SCIENTISTS IN SCHOOL
SCIENTIFIQUES À L'ÉCOLE

Teacher Resource Package

Let us help you piece together the science!

Background Information an overview of the topic and theoretical concepts.

Hands-on Activities

Activity 1 - pen/paper activity
Activity 2 - short, easy-to-do activity (30-60min)
Activity 3 - short, easy-to-do activity (30-60min)
Activity 4 - longer activity (greater than 1 hr)
Activity 5 - complex activity

Teacher Resources

Literary Resources
Website Resources
Interactive White Board Resources
Multi-media

Student Resources

Literary Resources
Interactive Websites

Please help us improve our teacher resource packages!

If you have any feedback about this package or suggestions for new resources to include, please don't hesitate to contact us at: virtual@scientistsinschool.ca

Finding Solutions!

Each and every day, close encounters of a chemical kind occur! No need to be anxious however, as even water is considered to be a chemical. Water is a chemical that is essential for human existence as it encompasses more than half of our body mass and is necessary for our organs to function. It is important to have an understanding of the composition of matter so we can treat diseases, bake the perfect cake, sort the contents of our recycling bins and clean up hazardous spills. When it comes to chemical encounters, remember not to judge a substance based on its appearance alone. A clear, colourless liquid may not be water. It could also be another pure substance with similar physical properties or a mixture.

Background Information

Everything that has mass and takes up space is considered to be matter. Matter can be further classified as pure substances or mixtures. Pure substances contain only one type of particle whereas mixtures contain two or more types of particles.

Particle Theory of Matter

The particle theory of matter was developed to explain the properties and behaviour of materials. It is a model that indicates what is happening at the molecular level and cannot be observed with the naked eye. There are many variations to the postulates of the particle theory but all variations encompass the following:

1. All matter is made up of particles.
2. The particles of matter are in constant motion.
3. All particles of one substance are identical.
4. Temperature affects the speed at which particles move.
5. There are spaces between particles.
6. Particles have forces of attraction between them.

The particle theory of matter can be used to explain many phenomenon relating to matter such as solubility and the homogeneity of pure substances.

Pure Substances

The periodic table of elements contains many common substances such as copper, oxygen, carbon, aluminium, iron and helium. In fact, it contains over 110 different elements in total. All elements are pure substances that consist of a single type of atom. When two or more different elements combine chemically they form a compound, another type of pure substance. Water is a classic example of a compound. Water contains two hydrogen atoms and one oxygen atom bonded together to form a single particle. In a glass of distilled water, each particle is identical making it a pure substance. Carbon dioxide, methane gas, salt and sugar are other examples of pure substances made up of two or more different types of atoms.

Mixtures

A mixture results when different types of substances are brought together. With some mixtures, the individual substances are visible. These are referred to as heterogeneous or mechanical mixtures. Combining sand and water results in a mechanical mixture because the particles of sand and the water can be differentiated. Pizza and chocolate chip cookies are more appetizing examples of mechanical mixtures as some of the individual components of these yummy foods can be easily identified and separated. In some instances, different types of substances can combine to yield only one visible phase. These homogenous mixtures, or solutions, are translucent and uniform throughout. Salt water, apple juice and gasoline are all solutions. Solutions can occur in many forms. We often think of a solution as a solid dissolved in a liquid, but other examples include a combination of liquids, a solution of gases or even a homogenous mixture of solids. The air we breathe is a solution of gases made up of nitrogen, oxygen, argon, carbon dioxide and small amounts of other gases. Brass is a solid solution composed of zinc and copper.

Solutions have two parts, a solute and a solvent. A solute is the substance that is dissolved and the solvent is doing the dissolving. Water can dissolve more chemicals than any other solvent and is therefore referred to as the universal solvent. This is an important characteristic of water, as what we flush down our drains and sewers will be carried out to our lakes and rivers.

Like water, many solvents are liquids. This, however, is not always the case. Gases and solids can also act as solvents. How does one determine which component is the solvent and which is the solute? The rule of thumb is that the solvent is generally the substance present in the largest quantity. In air, nitrogen would be considered to be the solvent, and the other gases are considered to be solutes. In steel, carbon is the solute and iron is the solvent.

When mixing substances together to form solutions, the amount of solute and solvent being combined is an important consideration. A solution containing a large amount of solute is said to be concentrated whereas a solution with only a small amount of solute is said to be dilute. There is a limit to the amount of solute that a solvent will dissolve. This depends on various factors, including the structure of the solute and solvent and environmental conditions, such as temperature. A solution is said to be unsaturated if it is still capable of dissolving more solute and saturated if it can no longer dissolve more solute.

Separation of Mixtures

There are times when it is desirable to separate a mixture into its individual components and we do so on a daily basis: separating our whites from our coloured clothes before we wash them; sorting our groceries into the cupboard or refrigerator; filtering or decanting our coffee grounds from the delicious mixture we've brewed. The method we use depends on the type of mixture and the properties of the individual components. Other examples include using evaporation followed by condensation to separate a saline solution back to the original salt and water and centrifuging your wet clothes at the end of the wash cycle.

