Summer Enrichment Packet for Rising Chemistry Students

PRINCE GEORGE'S COUNTY PUBLIC SCHOOLS
Division of Academics
Department of Curriculum and Instruction

<u>Note to Students</u>:

You have learned so much in school this year! It is important that you continue to engage in science content and practices over the summer to help prepare you for our Chemistry course next school year. In this packet, you will find weekly activities for the Summer Break.

Student Directions: The calendars provided are snapshots of the activities and assignments. Some of the assignments are to be completed entirely in your science journal, while for other assignments there are detailed information and directions provided on subsequent pages in this packet. Use the calendars to pace out the tasks. As a suggestion, you may wish to check off each assignment as it is completed.

Science Journal: You will need your Evidence Notebook to record brief constructed responses, extended responses, exploration ideas, flowcharts, and diagrams, etc. If you do not have your Evidence Notebook, then you will need to create a science journal to record your information.

- Create a science journal by stapling several pieces of paper together or use a notebook or binder with paper.

- Each journal entry should:
    - Have the title of the activity.
    - Have a clear and complete answer (to each question) that explains your thinking.
    - Be neat and organized.

June Activities			
<u>Week One</u> The Periodic Table	**Periodic Table Basics**		
<u>Week Two</u> Atoms and Bonding	**Days 1 and 2** ☐ Ionic Bonds ☐ Pulling Away Electrons	**Days 3 and 4** ☐ Covalent Bonds ☐ Oil Spills	**Day 5** ☐ In your science journal, compare/contrast ionic and covalent bonding. Provide examples of each bond.
Notes/References: • A periodic table can be accessed at: https://tinyurl.com/RisingChemistry-Periodic-Table • Information on Bohr Structures and Lewis Diagrams can be found at: https://tinyurl.com/bohrmodel-lewisdiagram			

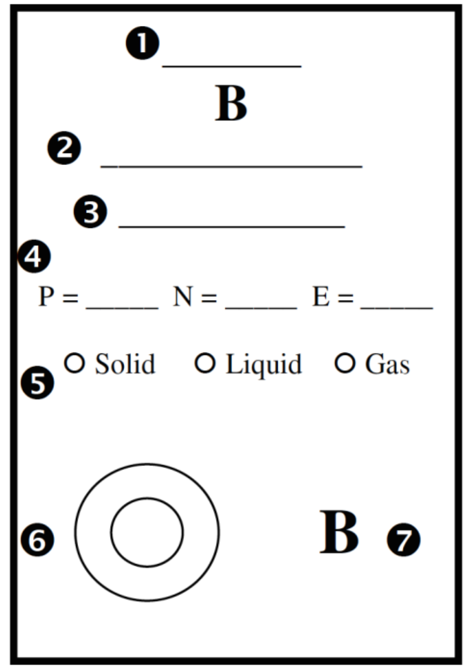
July Activities			
Week Three **Chemical Reactions (Part I)**	**Days 1 and 2** ☐ Observing Chemical Change Separation Science	**Days 3- 4** *What is a Chemical Reaction*? Read, annotate, and summarize the article.	**Day 5** ☐ Describing Chemical Reactions ☐ The Decomposition of Water
Week Four **Chemical Reactions (Part II)**	**Days 1 and 2** ☐ Controlling Chemical Reactions 'Causes and Effect' Graphic Organizer ☐ Read and annotate the text.	**Days 3- 4** ☐ Endothermic and Exothermic Reactions ☐ Making and Breaking Bonds	**Day 5** ☐ Flameless Ration Heaters
Week Five **Cycling of Energy in Ecosystems**	**Days 1 and 2** ☐ The Water Cycle	**Days 3, 4, and 5** ☐ Carbon Cycle: Model of the carbon cycle's role in photosynthesis and respiration ☐ Nitrogen Cycle: Scientific Explanation Phosphorus Cycle: Animals and the Phosphorus Cycle	
Week Six **Energy Transformations**	**Hydroelectric Station**		

August Activities			
Week Seven **Atoms and Bonding**	**Days 1 and 2** **Understanding Solutions** ☐ Make a graphic organizer to compare/contrast solutions, colloids, and suspensions (science journal) ☐ The Chemistry of Ice Cream	**Day 3** ☐ Temperature and Solubility	**Days 4 and 5** ☐ Acid and Bases in Solution: Swimming Pool Basics

Week 1 – Focus: Periodic Table Basics

Step One: Complete the card for each of the elements on pages (5-6).

1. Atomic number
2. Name
3. Atomic mass
4. Number of protons, neutrons, and electrons
5. Is the element a solid, liquid, or gas at room temperature?
6. Bohr diagram
7. Lewis Structure



Step Two: Use colored pencils to shade in the card for each element. Hydrogen is not colored

Green = Li & Na
Pink = O & S
Orange = B & Al
Red = C & Si
Blue = Be & Mg
Tan (or light brown)= N & P
Purple = F & Cl
Yellow = He, Ne, & Ar

Step 3: Cut the cards apart and arrange according to atomic number in the pattern shown below on a large sheet of construction paper.

Periodic Table Basics

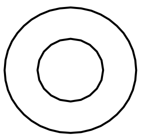
1							2
3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18

Step 4: After you have the cards arranged in the correct order, glue them to the paper. Add a title at the top of the page, and complete questions 1-9 on page 7 of this packet.

B

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

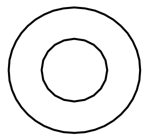


B

Li

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

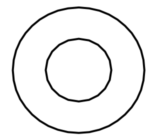


Li

Ne

P = ______ N = ______ E = ______

O Solid O Liquid O Gas



Ne

He

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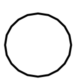
O Solid O Liquid O Gas

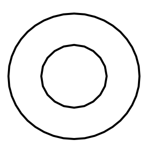


He

C

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

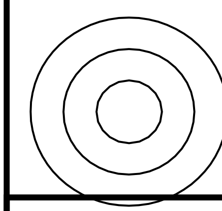


C

P

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

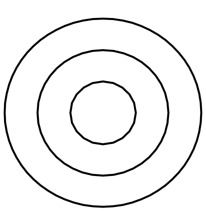


P

S

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

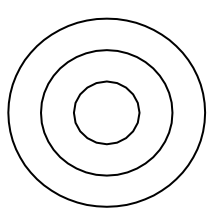


S

Mg

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

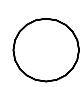


Mg

H

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

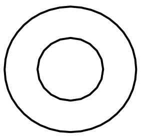


H

N

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

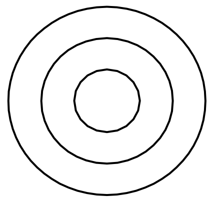


N

Al

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

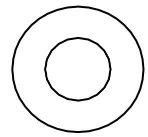


Al

F

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

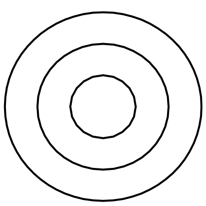


F

Ar

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

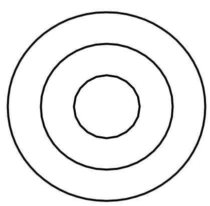


Ar

Si

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

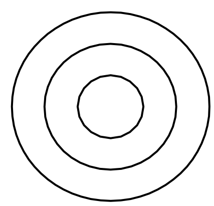


Si

Na

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

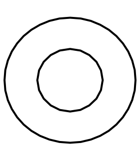


Na

Be

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

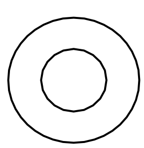


Be

O

P = ______ N = ______ E = ______

O Solid O Liquid O Gas

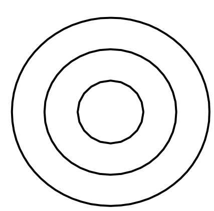


O

Cl

P = ______ N = ______ E = ______

O Solid O Liquid O Gas



Cl

Periodic Table Basics

Directions: Respond to the questions 1-9 in your science journal or on your Periodic Table chart.

