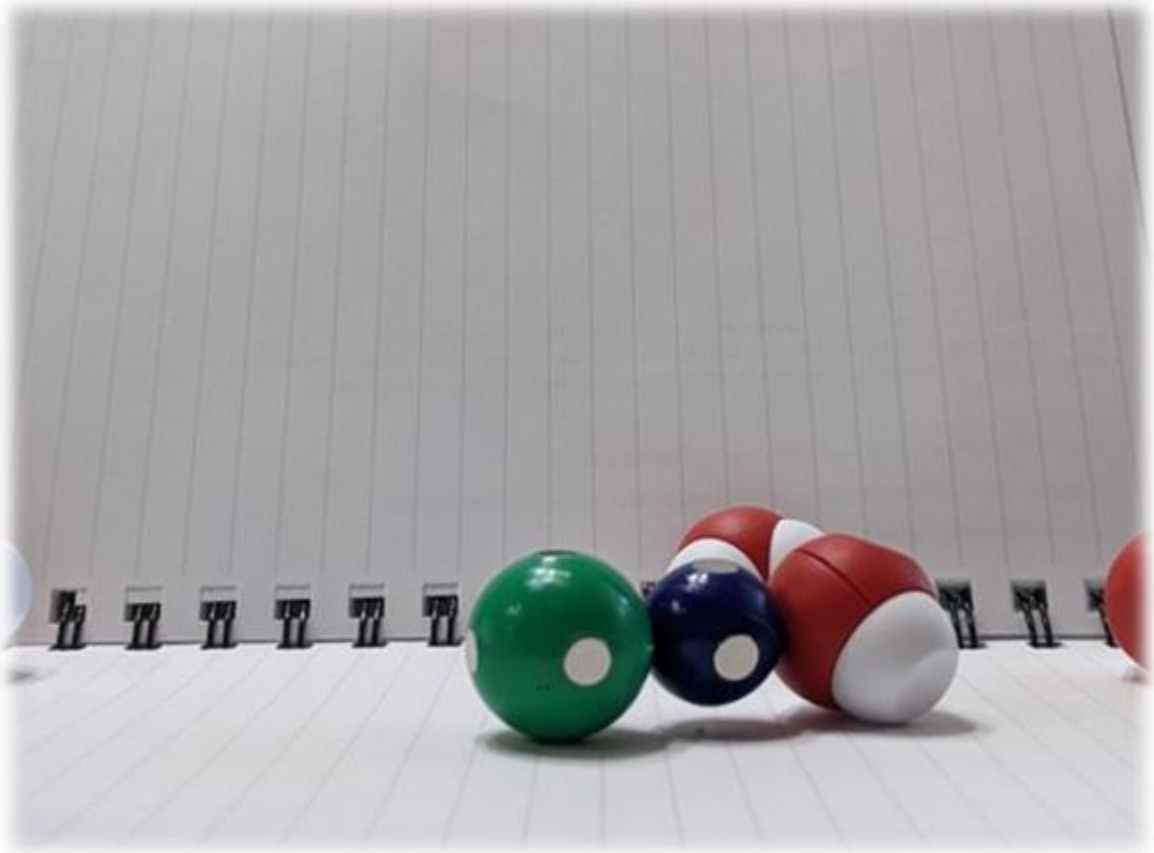
Identify the location of the covalent bonds in the ethanol molecule.

Where do you find hydrogen bonding?

How does sodium chloride interact with water?