Fun Fact: What is an Alloy? Or a Colloid?

Alloys are homogenous mixtures of elements that have the characteristic of a metal. At least one of the elements mixed is a metal. For example, steel is an alloy which is made from a mixture of iron and carbon.

Colloids are mixtures where small particles of one substance are evenly distributed throughout another substance. The particles are suspended in the solution and they do not settle out. Milk is an example of a colloid.

Activity 1: Playing with Particle Theory

Time: 45-60 minutes

Key Terms: particle theory

Group Size: Class discussion with individual writing

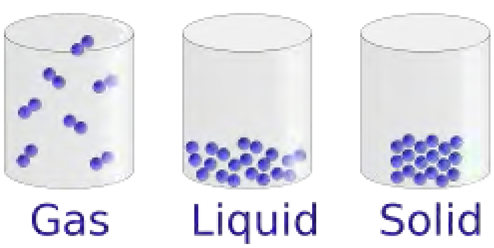
Materials:

- ☐ index cards, Bristol board or Smart Board
- ☐ paper
- ☐ pencils

Learning Goal: Students will learn about the particle theory.

Procedure:

1. Write out the six postulates of the particle theory on index cards or Bristol board strips. If you have access to a Smart Board you could do this exercise as a drag and drop. There are many variations of the postulates. For the purpose of this activity, the following have been used:
   - A. All matter is made up of particles.
   - B. The particles of matter are in constant motion.
   - C. All particles of one substance are identical.
   - D. Temperature affects the speed at which particles move.
   - E. There are spaces between particles.
   - F. Particles have forces of attraction between them.
2. Write the following scenarios on the board or display them on the Smart Board.
   - a. When sugar is added to a cup of water and stirred, the sugar disappears and spreads throughout the liquid.
   - b. All pure substances look the same throughout.
   - c. Water pours easily from a container, while honey flows slowly.
   - d. A gas spreads through a container quickly.
   - e. The volume of a liquid decreases after it has been left in an open container. The hotter the liquid, the sooner it disappears.



Source: Yelod, Wikimedia Commons

3. Have students match the postulates to the scenarios one at a time. In many cases there is more than one selection that can be made. Choose all of the postulates that apply.
4. Have students write a paragraph explaining how the chosen postulates are connected to the scenario.

Fun Fact: What is an Allotrope?

Allotrope refers to one or more forms of a pure element. For example, diamond and graphite are both allotropes of pure carbon.

Discussion:

The purpose of this activity is to have the students make connections. As long as they can justify their choices with respect to the particle theory postulates, using logic and correct science, they have met the objective of this writing activity. The following are suggestions as to which postulates would be appropriate.

Application	Postulates
a. When sugar is added to a cup of water and stirred, the sugar disappears and spreads throughout the liquid.	A, E and F
b. All pure substances look the same throughout.	A and C
c. Water pours easily from a container, while honey flows slowly.	A, B and F
d. A gas spreads through a container quickly.	A, B and E
e. The volume of a liquid decreases after it has been left in an open container. The hotter the liquids, the sooner it disappears.	A, B and D

Fun Fact: A Brief History on Particle Theory

442 BC	Democritus, a Greek philosopher, co-originated the idea that all matter is composed of indivisible elements
1803	Dalton developed a theory that matter is composed of atoms of different weights
1898	Thomson discovered the electron using properties of cathode rays
1900	Planck introduced what was later known as the quantum theory
1909	Rutherford developed the theory for the structure of the atom
1913	Bohr further developed the atomic model
1931	Chadwick discovered the neutron component of the atomic nucleus

Activity 2: Colourful Chromatography

Time: 60 minutes

Key Term: chromatography

Group Size: Pairs

Materials (per pair):

- ☐ Smarties – red, green, orange, purple, brown
- ☐ Skittles – red, green, orange, purple
- ☐ 4 lunch size paper plates
- ☐ 8 basket coffee filters
- ☐ waterproof marker
- ☐ 4 cotton balls
- ☐ warm water
- ☐ eyedropper

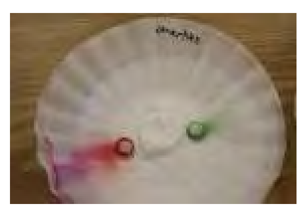
Fun Fact: Natural Red!
For centuries, the Aztecs used an insect called cochineal to dye fabrics a deep-red colour. If you crush up 100,000 of these bugs, you can extract a kilo of a deep-red dye, called carminic acid.

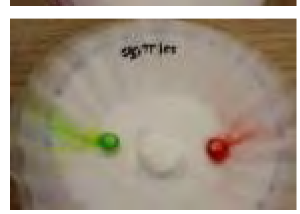
Learning Goal: Students will learn about chromatography as a method of separation.

Candies use food colouring to create those eye-popping colours. Some colours are a result of a single dye, whereas others use a combination of dyes to create a colour. Chromatography is a technique that is used to separate individual components from a complex mixture. In paper chromatography, different pigments can be separated based on their affinity for either the paper (stationary phase) or solvent (mobile phase).