1. Which elements have complete outer shells? Give the name and symbol for each.
2. Which elements had only one valence electron? Give the name and symbol for each.
3. What do you notice about the number of valence electrons as you move from left to right across a row or period in the periodic table? (Na Mg Al Si P S Cl Ar)
4. What do you notice about the number of energy levels or shells as you move down a group or column in the periodic table? (H Li Na)
5. Write the name of each family at the top of the columns on your periodic table using the following information.

<u>Alkali Metals</u> - 1 valence electron

<u>Alkaline Earth Metals</u> - 2 valence electrons

<u>Boron Family</u> - 3 valence electrons

<u>Carbon Family</u> - 4 valence electrons

<u>Nitrogen Family</u> - 5 valence electrons

<u>Oxygen Family</u> - 6 valence electrons

<u>Halides</u> - 7 valence electrons

<u>Noble Gases</u> - Complete outer shells

6. What do you notice about the location of the elements in each family?

7. In what family would you classify hydrogen? Explain your choice.

8. In what family would each of these elements be classified?

    A. Radium-

    B. Iodine-

9. Predict the number of valence electrons for each element based on its location in the Periodic Table of Elements.

    A. Barium-

    B. Lead-

    C. Bismuth

    D. Potassium

Week 2 – Focus: Atoms and Bonding

Ionic Bonds

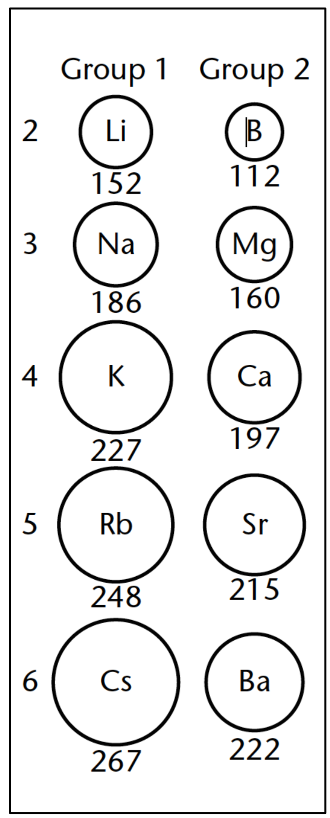
Directions: Use the chart below to answer the following questions.

Ions and Their Charges		
Name	**Charge**	**Symbol/Formula**
Ammonium	1+	NH_4^+
Potassium	1+	K^+
Calcium	2+	Ca^{2+}
Magnesium	2+	Mg2+
Chloride	1-	Cl^-
Oxide	2-	O^{2-}
Sulfide	2-	S^{2-}
Phosphate	3-	PO_4^{3-}

1. How many potassium ions are needed to balance the charge of one sulfide ion? Explain.
2. Predict the formulas for calcium chloride and potassium phosphate.
3. Name the following compounds: MgS, NH_4Cl, and K_2O.
4. Which ions in the table are polyatomic ions?

Pulling Away Electrons

In the periodic table, the metals in Group 1 and 2 are quite reactive. They combine easily with certain other elements to form compounds by losing electrons. Atoms from Group 1 lose one electron; atoms from Group 2 lose two electrons. It takes energy to remove an electron from an atom. Some atoms hold their electrons tighter than others do. Also, an individual atom holds some of its electrons tighter than others of its electrons. The size of an atom's radius affects how tightly it holds its electrons. The larger the radius of an atom, the farther away from the nucleus some of its electrons are. The electron held the least tightly is easiest to remove. To remove yet another electron requires more energy than was needed to remove the first. The figure below compares the atomic radii of the Group 1 and 2 elements. The number underneath each element represents the atomic radius measured in picometers (pm).



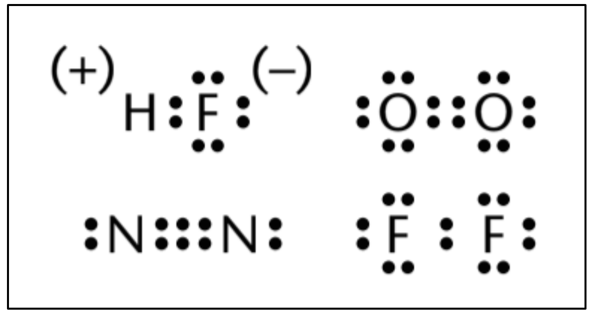
Directions: Use the graphic on the right to answer the following questions in your science journal.

1. What do you notice about atomic radius as you move down a group? As you move across a period from Group 1 to Group 2?
2. Which element would you expect to be the most reactive in Group 1? In Group 2? Explain your answer.
3. Within each period, which element of the two elements would you expect to be more reactive? Explain your answer.
4. As you go across the periodic table, atomic radius continues to decrease. How does this fact help explain why the atoms of noble gases don't react easily with other atoms?

Covalent Bonds

Understanding Main Ideas

1. Circle all the covalent bonds in the four electron dot diagrams in the graphic on the right.
2. Which bond(s) shown are double bonds?
3. Which bond(s) shown are triple bonds?
4. What makes the bond in HF a polar bond?
5. Which molecule(s) shown have nonpolar bonds?
6. How do the melting points, boiling points, and conductivity of molecular compounds compare to those of ionic compounds?



Oil Spills

Each year over 907,000 metric tons of crude oil are spilled in Earth's oceans. This is enough oil to fill 100 school gymnasiums! It is important to clean up crude oil as soon after a spill as possible, because spilled crude oil has negative effects on the environment. Oil on ocean surfaces is harmful to ocean life because it blocks sunlight and reduces the level of dissolved oxygen in the water. In addition, many birds and fish die from contact with crude oil because the oil damages feathers and gills. Two methods used to clean up oil spills are:

1. A floating barrier is placed around the spill to keep it from spreading. Because oil floats on water, the oil can be skimmed off the top of the water. Skimming the top of the water using a net with extremely small holes allows the water to escape but not the oil.
2. Chemicals that act like detergents are sprayed onto the surface of the spill. These chemicals break up the oil into tiny droplets. The small particles of oil spread over a large area have less effect on marine life than larger particles.

Both of these methods work because of the chemical properties of oil molecules. Oil molecules are nonpolar, so they will not mix with polar water molecules. Detergents are long molecules that have a polar end and a nonpolar end, like the molecule shown in Figure 1. The polar end of the detergent attracts water molecules, and the nonpolar end attracts oil molecules. Figure 2 shows how detergent molecules cause the formation of droplets of water, detergent, and oil molecules.

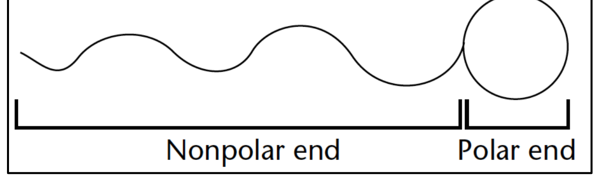


Figure 1
Detergent Molecule

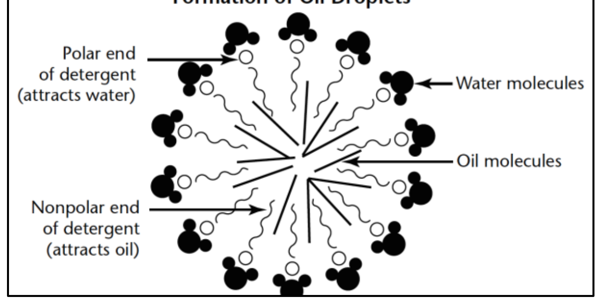


Figure 2
Formation of Oil Droplets

Directions: Answer the following questions in your science journal.