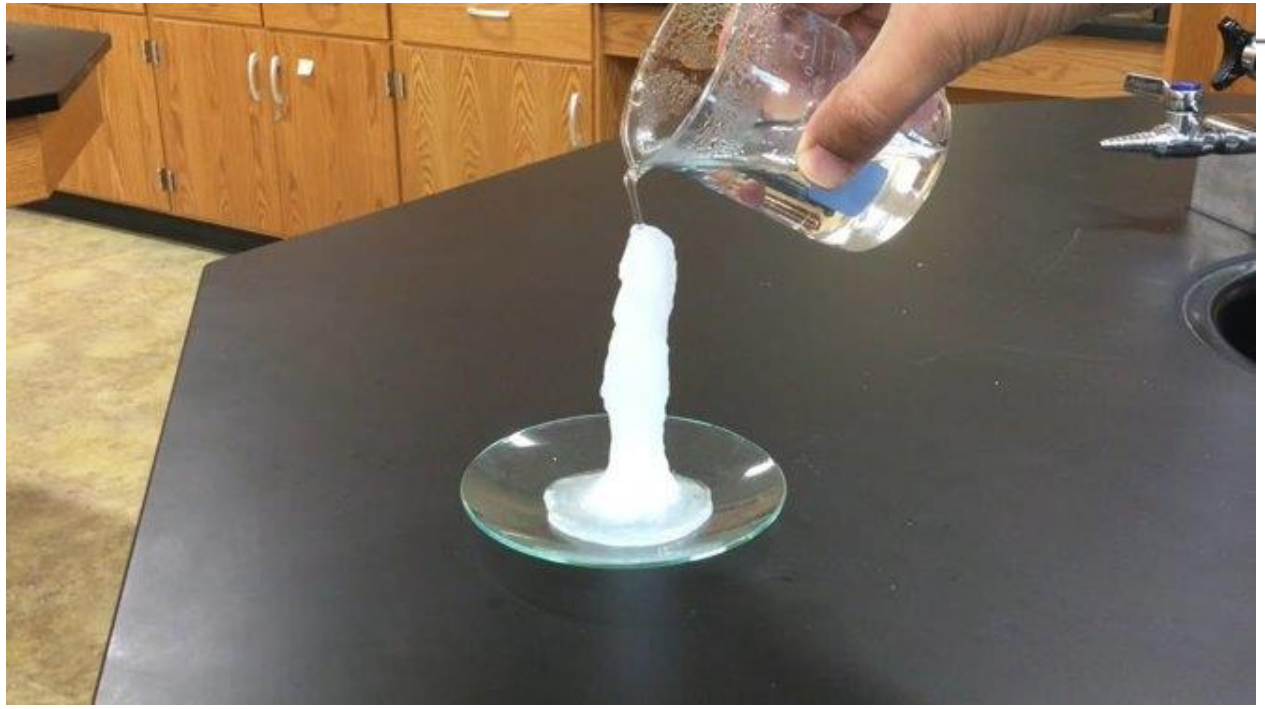
How do the sodium ion and the chloride ion interact with each other?

Compare the three types of chemical bonds about which you have learned. Rank them in order of strength of the bond.



Comparing Types of Forces	COVALENT BONDING	IONIC BONDING	HYDROGEN BONDING
What is it?	Formed when two atoms share a bond within one molecule, can be partially charged or without charge.	Complete transfer of electrons between two atoms resulting in one that is positively charged, and one negatively charged.	A weak attraction of a hydrogen atom that is covalently bound to a more electronegative “donor” atom or group.
How is it represented by the model?	The plastic post connecting the oxygen and the hydrogen in water	The magnet in the sodium atom connecting to the magnet of chlorine atom	The hydrogen of one water molecule attracted to the oxygen of another water molecule
Type of force	Intramolecular Force	Intramolecular Force	Intermolecular Force

Based on what you have learned about hydrogen bonding and covalent bonds, use the Water Kit to help explain what is happening in this picture.