Procedure:

1. Hand out two paper plates, four basket coffee filters, waterproof marker and two cotton balls to each student. Have students place two of the basket coffee filters on each paper plate, labelled with their name and either "Smarties" or "Skittles".
2. Give one student in the pair one Skittle of each of the following colours: red, green, orange and purple. The other student will get one Smartie of each of the following colours: red, green, orange, brown and purple. One plate will hold the red/green combination, while the other plate will have the brown/purple/orange.
3. Have students dip each candy quickly into warm water and place them onto their coffee filter so that they are at the edge of the flute and opposite the other candy that is sharing the plate.
4. Have students dip the cotton ball in warm water. Ensure that the cotton is very wet but not dripping. Have students place the cotton ball in the middle of the coffee filter.
5. Allow the experiment to stand for 10 minutes. Have students flip the candy over and add a small amount of water to the cotton ball using an eyedropper.
6. Let the experiment stand for another 60 minutes and have students make their observations.
7. Leave the experiment overnight. Observe the dry filter the following morning. Ask students if they observe any differences.





Set up of filters and sample results after one hour.

Observations:
Students will notice that although the candies are almost the same colour, their chromatography pattern shows that they have very different combinations of dyes. Sample observations are included in the following table. The colours on the filter are more distinct after the filter dries.

Sample observations:

Candy Colour	Skittles	Smarties
red	The colour stays close to the candy and only red is visible on the filter.	The red stays close to the Smartie with purple showing up near the filter edge.
green	Green is closest to the Skittle and then mostly yellow, with blue at the edges.	Green is the only colour visible.
purple	Red stays close to the Skittle, while blue is visible at the edges of the red.	Purple is close to the Smartie with pink at the edge of the filter.
orange	Intense orange colour stays in a circle close to the Skittle.	Orange is close to the Smartie with faded orange close to the edge of the filter.
brown	Not available	Brown is close to the Smartie with faded brown at the edge.

Discussion:
Paper chromatography is an example of solid-liquid chromatography. It is a technique that can be used to separate and identify mixtures that contain pigments. The stationary phase is usually a piece of high quality filter paper. The mobile phase (or eluent) is a developing solution that travels through the stationary phase, carrying the samples with it. Components of the sample will separate according to how strongly they adsorb onto the stationary phase versus how readily they dissolve in the mobile phase. Depending on their relative affinity for the two phases, pigments can separate into their constituent colours and can be seen as bands of different colours.

Food dyes can be either natural or artificial. Some natural food dyes that have been used for centuries are carotenoids, chlorophyll, anthocyanins, mustard, turmeric and carmine. Some of these dyes are water soluble while others are fat soluble. It is tempting to think we should only use natural dyes but some of these dyes such as saffron, carmine and annatto have been known to cause allergic reactions. Artificial food colours are used in many products as they have a more stable shelf-life, a greater variety of colours can be produced and they are more cost effective. Canada has only nine synthetic dyes that are approved for use in food products. Manufacturers use different combinations of dye to produce a unique colour for their candy. We are able to see this in the results of the chromatography experiment. The colour of the red Skittle is created using a red dye while the red colour of the Smartie is created from a combination of red and blue dyes.

The most successful food dyes are water soluble, which provide an even colour throughout the product. In these dyes, the molecules are ionic, meaning that they have both positive and negative ions held together by an ionic bond. These dyes dissolve in water because they can associate with the polar ends of the water molecules. This allows them to move with the water as it flows across the stationary phase.

Extensions:
1. Experiment with other candies, Jello or Kool-Aid to see which colour combinations are present.
2. Experiment with a different mobile phase and compare the resulting patterns with those obtained using water as the mobile phase. Some suggested liquids include salt water, vegetable oil and isopropanol (rubbing alcohol).

Activity 3: Spinning Away!

Time: 20 minutes

Key Terms: emulsion, centrifuge

Group Size: 4 students

Materials (per group):

- ☐ salad spinner (ask students to bring from home, if available)
- ☐ 3 plastic containers such as small shampoo travel containers or silicone salad dressing containers; ensure they are not taller than the salad spinner
- ☐ tape
- ☐ twist ties
- ☐ vinegar
- ☐ vegetable oil
- ☐ prepared mustard
- ☐ tablespoon and teaspoon for measuring
- ☐ marker
- ☐ stopwatch

Learning Goal: Students will learn about emulsions and methods used to separate them.

An emulsion is a mixture of two or more immiscible liquids in which one is present as minute droplets dispersed throughout the other. An emulsifier is a substance that is able to increase the stability of an emulsion and keep the liquids from separating.

Centrifuges are machines that separate the components of a mixture. An everyday example of a centrifuge would be a salad spinner, which separates water from lettuce leaves.