1. Explain how the nonpolar character of oil molecules helps when removing oil from water using nets and floating barriers.
2. The long "tail" on a detergent molecule is made up mostly of carbon atoms bonded to other carbon atoms. Why would you expect the tail to be nonpolar?
3. How does detergent sprayed on an oil spill break up the spill?
4. The action of waves can break up large sections of an oil spill. The oil looks like it has mixed with the water, but has it? Explain your answer.

Week 3 – Focus: Chemical Reactions (Part I)

Observing Chemical Change

Directions: Complete the following table. Describe changes in properties that you might notice during each process and state whether the changes are chemical or physical.

Changes in Matter		
Event	**Observable Changes**	**Type of Change**
Baking a cake	1.	2.
Burning a log	3.	4.
Freezing water	5.	6.

Separation Science

A mixture is a combination of two or more pure substances, and the substances do not combine to form new material. Therefore, you should be able to separate a mixture into the substances that make it. There are several ways to separate mixtures. Figure 1 shows a mixture of sand and water being separated by filtration. The salt in a solution of salt water can be separated by evaporation, shown in Figure 2. When you let the sand particles in a mixture of sand and water settle to the bottom of a container, then carefully pour the water off into another container, you are using a method called decanting, shown in Figure 3.

Study the following illustrations. Answer the questions below in your science journal.

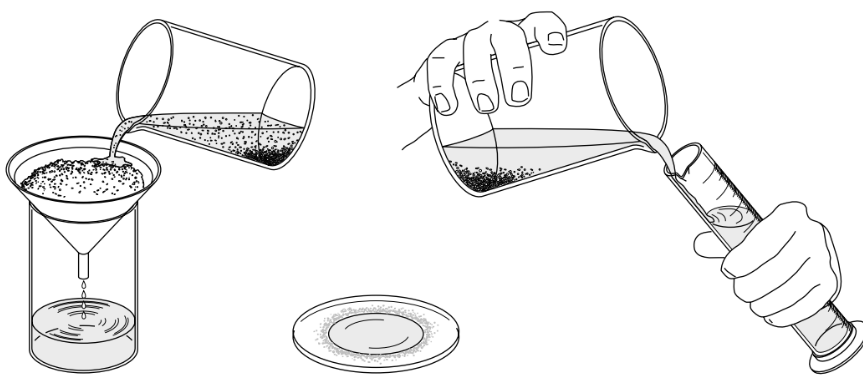


Figure 1 **Figure 2** **Figure 3**

1. Using Figure 1, explain the process of filtration. Give another example of filtration used to separate a mixture.
2. Discuss a use for evaporation.
3. What types of mixtures could be separated by decanting? Is laboratory equipment necessary for decanting a mixture? Why or why not?
4. Would a separation of the types of mixtures described above cause a chemical change or a physical change? Explain your answer.

What is a Chemical Reaction?

(Newsela, 2020)

Directions: Read and annotate the article. In your science journal, write a summary of the text.

You encounter chemical reactions all the time. Fire, respiration and cooking all involve chemical reactions. Yet, do you know what exactly a chemical reaction is?

Chemical Reaction Definition. Simply put, a chemical reaction is any transformation from one set of chemicals into another set. If the starting and ending substances are the same, a change may have occurred, but not a chemical reaction. A reaction involves a rearrangement of molecules or ions into a different structure. Contrast this with a physical change, where the appearance is altered, but the molecular structure is unchanged, or a nuclear reaction, in which the composition of the atomic nucleus changes. In a chemical reaction, the atomic nucleus is untouched, but electrons may be transferred or shared to break and form chemical bonds. In both physical changes and chemical changes (reactions), the number of atoms of each element is the same both before and after a process occurs. However, in a physical change, the atoms maintain their same arrangement into molecules and compounds. In a chemical reaction, the atoms form new products, molecules and compounds.

Signs A Chemical Reaction Has Occurred. Since you can't look at chemicals at a molecular level with the naked eye, it's helpful to know signs that indicate a reaction has occurred. A temperature change, bubbles, color change, or precipitate formation often accompanies a chemical reaction.

Chemical Reactions And Chemical Equations. The atoms and molecules that interact are called the reactants. The atoms and molecules produced by the reaction are called products. Chemists use a shorthand notation called a chemical equation to indicate the reactants and the products. In this notation, the reactants are listed on the left side, the products are listed on the right side, and the reactants and products are separated by an arrow showing which direction the reaction proceeds. While many chemical equations show reactants forming products, in reality, the chemical reaction often proceeds in the other direction, too. In a chemical reaction and a chemical equation, no new atoms are created or lost (conservation of mass), but chemical bonds may be broken and formed between different atoms. Chemical equations may be either unbalanced or balanced. An unbalanced chemical equation doesn't account for conservation of mass, but it's often a good starting point because it lists the products and reactants and the direction of the chemical reaction. As an example, consider rust formation. When rust forms, the metal iron reacts with oxygen in the air to form a new compound, iron oxide (rust). This chemical reaction may be expressed by the following unbalanced chemical equation, which may be written either using words or using the chemical symbols for the elements:

Iron plus oxygen yields iron oxide: $Fe + O \rightarrow FeO$

A more accurate description of a chemical reaction is given by writing a balanced chemical equation. A balanced chemical equation is written so the number of atoms of each type of element is the same for both the products and reactants. Coefficients in front of chemical species indicate quantities of reactants, while subscripts within a compound indicate the number of atoms of each element. Balanced chemical equations typically list the state of matter of each reactant (s for solid, l for liquid, g for gas). So, the balanced equation for the chemical reaction of rust formation becomes:

$2\ Fe(s) + O_2(g) \rightarrow 2\ FeO(s)$

Examples Of Chemical Reactions

There are millions of chemical reactions! Here are some examples: fire (combustion); baking a cake; cooking an egg; and mixing baking soda and vinegar to produce salt and carbon dioxide gas.

Chemical reactions may also be categorized according to general types of reactions. There's more than one name for each type of reaction, so that may be confusing, but the form of the equation should be easy to recognize:

- Synthesis reaction or direct combination: $A + B \rightarrow AB$
- Analysis reaction or decomposition: $AB \rightarrow A + B$
- Single displacement or substitution: $A + BC \rightarrow AC + B$
- Metathesis or double displacement: $AB + CD \rightarrow AD + CB$

Other types of reactions are redox reactions, acid-base reactions, combustion, isomerization and hydrolysis.

Describing Chemical Reactions

Directions: Balance the equations on the lines below. State whether the reaction is a synthesis, decomposition, or replacement reaction.

Given Equation	Balanced Equation	Type of Reaction
1. $FeS + HCl \rightarrow FeCl_2 + H_2S$	a.	b.
2. $Na + F2 \rightarrow NaF$	a.	b.
3. $HgO \rightarrow Hg + O_2$	a.	b.

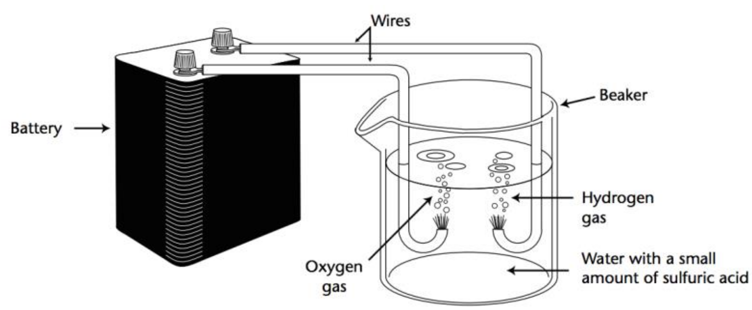
Answer questions 4 and 5 in your science journal.

4. Describe in words the chemical composition of the molecules involved and the reaction represented by the equation: $2H_2 + O_2 \rightarrow 2\ H_2O$
5. Use the principle of conservation of mass to explain why the equation in question 4 is balanced.