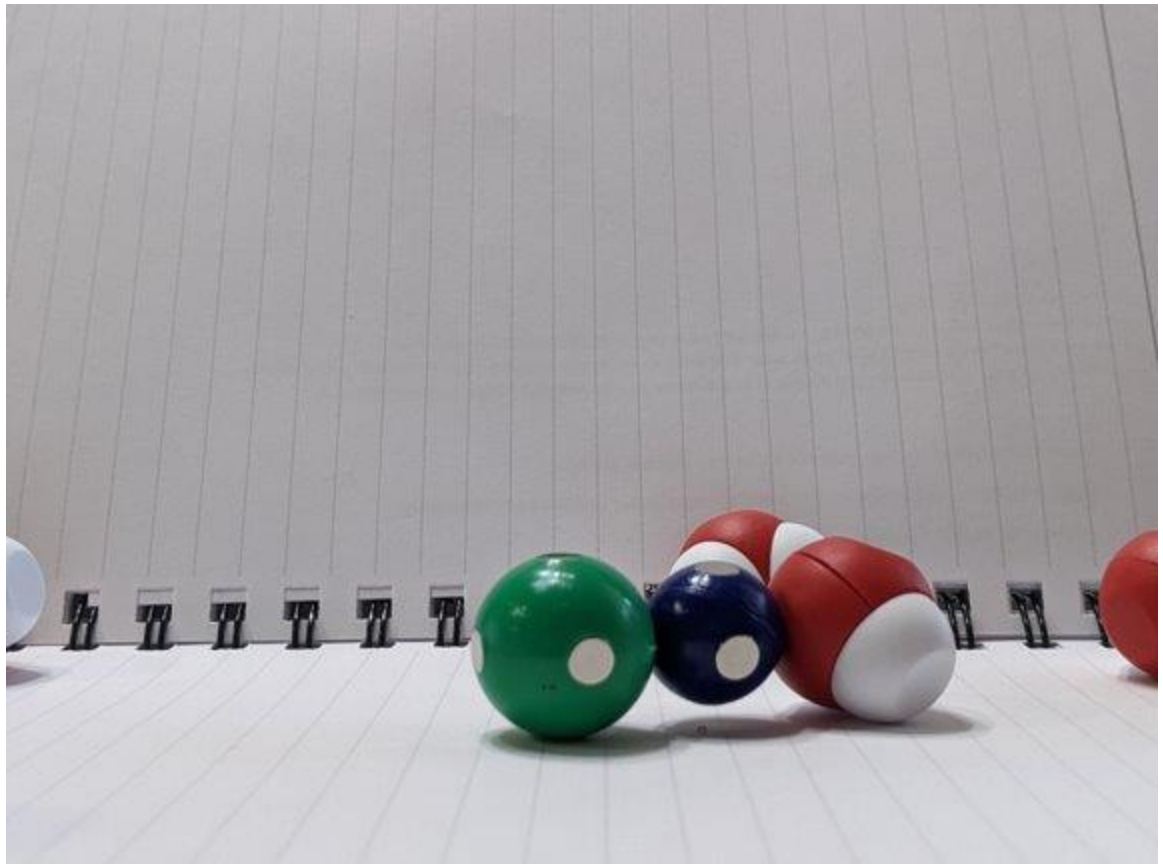
I notice	I wonder

Let’s start by modeling sodium chloride’s interaction with water

Describe what occurs when water interacts with sodium chloride.

Which ion interacts with oxygen? Why?

Which ion interacts with hydrogen? Why?



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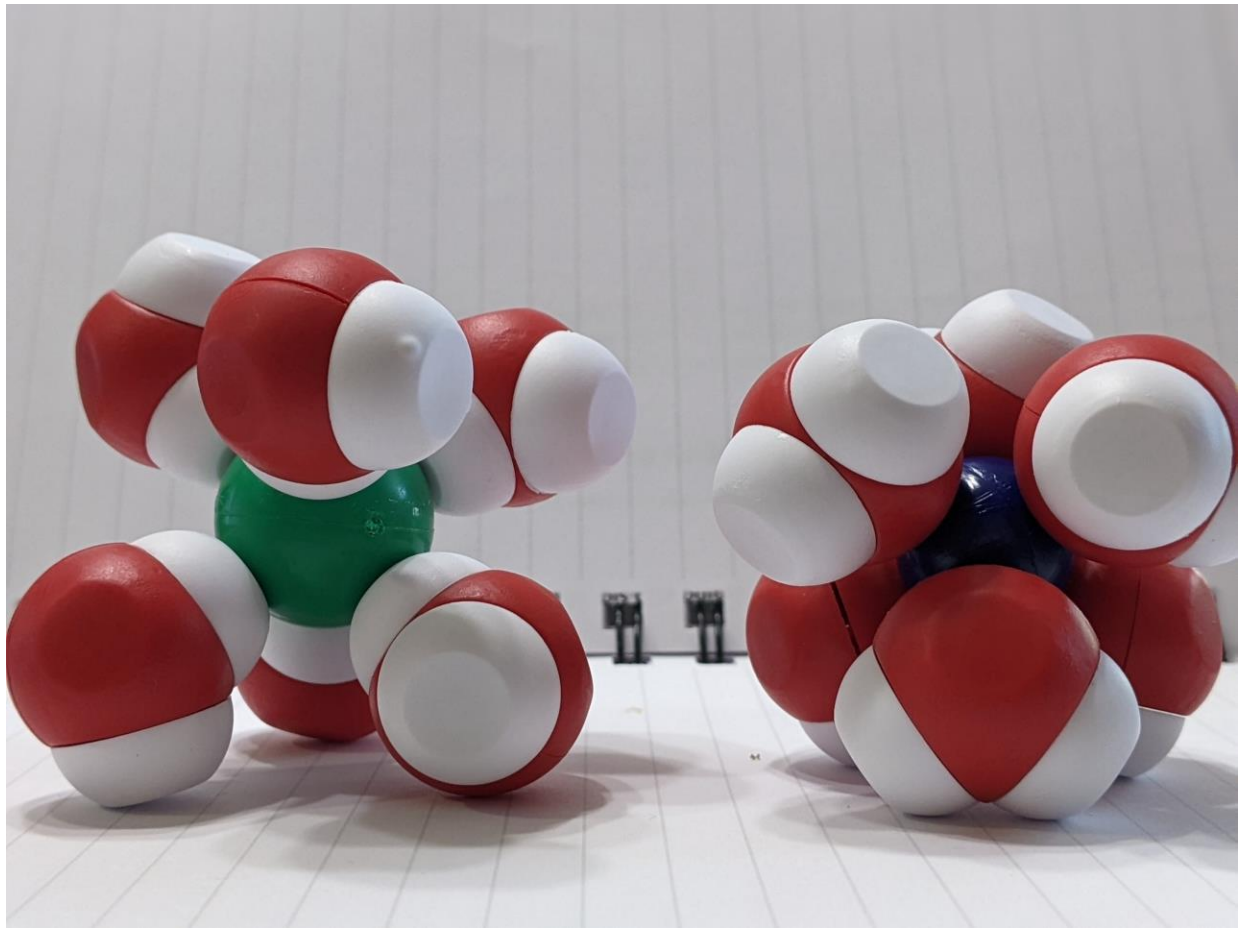