Procedure:

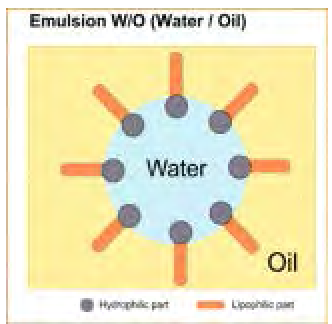
1. Provide each group the materials for the experiment. Have students label two of the plastic containers as #1 and #2.
2. In container #1, have students measure 1½ Tbsp. of vinegar, ½ Tbsp. of oil and ⅛ tsp. of mustard. In container #2, have students measure ½ Tbsp. vinegar, 1½ Tbsp. oil and ⅛ tsp. mustard. Have students secure the lids on each of the containers and seal the bottle tops with tape. Have students observe the contents of each container.
3. Have students shake the containers for approximately 10 seconds until the contents of each container are thoroughly mixed. Have students observe the containers after shaking.
4. Have students measure 2 Tbsp. vinegar into the third plastic container. This container will act as the ballast in the salad spinner to keep it balanced.
5. Have students place the ballast container in the basket of the salad spinner onto the most reinforced part of the spinner. Have students use twist ties or tape to secure the container. If twist ties are not long enough, attach multiple twist ties together. Directly opposite the ballast container, have students secure container #1 in the same way.
6. Using a clock or stopwatch, have one student time while the other student spins the centrifuge for 1 minute, letting it stop naturally. Remove container #1.
7. Have students repeat this process with container #2 and then compare the contents of the two containers.

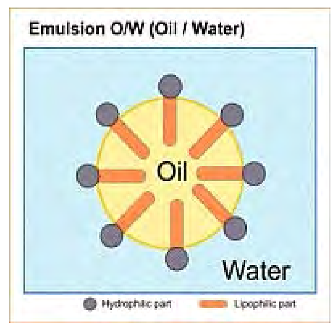
Observations:

Students will notice that the oil will float on top of the vinegar and mustard until the container is shaken. Container #1 with more vinegar than oil will stay emulsified after one minute in the salad spinner. Container #2 will have separated after one minute in the salad spinner.

Discussion:
Vinaigrette salad dressings are often shaken to create a suspension before they are used. When shaking stops, the oil and vinegar in the salad dressing begin to separate. An emulsion is a mixture of two or more immiscible liquids in which one is present as minute droplets dispersed throughout the other. There are two phases in an emulsion: the dispersed phase (droplets) and the continuous phase which suspends the droplets. Oil and water can form different types of emulsions depending on whether oil or water is the continuous phase. For example, in an oil-in-water emulsion, such as milk or salad dressing, the continuous phase is water and the dispersed phase is oil; while in a water-in-oil emulsion, such as margarine, oil is the continuous phase and water is the dispersed phase.

An emulsifier provides an interface between two immiscible liquids that make the emulsion temporarily stable. The emulsifier has a hydrophobic or fat-loving end and a hydrophilic or water-loving end. In this experiment, mustard acts as an emulsifier. It surrounds the oil droplets, with the hydrophobic end directed towards the oil and the hydrophilic end outward towards the water. Mustard is one of several natural emulsifiers. The polysaccharide found in the seed coat of mustard is the compound that makes it an effective emulsifier. Honey, turmeric or egg yolk, which contains lethicin and cholesterol, are also great emulsifiers.





Centrifuges are used daily when milk and cream are separated in food plants, water is removed from clothes in the washing machine and whole blood is divided into its components: plasma, red blood cells and white blood cells. Centripetal force is used to separate these mixtures. The denser materials in the container are pushed farther from the center of rotation to the bottom of the container and the less dense liquid remains on top.

One of the things that can affect stability of an emulsion is droplet size. In container #1, there was less oil than vinegar and therefore shaking was more effective in reducing the size of the oil droplets. This helped increase the effectiveness of the mustard as an emulsifier as the smaller droplets were more easily surrounded by the mustard, making the emulsion more stable. It would take more force than we are able to generate in the salad spinner to separate the mixture in container #1.

Ask students how this knowledge may help them make better homemade salad dressing. A stable salad dressing that does not separate can be created by adding mustard to a combination of oil and vinegar. Ensuring that there is more vinegar than oil will help stabilize the resulting emulsion. Mixing the dressing with a whisk will be more effective at stabilizing the dressing than mixing with a spoon. The whisk creates smaller droplet sizes which results in a more stable emulsion.

Extensions:
1. Have students test other emulsifiers to compare their ability to emulsify oil and vinegar. Some possible examples to test can include egg yolk, honey or turmeric.
2. Students can test whether changing the amount of mustard in the 1:3 vinegar-oil combination changes the results in the centrifuge.

Activity 4: Factors Affecting Solubility

Time: 60 minutes

Other Applications: Math

Key Terms: solubility, dissolving

Group Size: 4 students

Materials (per pair):

- ☐ electronic balance
- ☐ kettle
- ☐ thermos for hot water
- ☐ 100 mL graduated cylinders
- ☐ 8 x 250 mL beakers or plastic cups
- ☐ 500 mL measuring cup
- ☐ water
- ☐ ice
- ☐ salt
- ☐ small cup to weigh the solute
- ☐ metal spoon
- ☐ thermometer
- ☐ graph paper
- ☐ “Factors Affecting Solubility” datasheet

Learning Goal: Students will learn about some of the factors that affect solubility.