The Decomposition of Water

Hydrogen gas and oxygen gas can react to produce water. The reverse of this reaction can also occur. In other words, water can be broken down to make hydrogen gas and oxygen gas. The breakdown of water is a decomposition reaction. The unbalanced equation for this reaction is: $\mathbf{H_2O \rightarrow H_2 + O_2}$

For this reaction to occur, there must be an electric current through the water as shown in the figure below. Two wires are connected to a battery, and the free ends of the wires are put into a beaker of water that contains a small amount of sulfuric acid. The sulfuric acid helps to increase the flow of current through the water.



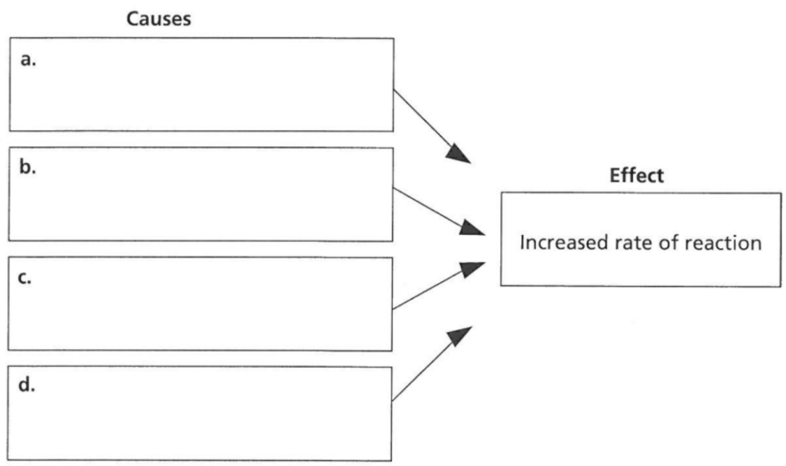
Answer the following questions in your science journal.

1. Write a balanced equation for the decomposition of water.
2. How many atoms of hydrogen are on the left side of the balanced equation? How many oxygen atoms? How many hydrogen atoms are on the right side of the balanced equation? How many oxygen atoms?
3. The water in a beaker has a mass of 200 g. An electric current is turned on in the water for two hours. Afterward the water has a mass of only 176 g. What happened to the missing mass?
4. Suppose a sample of water decomposes to make 4 g of hydrogen gas and 32 g of oxygen gas. What mass of water decomposed? How do you know?
5. Look at the figure above. How can you tell that a reaction is occurring?

Week 4 – Focus: Chemical Reactions (Part II)

Controlling Chemical Reactions *(Newsela, 2018)*

Directions: Create a 'Causes and Effect' graphic organizer in your science journal. Complete the graphic organizer as you read and annotate the text below.



Activation energy is the minimum amount of energy needed to start a chemical reaction. All chemical reactions need a certain amount of activation energy to get them started. Even exothermic reactions need activation energy to get started. Once a few molecules react, the rest will quickly follow, because the first few reactions provide the activation energy for more molecules to react. Endothermic reactions not only need activation to get started. They also need additional energy from the environment to keep going.

Chemical reactions don't all occur at the same rate. How fast a reaction happens depends on how often and with how much energy the particles of the reactants come together. Chemists can control rates of reactions by changing factors such as surface area, temperature, and concentration, and by using substances called catalysts and inhibitors. A third way to increase the rate of a reaction is to increase the concentration of the reactants. The concentration is the amount of a substance in a given volume. Increasing the concentration of reactants makes more particles available to react.

When a solid reacts with a liquid or a gas, only the particles on the surface of the solid come in contact with the other reactant. To increase the rate of reaction, you can break the solid into smaller pieces that have more surface area. More material is exposed, so the reaction happens faster. Another way to increase the rate of a reaction is to increase its temperature. When you heat something, its particles move faster. Faster moving particles come into contact more often, which means there are more opportunities for a reaction to occur. Faster-moving particles also have more energy. This energy helps the reactants get over the activation energy "hump." You can also control the rate of a reaction is to change the activation energy needed. If you decrease the activation energy, the reaction happens faster. A catalyst is a material that increases the rate of a reaction by lowering the activation energy. Catalysts affect the reaction rate, but they are not considered reactants. The cells in your body contain biological catalysts, called enzymes. Enzymes increase the reaction rates of chemical reactions necessary for life.

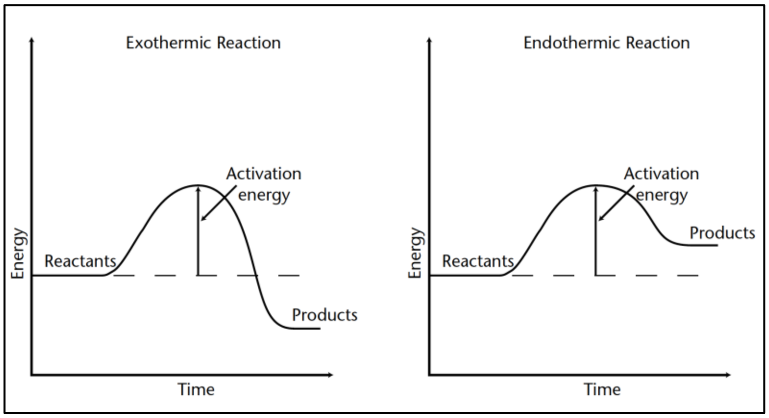
Sometimes a reaction is more useful when it can be slowed down rather than speeded up. A material used to decrease the rate of a reaction is called an inhibitor. Most inhibitors work by preventing reactants from coming together.

Directions: In your science journal, respond to the following questions.

1. What factors affect the rate of a chemical reaction?
2. Applying Concepts: Which would react more quickly in a chemical reaction: a single sugar cube or an equal mass of sugar crystals? Explain your response.

Endothermic and Exothermic Reactions

Directions: Use the figures below to answer questions 1-3. All responses should be written in your science journal.

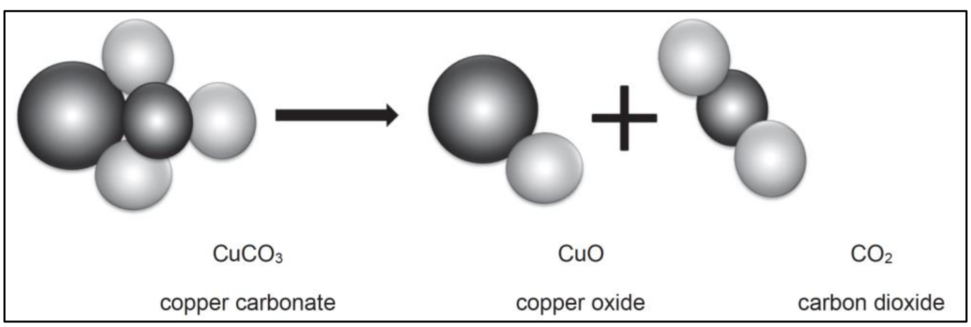


1. Use what you know about endothermic and exothermic reactions to explain the differences in the graphs above.
2. Why is the activation energy pictured as a hill in the two diagrams?
3. Explain how adding heat to the reactions shown in the diagram would change the rate of these chemical reactions. Name two other ways to change the rate of a chemical reaction.

Making and Breaking Bonds

During chemical reactions the bonds between atoms break and new bonds form. Energy must be absorbed to break a bond, so breaking bonds is endothermic. Making new bonds is exothermic because energy is released.

1. When green copper carbonate decomposes, the equation is:



   Is the reaction exothermic or endothermic? Use ideas about bonds to explain why.

2. The following shows what happens when hydrogen reacts with oxygen. The equation is: $\mathbf{2H_2 + O_2 \rightarrow 2H_2O}$
   Is the reaction exothermic or endothermic? Use ideas about bonds to explain why.