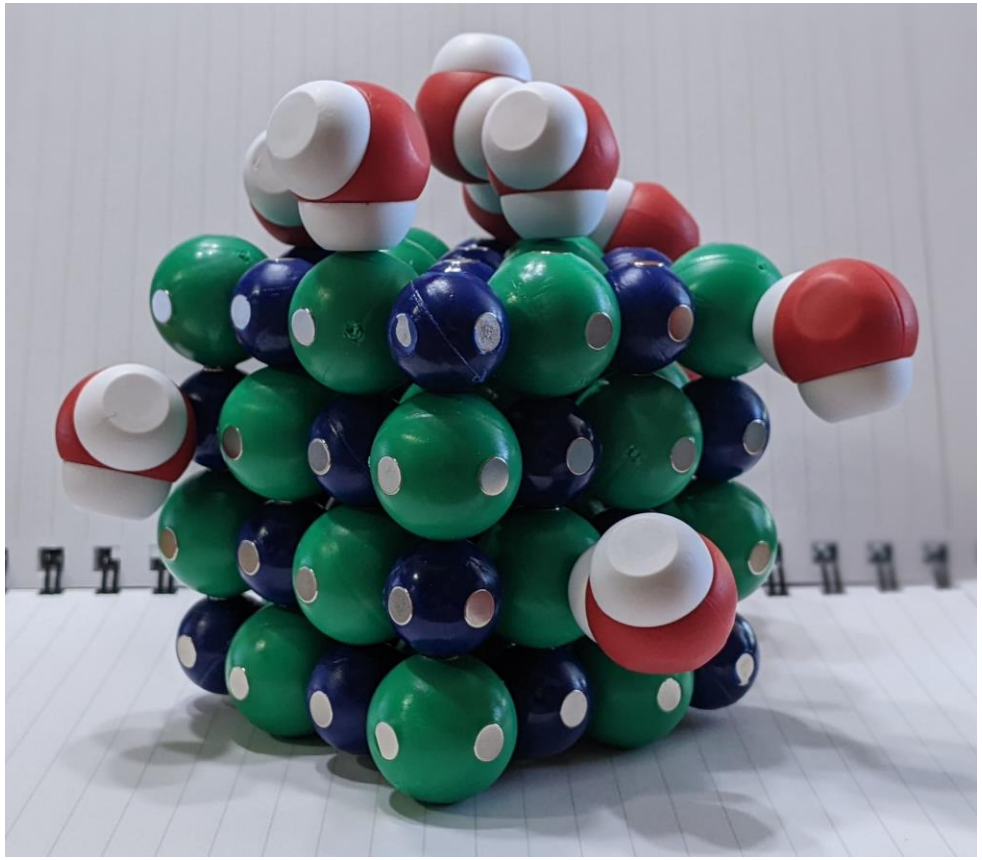
Misconception Alert

- Sodium chloride does not appear as a single molecule.

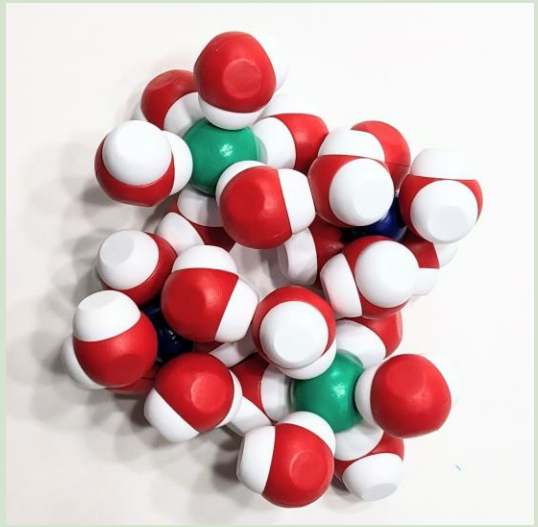
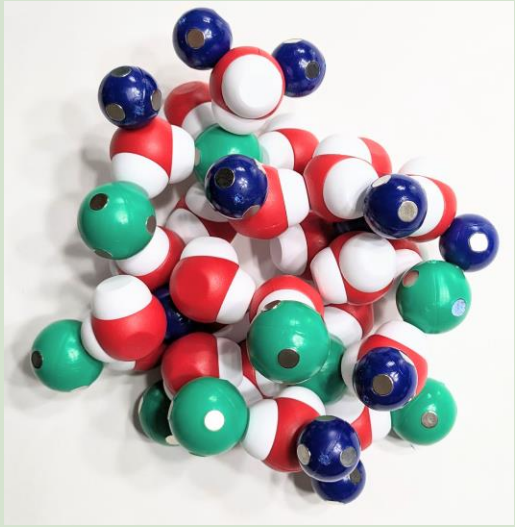
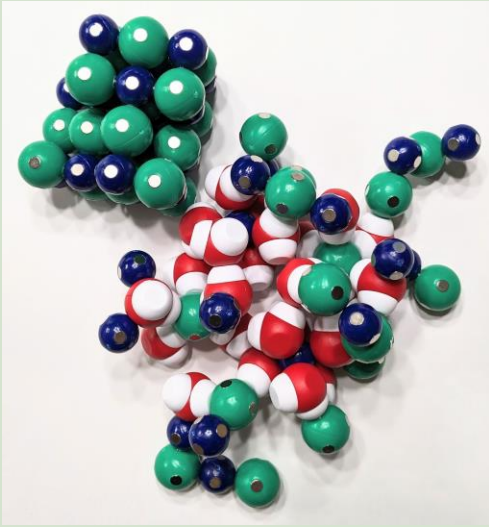
- Sodium chloride presents itself as crystals in nature.