A solution is comprised of two components: the substance that is dissolved, called the solute, and the substance in which it is dissolved, called the solvent. The amount of solute that can dissolve in a solvent at a particular temperature is referred to as the solubility of the substance.

Procedure:

1. Pre-boil the water in a kettle and store the hot water in a thermos. The temperature of the hot water should not exceed 70ºC for the safety of the participants.
2. For each group of students, measure 250 mL of cold water in a 500 mL measuring cup. Add 4 - 5 ice cubes to the water and let it stand for 5 minutes. The temperature of the cold water should be 5 - 10 ºC.
3. Within their group of four, each student will use a different volume of cold water: 25 mL, 50 mL, 75 mL and 100 mL. Have each student use a 100 mL graduated cylinder to measure out their quantity of cold water into a 250 mL beaker or plastic cup as well as measure and record the temperature of their water.
4. Have students work in pairs so that one will be stirring and the other will be weighing the solute. Using the electronic balance, have students weigh 5 g of salt into a small cup or weigh boat.
5. Have students begin by adding 5 g of solute to their water and stirring with a metal spoon for 1 minute. They can check to see if the salt has dissolved by looking to see if there are any crystals on their spoon.
6. Have students continue to add the solute in 5 g increments until the solute no longer dissolves, as observed by visibly undissolved crystals on the metal spoon.
7. Have students record the maximum mass of solute dissolved for each particular volume of water on their datasheet.
8. Have students switch tasks so that their partner can now test their volume of cold water. Have students repeat steps 4 to 7 with the other volumes of solvent.
9. Have students repeat steps 3 to 8 again with the hot water.
10. Have students record all the values for each volume on their datasheet. Instruct students to plot the volume of water versus the mass of solute dissolved using different coloured pens or pencil crayons to represent hot water and cold water.

Observations: Below are sample observations recorded for the experiment:

Temperature of Water (ºC)	Volume of Water (mL)	Maximum Mass of Solute Dissolved (g)
Cold Water: 5	25	5
5	50	15
5	75	20
5	100	25
Hot Water: 60	25	10
60	50	15
60	75	25
60	100	35

Discussion:

The arrangement of the atoms in some molecules is such that one end of the molecule has a partial positive electrical charge and the other end has a partial negative charge. In this case, the molecule is said to be polar, meaning that it has electrical poles. Otherwise, it is called a non-polar molecule. The degree of polarity of each molecule in a mixture will determine if it will form a solution.

A solution is comprised of two components: the substance that is dissolved (solute) and the substance in which it is dissolved (solvent). The cardinal rule of solubility is "like dissolves like". In other words, we must use a polar solvent to dissolve a polar solute and a nonpolar solvent to dissolve a nonpolar solute. When thinking about solubility, there are two facets to consider: the rate at which a solute dissolves and the amount of solute that dissolves. The rate of dissolution can be affected by things such as agitation, temperature and surface area.

This experiment is designed to investigate the effect of temperature on the amount of solute which will dissolve. To help with understanding how a solute dissolves, we can think about three distinct steps that have to take place. First, the solute is broken into individual components; then the intermolecular forces in the solvent are overcome to make room for the solute; and finally the solute and solvent are able to interact to form the solution.

Both sodium chloride (salt) and water are polar compounds and therefore have an affinity for one another. In order for sodium chloride to dissolve, it needs to break apart into sodium ions and chloride ions. Water molecules are attracted to each other through intermolecular forces called hydrogen bonds. These forces need to be overcome to make room for the sodium ions and chloride ions. This allows the positively charged sodium ion to interact with the partial negative charge on the oxygen atom in the water molecule. The negatively charged chloride ion interacts with the partial positive charge on the hydrogen atoms in the water molecule.

In the case of salt and most other solids, the heat required in the first and second steps (breaking apart the solute; overcoming intermolecular forces in the solvent) is greater than the heat given off in the third step (solute and solvent interacting). The overall process is endothermic. The addition of heat provides the energy needed to accomplish the overall process and increases the amount of solute that can dissolve in the solvent. Thus as the temperature increases, more salt is able to dissolve.

This experiment may lead students to think that solubility always increases with temperature. This is often but not always the case. The dissolving of a solid occurs more rapidly at high temperatures but the amount that can be dissolved may increase or decrease with increasing temperature. The only sure way to determine the temperature dependence of a solid's solubility is by experimentation.

Extension:

Test another solid, such as sugar, to see the similarities and differences that result on changing the solute. Students will observe that the mass of sugar that water can dissolve will be greater than that for salt.