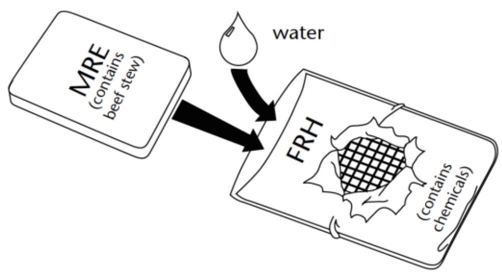
Flameless Ration Heaters

Suppose that you are a soldier on patrol far from your base camp. The weather is very cold and you wish you had something warm to eat. However, you aren't carrying a camp stove and it would be too dangerous to light a fire because its smoke would reveal your position. Luckily, you have a Meal Ready to Eat (MRE) and a Flameless Ration Heater (FRH) in your backpack. (A ration is a portion of food.)

An MRE is a meal, such as beef stew, inside a special pouch made of aluminum foil and plastic. To heat your MRE, you slide it into an FRH. An FRH is a kind of plastic envelope that contains certain chemicals. When you add water to the FRH, an exothermic reaction occurs. The heat produced by this reaction warms up your meal in about 15 minutes. The chemicals inside an FRH include magnesium (Mg), iron (Fe), and sodium chloride (NaCl). The reaction that takes place when water is added to an FRH is as follows.

$$\mathbf{Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2}$$

The reaction of magnesium and water is normally very slow. As a result, it gives off heat very slowly. In an FRH, however, this reaction occurs much faster and so it gives off heat much faster as well.



Answer questions 1-4 in your science journal.

1. Iron and sodium chloride are present in an FRH, but they are not reactants in the equation shown above. Why do you think they are included in an FRH?

2. Why do you think an FRH doesn't come with water already in it?

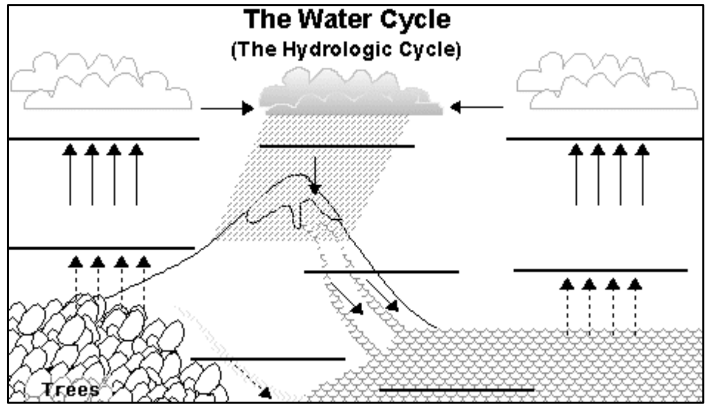
3. Do you think there are small pieces or large pieces of magnesium metal in an FRH? Explain.

4. Why is it important that the reaction in an FRH be fast?

Week 5 – Focus: Cycling of Energy in Ecosystems

The Water Cycle

Directions: Read and annotate the passage titled "*How do Solar Energy and Gravity Drive the Processes of the Water Cycle?"* (Discovery Education, 2018). In your science journal, answer the questions that follow the text.



How Do Solar Energy and Gravity Drive the Processes of the Water Cycle?

The water cycle is the movement of water among the various reservoirs, or storage locations, of water around the planet. Reservoirs of water include the oceans, lakes, and rivers; glaciers, soil, and rock; living things; and the atmosphere. There are four main processes that move water among these reservoirs: evaporation, condensation, precipitation, and flow. All of these processes involve force and energy. Water changes state between solid, liquid, and gas when it absorbs or releases energy. Water starts to move or changes how it is moving when a force is exerted on it. Water can be pulled downward by gravity, pushed upward by buoyancy, and pushed by winds.

Energy and the Water Cycle

The most important source of energy that drives the water cycle is the sun. Solar radiation (sunlight) provides the energy that melts ice to produce liquid water and that causes evaporation of liquid water to form water vapor. The phase changes can also operate in reverse: water vapor releases energy as it condenses, and liquid water releases energy as it freezes to form ice.

Sunlight also provides the energy that causes winds. As Earth's surface absorbs sunlight, it heats up. This thermal energy in the ground and water is then transferred to the atmosphere by conduction and radiation. As air warms up, it becomes less dense than the surrounding air. The cooler air sinks, forcing the warmer air upward. This force, called buoyancy, pushes air up through the atmosphere. This process of transferring energy within matter that is moving is called convection. The low pressure beneath these rising air masses is filled further by cooler air rushing in from nearby areas, which causes wind. Some winds are global winds and blow almost continuously in roughly the same direction, while others happen as a part of local weather. Winds move air masses containing water vapor from place to place. Winds also cause ocean currents, which move liquid water (and thermal energy) to different locations on Earth

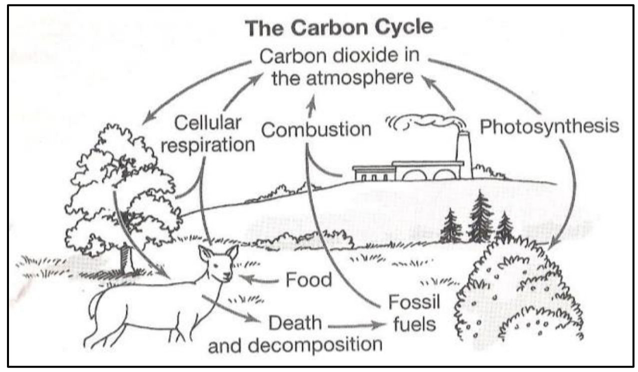
Force and the Water Cycle

The basic forces that drive the water cycle are gravity and buoyancy. Gravity causes ice crystals and water droplets in clouds to fall to the ground or ocean surface. It causes liquid water to flow downhill in streams and rivers toward lakes and oceans. It causes solid water to flow in glaciers from higher elevations to lower elevations, where the water melts and flows on the land or enters the oceans. Gravity also causes liquid water to percolate down into the ground to the groundwater reservoir. Groundwater itself flows because of gravity from higher elevations to lower elevations, and it will return to the surface in a stream within a valley.

Buoyancy is the force present when a mass has less density than the fluid around it. A warm air mass is buoyant compared to the cooler air around it. As a result, the warmer air will be forced upward by the cooler air below it. Similar processes occur in the oceans with warm masses of water. Humid air is less dense than dry air, thus as water evaporates into the air, the air becomes less dense and rises. In both cases, currents result. In the atmosphere, we call these currents winds.

1. Describe the different stages of the water cycle.
2. Explain what drives the cycling of water between the different phases and locations on Earth.

Biogeochemical Cycles: Carbon Cycle



Carbon is present in most chemical compounds that make up living things. Carbon is also stored in abiotic components of the Earth system. For example, carbon dioxide in the atmosphere, fossil fuels such as oil and coal, dead matter in the soil, and chemical compounds in rocks are all carbon reservoirs.

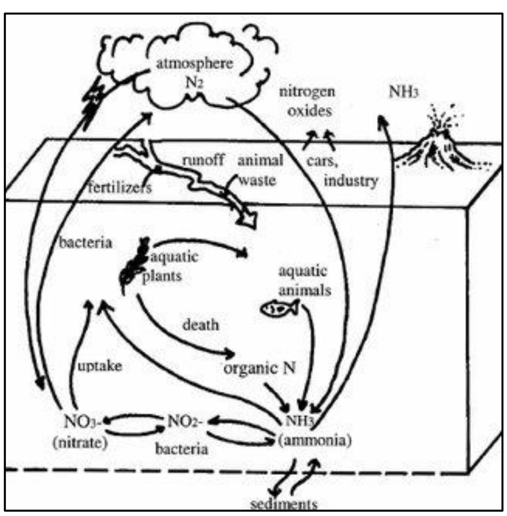
Producers remove CO_2 from the atmosphere through photosynthesis. Photosynthetic organisms incorporate the carbon into carbohydrates to store in their tissues. When consumers eat producers, they obtain the carbon, storing some of it in their tissues and releasing some back into the atmosphere through cellular respiration. When the consumers die, decomposers break down the organic matter and release carbon back into the atmosphere through cellular respiration. Carbon is also released into the soil.