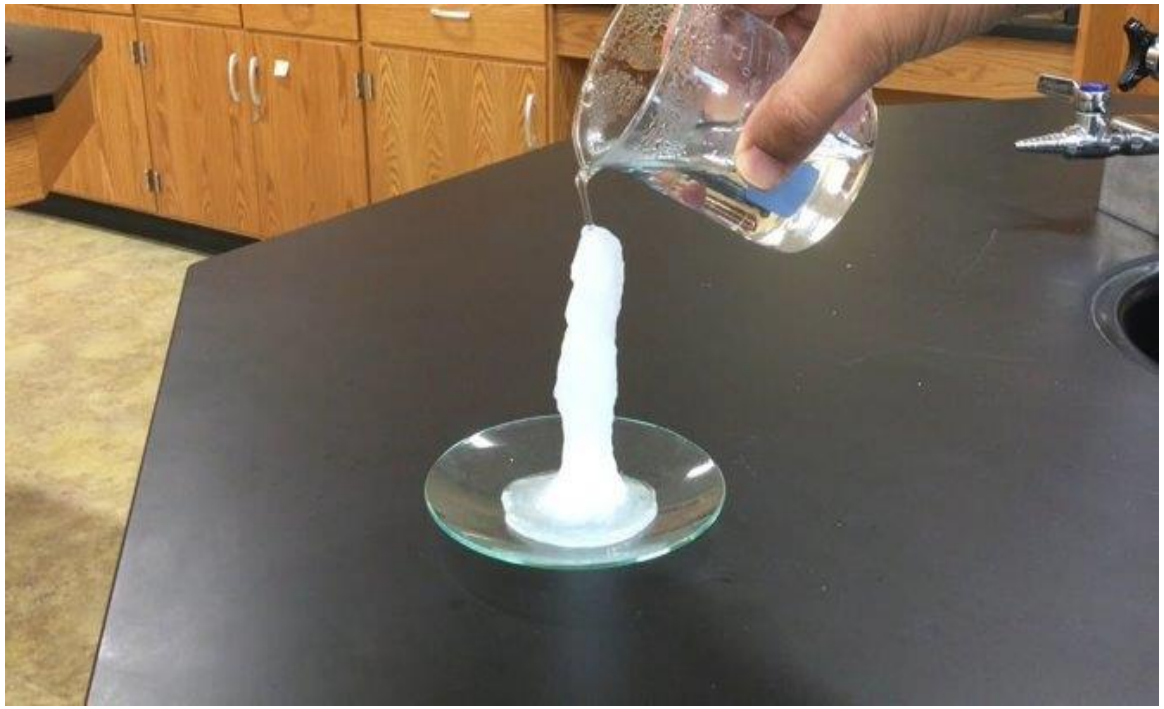
I notice	I wonder

Let’s model a sodium chloride lattice dissolving in water

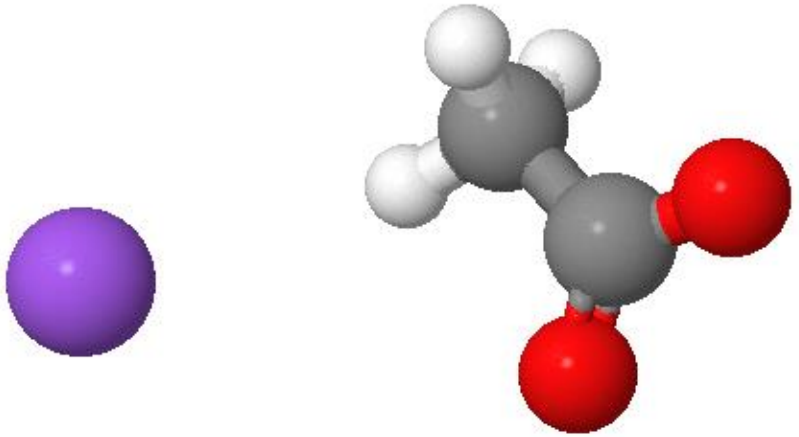


Modeling Solutions

Unsaturated	Saturated	Supersaturated
		
A solution that contains less than the maximum amount of solute that is capable of being dissolved.	A solution that contains the maximum amount of solute that is capable of dissolving.	A solution that contains more than the maximum amount of solute that is capable of being dissolved at a given temperature. By adding a seed crystal, the solution recrystallizes.