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Name: ____________________

Factors Affecting Solubility

Temperature of Water (°C)	Volume of Water (mL)	Maximum Mass of Solute Dissolved (g)
Cold Water:		
	25	
	50	
	75	
	100	
Hot Water:		
	25	
	50	
	75	
	100	

Activity 5: Effect of Concentration on a Chemical Reaction

Time: 30 minutes and then overnight

Key Terms: filtrate, precipitate, concentration, solute, solvent, saturated, unsaturated

Group Size: 4 students

Materials (per group):

- ☐ Epsom salts (unscented salts can be found in first aid section of stores)
- ☐ Arm & Hammer® So Clean®! Super Washing Soda (can be found in laundry aisle in some grocery and hardware stores)
- ☐ 4 basket coffee filters
- ☐ 9 clear plastic cups
- ☐ scale
- ☐ teaspoon and tablespoon for measuring
- ☐ food colouring
- ☐ 4 droppers
- ☐ water
- ☐ 4 funnels
- ☐ graduated cylinder or measuring cup
- ☐ 5 plastic spoons
- ☐ "Effect of Concentration on a Chemical Reaction" datasheet

Learning Goal: Students will learn about the concentration of a solution and its effects on the product of a reaction.

Dissolving sugar in our tea and having a drink of tap water are everyday examples of how we use solutions. There are two parts to a solution: the solute, which is the substance being dissolved; and the solvent, which is the material that does the dissolving. Tap water is an example of a dilute solution as it has many minute quantities of minerals such as calcium dissolved in it, while maple syrup is a concentrated solution, made by boiling off excess water from tree sap. Solutions can also be referred to as saturated and unsaturated. An unsaturated solution is one in which more solute can dissolve in the solvent. A saturated solution occurs when the solvent no longer dissolves more solute at a given temperature and pressure.

Washing soda is an additive that can be used to help soften water which will prevent clothes from being damaged. It is sometimes found in laundry and dishwasher detergent. Epsom salts are often used medicinally in a bath to soothe aching muscles.

Procedure:

1. Students will be testing four different concentrations of washing soda and water.
2. Provide the materials to each group. Have each student take two cups, coffee filter, funnel, plastic spoon and "Effect of Concentration on a Chemical Reaction" datasheet. Have one student label a cup with 6 g. The other students will label their cups as 12 g, 24 g or 36 g respectively.
3. Have each student add 100 mL of water to their cup.
4. Have each student take a turn placing their coffee filter on the scale and weighing their designated amount of washing soda onto their coffee filter. Students will then transfer the washing soda to the cup with the appropriate label. Have students use a plastic spoon to stir for 1 min. Repeat this for all of the different weights. Have students calculate the concentration (g/mL) of each washing soda solution as mass of solute (g) divided by volume of solvent (mL) and record on the datasheet. An alternative to weighing the washing soda, if a scale is unavailable, is to use 1 tsp., 2 tsp., 4 tsp. and 6 tsp.
5. Have each student place the coffee filter in the funnel and place the funnel in their empty cup.
6. Have each group prepare the Epsom salts solution in the last empty cup by mixing 60 mL (4 Tbsp.) of water with 25 g (2 Tbsp.) of Epsom salts. Add three drops of food colouring. Stir for 30 seconds.

7. Have students add 2 mL of Epsom salts solution, using the dropper, to each of the washing soda solutions. Have students record their observations on their datasheet, as to what happens to each solution after the addition of the Epsom salts.
8. Have each student use the dropper to wet their coffee filter with some of the mixture. Have students slowly and carefully pour their designated mixture onto their coffee filter and swirl the mixture. Scrape the precipitate with a spoon and transfer it to the filter. Use the dropper with a small amount of water to remove any remaining solid from the cup and add to the filter.
9. Have students observe any differences in the filtrate among the four concentrations and record on their datasheet.
10. Allow the setup to stand overnight to ensure that all of the liquid has filtered through.
11. The next day, have students observe any differences in the filtrate and record them on their datasheet.
12. Have students rank the cups with "1" containing the least amount of residue on the coffee filter and "4" having the most amount of residue.

Observations:
Sample observations are provided below. The colour of the residue became more intense overnight as it dried on the filter.

Observations after Epsom salts solution is added to the varying concentrations of washing soda solution (36 g on the left to 6 g on the right):

Observations after Epsom salts and washing soda solutions are poured into coffee filter:

A sample completed datasheet is provided below.

Weight (g)	Concentration of washing soda (g/mL)	Observations			Ranking amount of residue
		After addition of Epsom salts	Filtrate after initial filtration	Filtrate after leaving overnight	
6	0.06	Light and fluffy; solid sinks to bottom; appears to be the least amount of precipitate.	Blue filtrate	Darkest blue filtrate	1
12	0.12	Light and fluffy precipitate; solid sinks to the bottom.	Faint blue filtrate	Blue filtrate	2
24	0.24	Precipitate blue; some precipitate floats.	Very slight blue colour	Faint blue filtrate	3
36	0.36	Precipitate dark blue; some precipitate floats; appears to have the most precipitate.	Looks like water	No blue in the filtrate	4

Discussion:
When two different soluble salts are mixed together in a solvent, a chemical reaction may occur. Depending on the nature of the reaction, a new insoluble solid, called a precipitate, may form.