Some of the carbon in the organic matter may become fossilized. Under certain conditions, the burial process stores that carbon in Earth's crust where, over millions of years, it becomes fossil fuel. Since the 1800s, humans have extracted this carbon and combusted it, releasing large amounts of carbon back into the atmosphere.

Carbon dioxide diffuses into the ocean from the atmosphere. Oceans are carbon sinks that absorb and hold large amounts of carbon. Carbon enters the aquatic biotic cycle when algae and phytoplankton convert it during photosynthesis. Some dissolved CO_2 is used in the processes of sedimentation and burial to form different types of sedimentary rock. These processes are very slow, taking millions of years, but they form extremely large carbon reservoirs.

Directions: In your science journal, create a model illustrating the roles of photosynthesis and cellular respiration in the cycling of carbon among Earth's spheres. Be sure to include the inputs and outputs for both processes in your model.

Biogeochemical Cycles: Nitrogen Cycle



About 78 percent of Earth's atmosphere is composed of nitrogen gas (N_2). However, most organisms are not able to use nitrogen in this form to build organic molecules. The nitrogen must be fixed, or incorporated into other molecules that organisms can use. Bacteria, which are involved in many steps of the nitrogen cycle, fix nitrogen into ammonia, nitrite, nitrate, and other chemicals that organisms can use. Much of the nitrogen cycle takes place below ground.

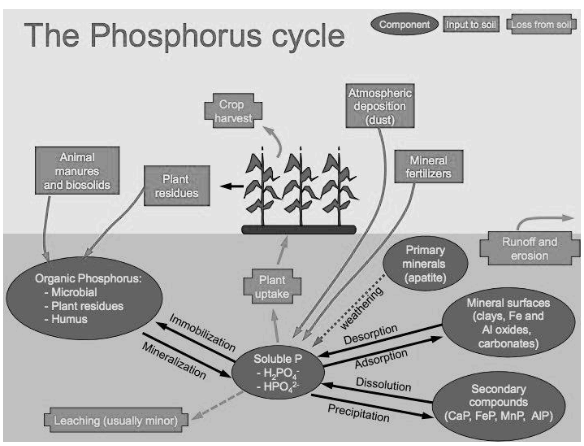
Certain types of bacteria convert gaseous nitrogen into ammonia (NH_3) through a process called nitrogen fixation. Some of these bacteria are aerobic, which means they use oxygen. Other bacteria are anaerobic, which means they do not use oxygen. In aquatic ecosystems, this task is performed by a few types of cyanobacteria. Some nitrogen-fixing bacteria on land live in small outgrowths, called nodules, on the roots of plants such as beans and peas. Other nitrogen-fixing bacteria live freely in the soil. The ammonia released by these bacteria is transformed into ammonium (NH_4^+) by the addition of hydrogen ions found in acidic soil. Some ammonium is taken up by plants, but most is used by nitrifying bacteria as an energy source. These bacteria change ammonium into nitrate (NO_3^-) through a process called nitrification.

Nitrates released by soil bacteria are taken up by plants through assimilation, which converts them into organic compounds such as amino acids and proteins. Nitrogen continues along the cycle as animals eat plant or animal matter. When decomposers break down animal excretions or dead animal and plant matter, nitrogen is returned to the soil as ammonium, in a process called ammonification. Denitrifying bacteria use nitrate as an oxygen source, releasing nitrogen gas back into the atmosphere as a waste product via denitrification.

Nitrogen fixation can occur through biological processes carried out by special types of bacteria, but it can also occur through industrial processes such as the production of fertilizer. Some nitrogen also enters the soil as a result of atmospheric fixation by lightning. Energy from lightning breaks apart nitrogen molecules in the atmosphere. Nitrogen recombines with oxygen in the air, forming nitrogen monoxide. The combination of nitrogen monoxide with rainwater forms nitrates, which are absorbed by the soil. Nitrates in the soil may be moved by water, eventually settling at the bottom of lakes, swamps, and oceans in a process called leaching.

Directions: Bacteria are microscopic organisms, but they are essential to life on Earth. In your science journal, use evidence from the nitrogen cycle to explain how the microscopic fixation of nitrogen can have such a large impact on life.

Biogeochemical Cycles: Phosphorus Cycle



Phosphorus is an important element for living things. It is a component of phosphate groups in ATP, DNA, and phospholipids in cell membranes. Phosphorus occurs in the form of phosphate salts found in ocean sediments and rocks. Geologic processes expose these rocks, and water and wind break them down, making them available to plants and animals.

Weathering of phosphate rocks by rain releases phosphate compounds in soil and water. On land, plants can take up phosphate compounds from the soil and consumers gain phosphorus by eating the producers. Decomposers then return phosphorus to the soil and water when they break down the organic matter and wastes of the producers and consumers.

Water can transport phosphorus to aquatic ecosystems through runoff and leaching. Phosphorus compounds dissolve into phosphates, where they can be taken up by algae and then consumed by other aquatic organisms. Some dissolved phosphates settle at the bottom of oceans in a process called sedimentation, becoming phosphate rocks over millions of years.

Certain geologic processes expose the phosphate rocks at the bottom of the ocean to the atmosphere. The rocks then undergo weathering, releasing phosphate compounds back into the ecosystem and continuing the phosphorus cycle. Humans also introduce phosphates into the ecosystem by mining them to make fertilizers and cleaners. Excess phosphates from human activities can enter aquatic ecosystems through runoff and leaching. Very little phosphate is naturally available in most bodies of water and any increases can lead to significant changes in the ecosystem.

Directions: In your science journal, explain how animals participate in the phosphorus cycle?

Week 6 – Focus: Energy Transformations

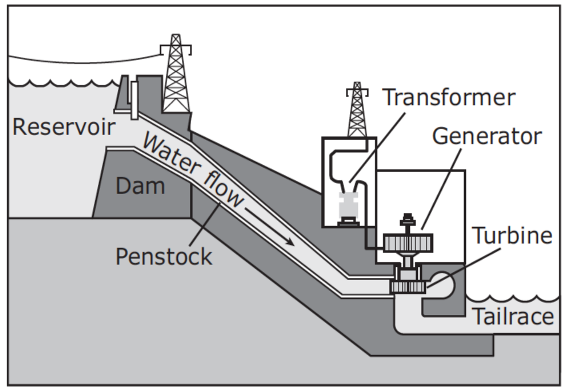
Hydroelectric Station Model: Downspout Generator

Directions: Read the information on pages 14-15 in this packet. Use the information to answer the questions 1-6.

Hydroelectric Station: The Deep Creek Hydroelectric Station is located in Garrett County, Maryland. It has two turbines that drive generators to produce 20 megawatts (MW) of electricity. The dam built for this hydroelectric station formed Deep Creek Lake. The description and model shows how a typical hydroelectric station works.

- Water enters the penstock, a large pipe running from the reservoir above the dam to the turbines near the base.
- At the end of the penstock, the water turns the turbine, a wheel or rotor with blades.
- The turbine is connected to a generator, which has several electromagnets inside many coils of copper wire.
- When the water spins the turbine, the moving electromagnets within the generator produce electricity.
- The transformer sends the electricity to the power station.
- The water flows out of the penstock and turbine at the tailrace.

Hydroelectric Station Model

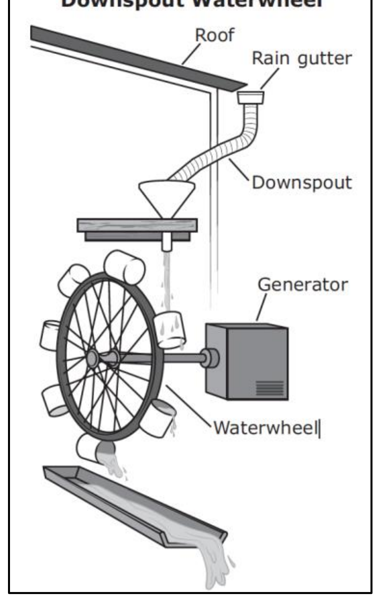


Downspout Generator: Students use the hydroelectric station model to build a downspout hydroelectric generator. A downspout is a pipe that carries rainwater down from a roof or rain gutter. Using materials from a local hardware store, the students build the waterwheel prototype shown.