Based on what you have learned about interactions between salt and water, use the Water Kit to help explain what is happening in this picture.



A closer look by other factors affecting solubility

How does the polarity of a substance affect its solubility in water?

Alcohol	Observations in Lab	Modeling
Methanol		
Ethanol		
Butanol		
Octanol		

What is going on in this beaker at the molecular scale?

Unknown Solution	Observations in Lab	Modeling
Methanol		
Ethanol		
Butanol		
Octanol		

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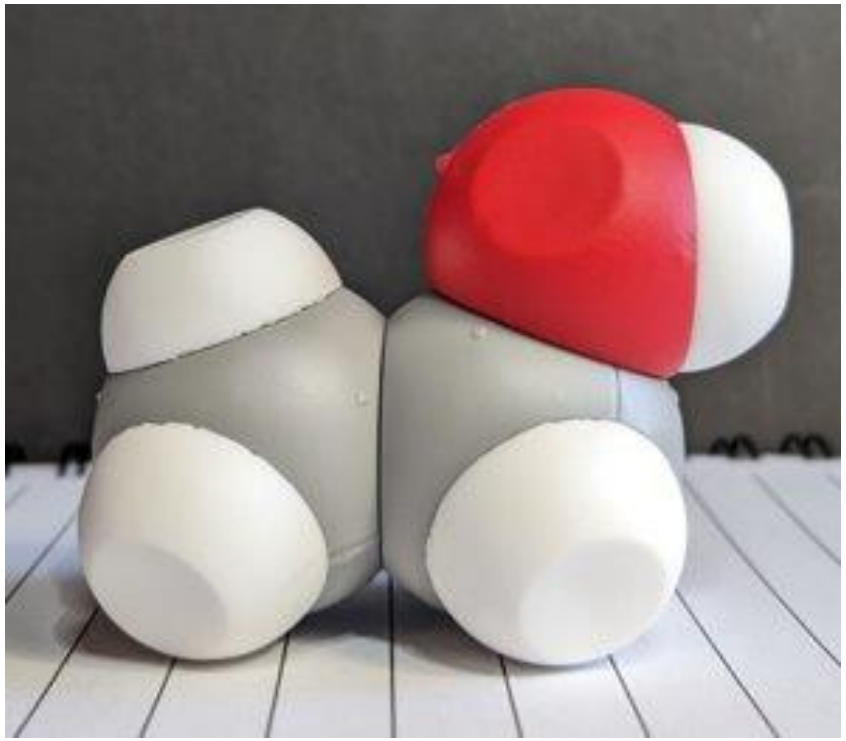

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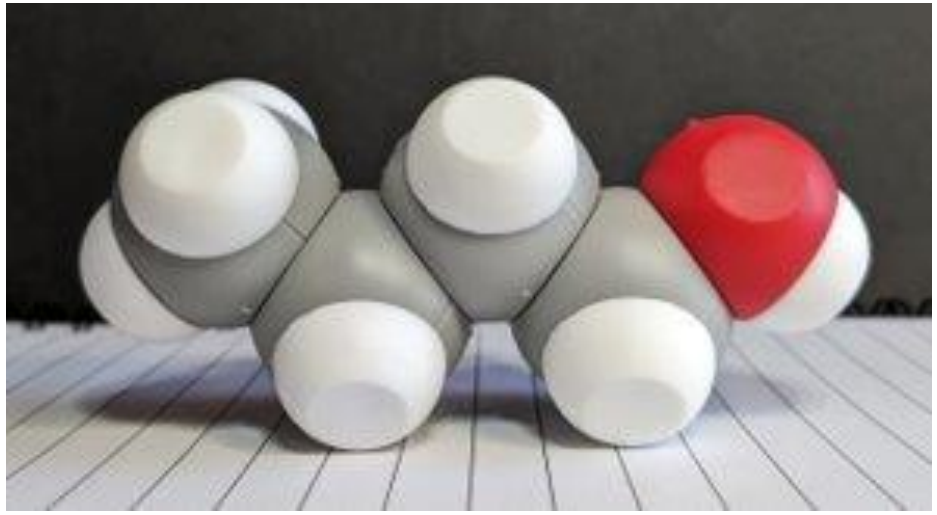