The main ingredient in Arm & Hammer® washing soda is sodium carbonate (Na_2CO_3) and Epsom salts are mostly composed of hydrated magnesium sulphate ($MgSO_4$). When washing soda and Epsom salts are mixed in aqueous (aq) solution, sodium carbonate and magnesium sulphate react to form an insoluble salt, magnesium carbonate ($MgCO_3$), as well as a soluble salt, sodium sulphate (Na_2SO_4).

The chemical reaction is: $MgSO_4\,(aq) + Na_2CO_3\,(aq) \rightarrow MgCO_3\,(s) + Na_2SO_4\,(aq)$

In this experiment, the precipitate ($MgCO_3$) was recovered using filtration. Other methods of separating a precipitate from the supernatant, such as centrifuging or decanting, could also have been used. Once the precipitate was isolated, students were able to visually determine how much magnesium carbonate had formed. The amount collected varied depending on the concentration of the original sodium carbonate solution (washing soda), with more precipitate being produced when the concentration of sodium carbonate was the highest.

All reactions have a limiting reagent which governs the amount of product which can be produced. A real life example of a limiting reagent could be demonstrated when assessing, for example, how many batches of chocolate chip cookies could be made from ingredients on hand. If you know your recipe needs one cup of chocolate chips per batch of cookies and you have two cups of chocolate chips and an excess of all other ingredients, then you are limited to baking a total of two batches of cookies. Since you have an excess of all other ingredients, the chocolate chips are the limiting reagent.

The reaction under investigation is a 1:1 reaction between magnesium sulphate and sodium carbonate. This means that each molecule of magnesium sulphate will react with one molecule of sodium carbonate. In this case, the limiting reagent was sodium carbonate (washing soda) as it was present in the smallest quantity.

The adsorption of molecules on the surfaces of solids is a very interesting and useful phenomenon. Surface adsorption is at the heart of such things as chromatography and activated charcoal filters to name just two examples. To some degree virtually all solids are capable of adsorbing material on their surfaces. In this experiment, adsorption of a coloured dye is used to assess the amount of precipitate which is produced during the reaction under investigation.

Students will notice that the colour of the filtrate changed depending on the original concentration of the washing soda solution. When using the 0.06 g/mL solution, the filtrate was dark blue, indicating that very little colour had been adsorbed by the precipitate. This is a visual indication that little precipitate had formed. When using the 0.36 g/mL solution of washing soda, a clear filtrate resulted. The clear filtrate indicated that a much larger amount of precipitate formed, adsorbing all of the food colouring from the solution.

Precipitation reactions occur all around us. For example, when the pipes in our homes get clogged, it is often because precipitates of magnesium and calcium oxides have collected in the pipes. This can happen with "hard" water. Another important precipitation reaction occurs at water filtration plants to ensure that we have drinkable water. Aluminium sulfate or alum is one type of coagulant that is added to the water in these plants to precipitate impurities, such as calcium, iron or manganese.

Extensions:

1. Have students test other laundry products to determine if sodium carbonate is present in the products formula. For example, experiment with Ivory versus Tide or test liquid detergent versus powder form.
2. Instead of looking at differing concentrations of sodium carbonate, washing soda, have students vary the amount of Epsom salts in solution.
3. Have students use the 36 gram solution of washing soda and experiment with different filters, such as different sized coffee filters, to see how pore size changes the filtrate.

Fun Fact: What is Washing Soda versus Baking Soda?

Washing soda, or sodium carbonate, is an alkaline chemical compound that is a common ingredient in homemade cleaners. It has many household and industrial uses but is primarily known as a substance to remove stubborn laundry stains. One source of washing soda is the ashes of plants. It can also be created from sodium chloride, known as table salt. Baking soda, or sodium bicarbonate, is not the same as washing soda but is a closely related chemical compound. Both washing soda and baking soda are naturally occurring substances that are mined from an ore called trona. Trona is a gray evaporate mineral that is mined underground and processed into washing soda and baking soda.

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Effect of Concentration on a Chemical Reaction

Weight (g)	Concentration of washing soda (g/mL)	Observations			Ranking amount of residue (1=least; 4=most)
		After addition of Epsom salts	Filtrate after initial filtration	Filtrate after leaving overnight	
6					
12					
24					
36					

Teacher Resources

Literary Resources

Science Rocks! Ian Graham. 2011. DK Publishing. ISBN 978-07566-7198-3.
A collection of science experiments to enhance this unit and others.

Teaching Chemistry with Toys. Jerry L. Sarquis, Mickey Sarquis and John P. Williams.1995. Terrific Science Press. ISBN 0-07-064722-4. Teaching basic chemistry principles with ordinary toys and play materials.