The waterwheel prototype uses rain as its source of water.

- Rainwater falling on the roof collects in the rain gutter and flows into the downspout.

Downspout Waterwheel



Annual Precipitation		
State	**Average Yearly Rainfall (mm)**	**Average Number of Rain Days/Years**
Florida	1572	128
Maryland	1131	111
Nevada	244	13
Texas	1150	106
Utah	310	94

Washington	943	147

- Rainwater in the downspout flows into the containers attached to the waterwheel, making the waterwheel turn.
- The greater the volume of rainwater flowing into the container, the faster the waterwheel turns.
- As the waterwheel spins, it rotates the shaft attached to the electromagnets producing electricity.

The students gathered information on the average yearly rainfall for six states.

Calculated Downspout Power Generation	
Downspout Flow Rates (m^3/s)	**Power Generation (watts)**
5.8×10^{-3}	284.5
4.7×10^{-3}	230.5
3.15×10^{-3}	154.4
1.6×10^{-3}	78.5

Hydroelectric Station Model: Downspout Generator

The students researched data on the flow rates of water based on the amounts of rainfall, the roof area drained, and the distance between the roof and the waterwheel. The flow rate is the rate at which water is falling from the roof onto the waterwheel. The students calculated the estimated power (P) in watts (W) of the waterwheel by using the formula, $P = \rho q g h \eta$, where

Density of water (ρ) = 1000 kg/m3

Flow rate (q) = Rate of water flowing in the downspout (penstock) in m3/s

Acceleration due to gravity (g) = 9.81 m/s2

Height (h) = Change in the height of water in m

Efficiency (η) = Efficiency of the system

The students predicted the performance of a downspout waterwheel from a roof height of 5 m with different flow rates, and assuming 100% efficiency. The table shows the data calculated by students.

To check if the waterwheel generator was producing enough power to run a small household appliance, the students connected an incandescent light bulb to the generator.

Hydroelectric Station Model: Downspout Generator

1. Which statement best describes the energy of the water molecules as they move through a hydroelectric station?

A. The potential energy of the water molecules in the reservoir is equal to the kinetic energy of the water molecules being discharged from the tailrace.

B. The potential energy of the water molecules in the reservoir is equal to the electrical energy produced by the hydroelectric station.

C. The potential energy of the water molecules in the reservoir is equal to the kinetic energy of the water molecules discharged from the tailrace combined with the kinetic energy of the moving turbine.

D. The potential energy of the water molecules in the reservoir is equal to the kinetic energy of the water molecules discharged from the tailrace combined with the electrical energy produced by the hydroelectric station.

2. Select the phrases that best show the inputs and outputs of the turbines in a hydroelectric station while the turbines are in motion, and write them into the appropriate boxes. Each phrase can be used once.

Energy Inputs	**Energy Outputs**

Phrases to use:

- Kinetic energy of water
- Electrical energy
- Thermal energy
- Gravitational potential energy of water
- Sound of energy

Effect of Flow Rate on Light Bulb		
Downspout Flow Rates (m^3/s)	**Power Generation (watts)**	**Effect on Light Bulb**
8.3×10^{-4}	30.5	No light
1.67×10^{-3}	61.4	No light
2.5×10^{-3}	92.0	Flickering yellow light
4.1×10^{-3}	150.8	Dim yellow light

3. Different hydroelectric stations have different distances between their reservoirs and their tailraces.

Which statement best describes how the power generated from a hydroelectric station with a greater distance between its reservoir and tailrace compares to the power generated from Deep Creek Hydroelectric Station?

A. The power output is less due to less initial kinetic energy.

B. The power output is less due to less initial gravitational potential energy

C. The power output is greater due to greater initial kinetic energy.

D. The power output is greater due to greater initial gravitational potential energy.

Hydroelectric Station Model: Downspout Generator

4. Select the word in each set of parentheses that best completes the statements to demonstrate how energy is transformed by the downspout waterwheel prototype.

   Rainwater on the roof has (chemical/gravitational/mechanical) energy, which is converted to (electrical/gravitational/mechanical) energy when it flows to the downspout and spins the waterwheel. As the waterwheel spins, the generator converts the energy to (chemical/electrical/gravitational) energy.

5. The students want to power a fan that uses 350,000 W of electricity. At what distance below the roof would the waterwheel prototype have to sit in order to generate enough power when the flow rate is 5.0 m^3/s, assuming the efficiency of the system is 110%?

   A. 5.0 m

   B. 7.1 m

   C. 9.5 m

   D. 350 m

6. Use evidence from the waterwheel prototype to explain how the performance of the prototype could be improved. Be sure to note any trade-offs in the suggested modifications. Write your answer in your science journal.

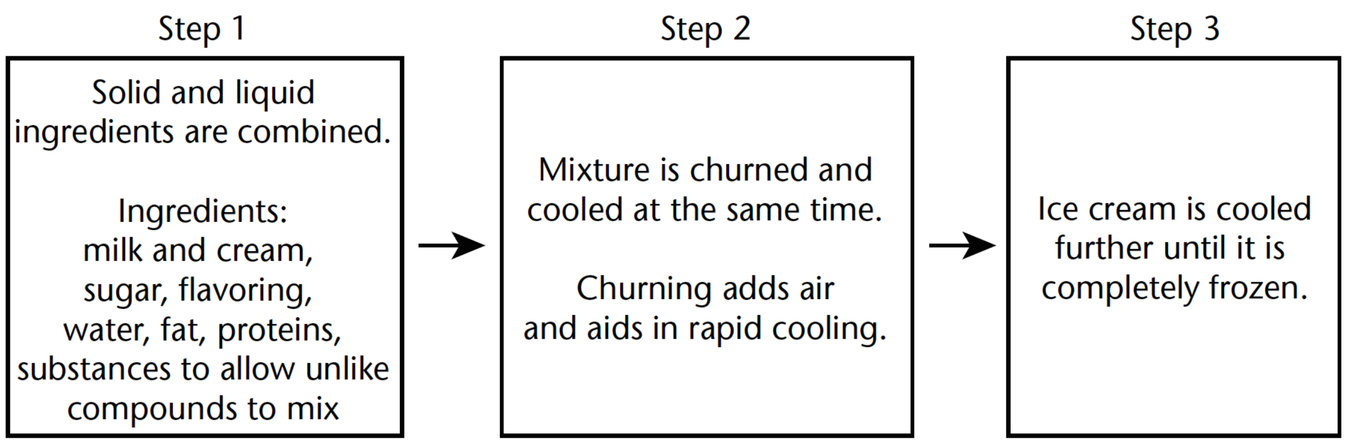
Week 7 – Focus: Acids, Bases, and Solutions

Understanding Solutions: The Chemistry of Ice Cream

A colloid is similar to a suspension in that its particles are larger than those of a solution. However, the particles of a colloid, like those of a solution, are small enough that they cannot be separated by settling or filtration. The particles in a colloid are said to be dispersed, rather than dissolved or suspended. Familiar colloids include shaving cream, whipped cream, fog, and smoke.

Ice cream is another familiar colloid. The particles in this colloid are solid fat, tiny crystals of ice, and droplets of water. A high concentration of sugars, salts, and proteins is dissolved in the water. Here, air acts something like a solvent. The particles of ice cream are dispersed in many tiny bubbles of air. Ice cream also contains other substances that allow "unlike" compounds to mix and stay mixed under the proper conditions. The unlike compounds in ice cream are water, which is polar, and fat, which is nonpolar.