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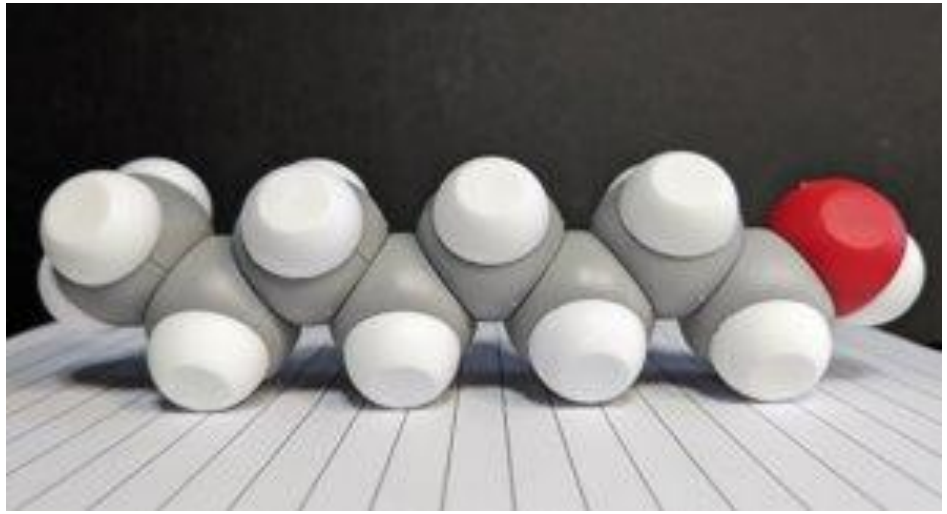


Unknown Solution	Observations in Lab	Modeling
Methanol		
Ethanol		
Butanol		
Octanol		

Based on what you have learned about polarity use the Water Kit to help explain why alcohols become less soluble in water as their carbon chain increases in length.

I notice	I wonder

Switching to acid-base models

Create physical representation of the autoionization of water.

$$H_2O\,(l) \rightleftharpoons H^+\,(aq) + OH^-\,(aq)$$

$$H_2O\,(l) + H_2O\,(l) \rightleftharpoons OH^-\,(aq) + H_3O^+\,(aq)$$

Switching to acid-base models

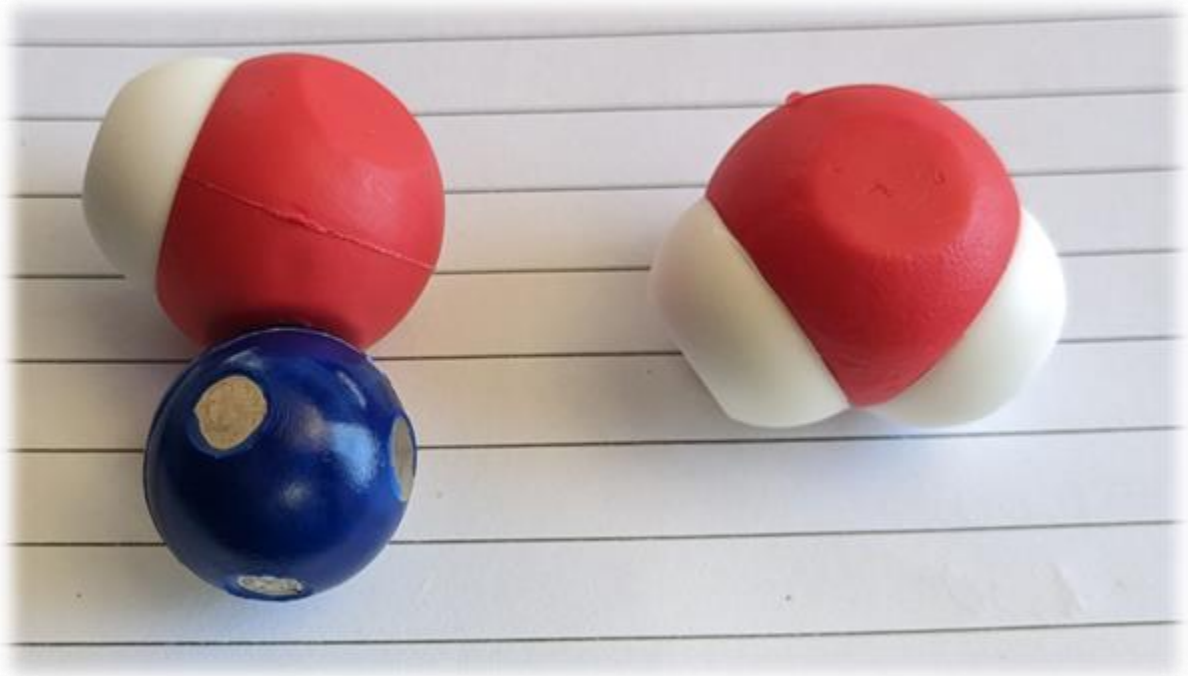
Create physical representation of the dissociation of hydrochloric acid in water.