Website Resources

http://www.chemguide.co.uk/analysis/chromatography/paper.html *(11/03/2016)*
An in depth explanation of chromatography and how it works.

http://www.solubilityofthings.com/basics/factors_affecting_solubility.php *(11/03/2016)* An explanation of the factors affecting solubility.

http://www.ift.org/food-technology/past-issues/2013/august/columns/processing-1.aspx?page=viewall *(11/03/2016)* Discussion of emulsifiers and how they are used.

http://chemistry.about.com/ *(11/05/16)* Comprehensive website that covers abundant information on chemistry.

Multimedia

https://www.youtube.com/watch?v=IIu16dy3ThI "Precipitation Reactions: Crash Course Chemistry #9" 11:30 min (03/11/2016). Learn about precipitation reactions, precipitates, anions, cations and how to describe and discuss ionic reactions.

https://www.youtube.com/watch?v=xdedxfhcpWo "How Water Dissolves Salt" 1:34 min. *(11/03/2016)* Canadian Museum of Nature video on how salt dissolves in water.

Fun Fact: An Emulsion for Breakfast!

Milk is an example of an emulsion as it is made up of tiny globules of fat scattered throughout water. It is a special type of colloid in which oils or fats are mixed with water to create a creamy liquid or paste.

Student Resources

Literary Resources

The Usborne Library of Science: Mixtures and Compounds. Alastair Smith, Phillip Clarke and Corinne Henderson, 2001. Usborne Publishing ISBN0 7460 4628 6. An overview of pure substances and mixtures with an explanation of separation methods.

Interactive Websites

https://sciencesource.pearsoncanada.ca/quizzes/quiz_07_2b3Xn9.htm *(11/03/2016)*
Interactive test on Particle Theory

http://www.canaryzoo.com/Penalty%20Shootout%20Chemistry/The%20Particle%20Theory1.html *(11/03/2016)* A set of 10 questions pertaining to particle theory. After every correct response students get to take a soccer penalty shootout.

http://www.harcourtschool.com/activity/science_up_close/502/deploy/interface.swf *(11/03/2016)*
An interactive explanation of elements and the periodic table.

Fun Fact: Chromatograph Invention

Chromatography was a technique first discovered by the Russian botanist Mikhail Semenovich Tsvett in 1900 as he was attempting to separate a mixture of plant pigments called chlorophyll. To isolate different types of chlorophyll, he trickled a mixture of dissolved pigments through a glass tube packed with calcium carbonate powder. As the solution washed down the column, each pigment adhered to the powder to a different extent. This created a series of coloured bands that each represented a different substance. Tsvett referred to the coloured bands as a chromatogram. He also suggested that the technique, now called adsorption chromatography, could be used to separate colourless substances.

References
In addition to resources listed above, the following resources and websites were also used to develop this package:
Investigating Science and Technology 7. Pearson Education Canada. 2008. Pearson Canada Inc. ISBN 978-0-13-208004-0.
http://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/2015-2016/october-2015/food-colorings.html *(28/01/16)*; http://www.inspection.gc.ca/food/labelling/food-labelling-for-industry/list-of-ingredients-and-allergens/food-colours/eng/1348150903240/1348150959157 *(28/01/16)*;
http://chemwiki.ucdavis.edu/Inorganic_Chemistry/Reactions_in_Aqueous_Solutions/Precipitation_Reactions *(04/02/16)*;
http://www.iun.edu/~cpanhd/C101webnotes/chemical%20reactions/precipitation.html *(04/02/16)*;
http://www.softschools.com/timelines/atomic_theory_timeline/95/ *(16/03/16)*;
http://www.middleschoolchemistry.com/lessonplans/chapter5/lesson3 *(29/03/16);*
http://www.factmonster.com/dk/science/encyclopedia/mixtures.html *(30/03/16)*; http://www.discoveriesinmedicine.com/Bar-Cod/Chromatography.html#ixzz42d9YBRvd *(30/03/16)*; http://www.wisegeek.com/what-is-washing-soda.htm *(25/05/16);*
http://www.wyomingmining.org/minerals/trona/ *(25/05/16)*.

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Science Education Through Partnership

Scientists in School is a leading science education charity that reaches more Kindergarten to Grade 8 youth than any other science non-profit in Canada – more than 700,000 in the 2018-19 school year.

Through our hands-on, inquiry-based science, technology, engineering, math (STEM) and environmental classroom and community workshops, we strive to ignite scientific curiosity in children so that they question intelligently; learn through discovery; connect scientific knowledge to their world; get excited about science, technology, engineering and math; and have their interest in careers in those fields piqued.

By making science a verb - something you do - our workshops allow children's natural curiosity to reign, inspire kids to see themselves as scientists and engineers, and make connections between science and the world around them. This sets the stage for a scientifically-literate future generation who will fuel Canada's economic prosperity and think critically about the scientific challenges facing our society.

Scientists in School relies upon corporate, community, government and individual donors, as well as school board partners for support to develop new programs, continuously improve our existing programs, reach new geographic areas, provide complimentary workshops to less-privileged schools, and subsidize the cost of every one of our 24,870 annual classroom workshops.

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TD Friends of the Environment Foundation, The Flanagan Foundation

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