The colloid formed by ice cream remains stable only at cold temperatures. When ice cream is warmed above freezing, its dispersed particles absorb energy and begin to move faster. When the fast-moving particles collide, they sometimes stick together. Eventually, the particles grow so large that they can no longer remain dispersed, and they settle out of the colloid.

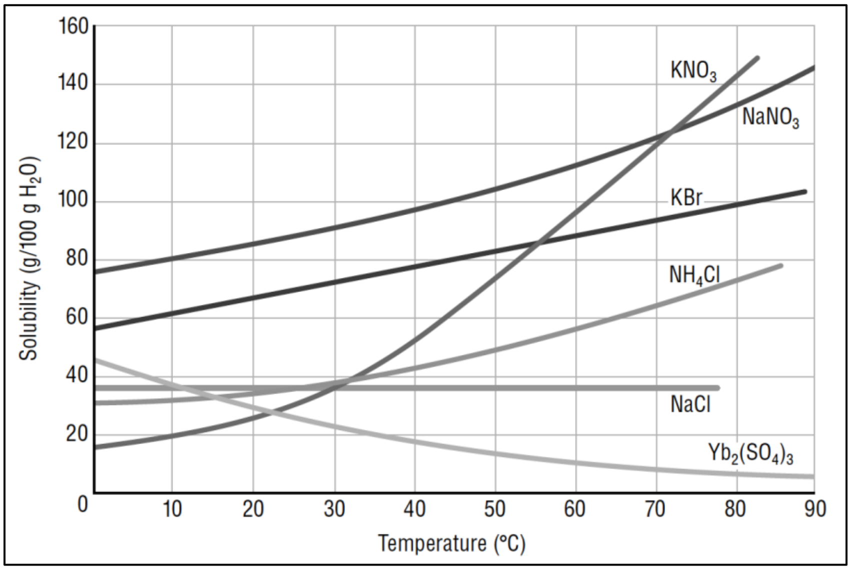


Directions: Answer the following questions in your science journal.

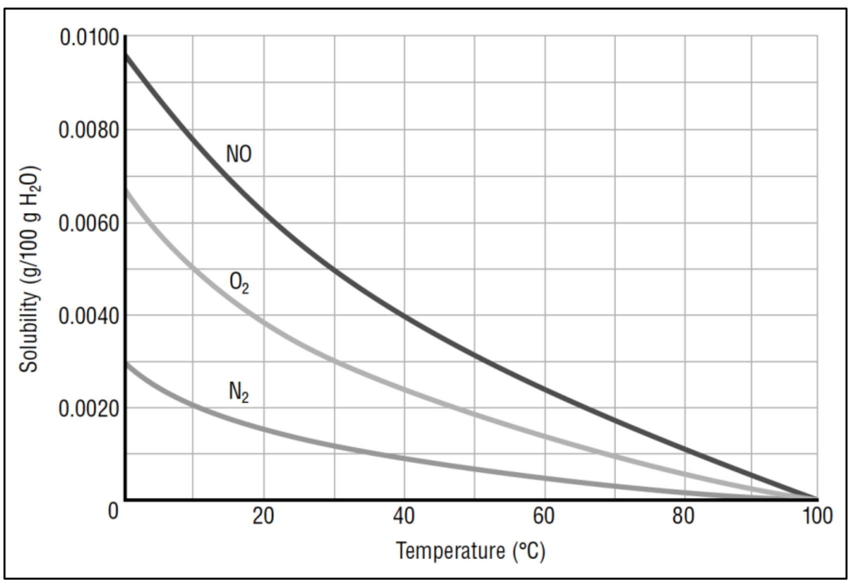
1. Suppose the liquid water in ice cream did not have solutes dissolved in it. What effect do you think this would have on ice cream? (Hint: Consider the temperature at which ice cream is kept.)
2. What do you think happens to the air in the colloid when ice cream melts?
3. Look at the diagram above. Why do you think air isn't added until Step 2 when the mixture is cooled?
4. Milk is also a colloid. It consists mainly of water, proteins, and fat. Which colloid is more stable, milk or ice cream? How do you know?

Temperature and Solubility

One of the factors that affects the solubility of a substance is temperature. The graph below shows how the solubilities of different solids change with the temperature of water.



The next graph shows how the solubilities of different gases change with the temperature of water.



Directions: Answer the following questions in your science journal.

1. What are the independent (manipulated) variables and the dependent (responding) variables on each graph?
2. What are the general trends in solubility implied by the two graphs?
3. Do all of the solids in the first graph follow the trend? Explain.
4. Which solid shows the greatest change in solubility with temperature?
5. At higher temperatures, gas particles move faster. Use this behavior to explain the change in solubility of gases.

Acids and Bases in Solution

Swimming Pool Basics

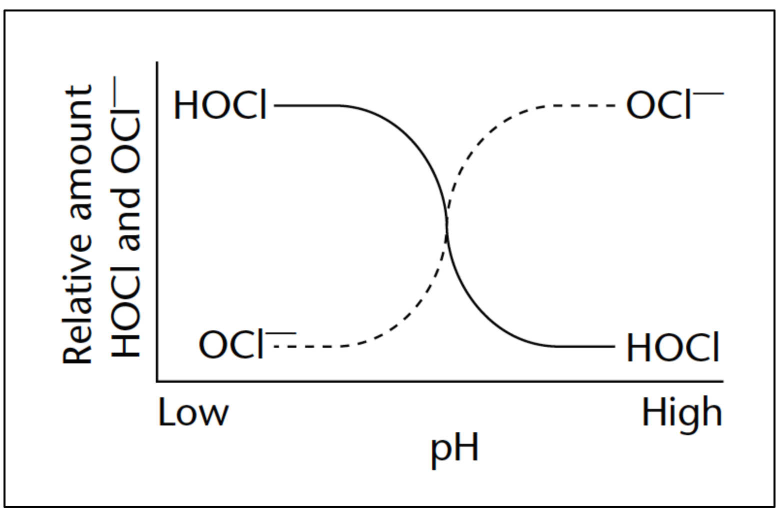
If chemicals are not added to swimming pools, tiny organisms such as bacteria and algae can multiply in the water. Algae growth can turn the water in a swimming pool cloudy and make the sides and bottom of the pool slimy. Disease-causing bacteria can make swimmers sick. One chemical added to pools contains hypochlorite ions (OCl^-). A hypochlorite ion reacts with water in the pool to produce hypochlorous acid (HOCl) and a hydroxide ion. Hypochlorous acid kills algae and bacteria. The equation for this reaction is:

OCl^-	+	H_2O	→	$HOCl$	+	OH^-
Hypochlorite ion		Water		Hypochlorous acid		Hydroxide ion

The amount of hypochlorous acid that is produced by this reaction depends on the pH of the pool water. The ideal pH for the above reaction is 7.4. Therefore, the pH of the pool water must be carefully controlled. If the pH is too high (above 7.6), the reverse of the reaction shown above occurs:

$HOCl$	+	OH^-	→	OCl^-	+	H_2O
Hypochlorous acid		Hydroxide ion		Hypochlorite ion		Water

As a result, there will not be enough hypochlorous acid in the pool water to control the bacteria and algae. Problems also occur when the pH of the pool water is too low (less than 7.2). Pool water having a low pH can damage the sides and bottom of the pool. Pool water having pH levels that are either too high or too low can cause eye irritation in swimmers. The graph below shows how the relative amounts of hypochlorous acid and hypochlorite ions vary with the pH of the pool water.



Directions: Answer the following questions.

1. What happens to the amount of hypochlorous acid (HOCl) in a swimming pool as the pH increases? What happens to the amount of hypochlorite ion (OCl-)?
2. What type of chemical could you add to a swimming pool to decrease the pH of the water? Explain.
3. What type of chemical could you add to a swimming pool to increase the pH of the water? Explain.