$$HCl\ (aq) + H_2O\ (l) \longrightarrow H_3O^+\ (aq) + Cl^-\ (aq)$$

Switching to acid-base models

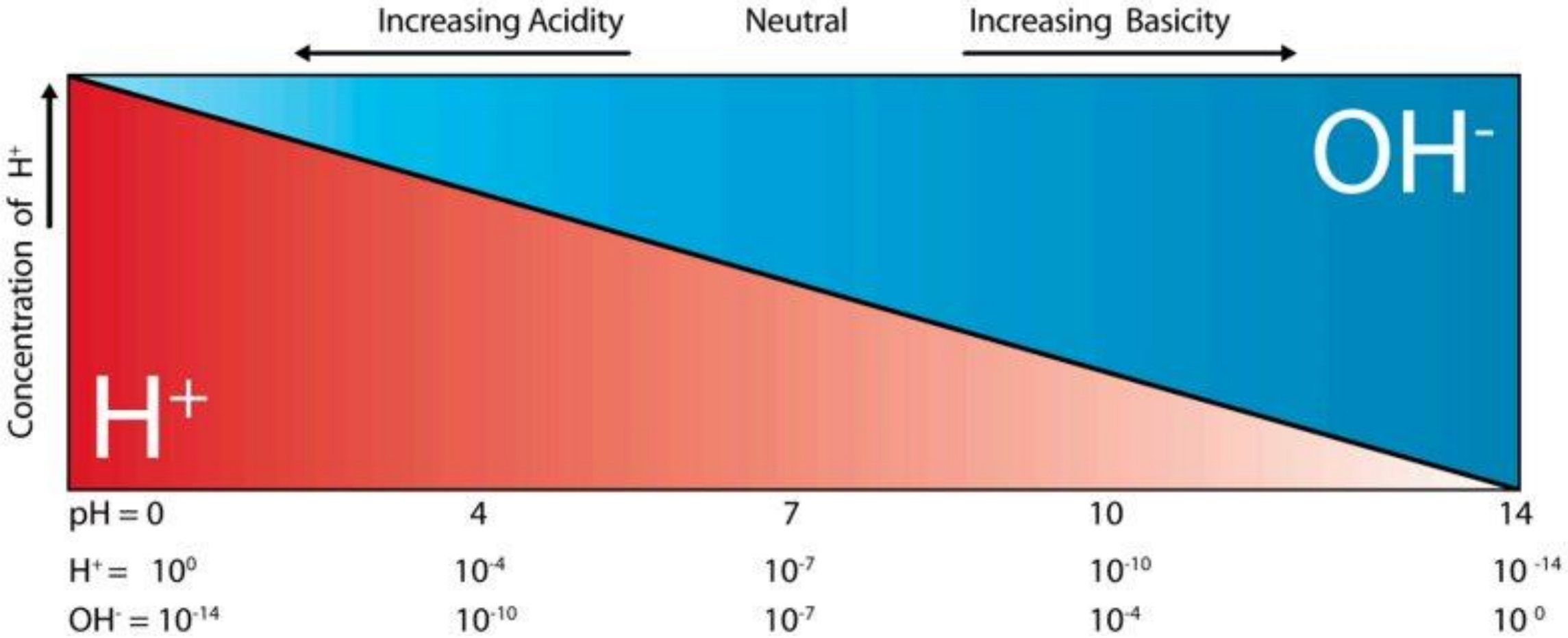
Create physical representation of the dissociation of sodium hydroxide in water.

$$NaOH\,(s) \longrightarrow Na^{+}(aq) + OH^{-}\,(aq)$$



Switching to acid-base models

Create physical representation of a neutralization reaction using the parts from the Water Kit.


Increasing Acidity
Neutral
Increasing Basicity
Concentration of H+
H+
OH-
pH = 0
4
7
10
14
H+ = 10^0
10^-4
10^-7
10^-10
10^-14
OH- = 10^-14
10^-10
10^-7
10^-4
10^0

Based on what you have learned about acids and bases, use the Water Kit to help explain the difference between a strong acid like HCl in water and a strong base like NaOH in water.

We value your opinion! Let us know what you think.

Scan the QR Code and complete this short survey.

Workshop NGSS & TEKS Connections

SEPs	CCCs	DCIs	TEKS
Asking Questions and Defining Problems	Scale, Proportion, and Quantity	MS-PS1-1	Student Expectation-8.5E
Developing and Using Models	Patterns	MS-PS1-5	Student Expectation-C.10A
Planning and Carrying Out Investigations	Cause and Effect	HS-PS1-3	Student Expectation-C.10G
Constructing Explanations and Designing Solutions		HS-PS1-7	

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