Chemistry Notes

Introduction to Chemistry

All matter consists of particles. The particles are made up of even smaller things called atoms and molecules. Atoms are used to describe elements and molecules are used to describe compounds. Matter, whether it is an element or a compound, is in one of three states. It can be a solid, a liquid, or a gas. The state matter is in depends on the amount of kinetic energy (energy of movement), the particles have.

If the particles have low kinetic energy, then they can only really move in one place. This would give the characteristics of a solid.

If there is heat added, the forces between the particles are weakened, and so the particles begin to move, sliding past each other. This is matter in a liquid state.

If there is a great deal of movement, where the particles are independent of one another, and they take up the full volume of space they are given, then the substance is in the gaseous state.

Forces of attraction (cohesion) between particles in liquids are fairly weak and vary from one liquid to another. In water, they are quite strong, giving water some unique properties not found in other liquids. Water molecules are attracted to each other and water beads when a drop is placed on wax paper or on glass. In a container of water, the surface molecules strongly attract each other generating surface tension which forms a skin that is difficult to break through. This skin can support pins, paper clips, and other objects that are denser than water and which should normally sink.

Matter can usually be mixed. A mixture results when the particles of one substance are mixed with those of another substance in any proportion. Some examples of mixtures are: soil, air, rocks, wood, steel, fresh and salt water, paints and blood.

When one substance is mixed in another so that it is evenly dispersed throughout, the mixture is called a homogeneous mixture. If one substance is unevenly mixed with the other, the mixture is known as a heterogeneous mixture. A solution is a special homogeneous mixture formed when one substance is dissolved in another. Dissolving is a process by which the particles of one substance become completely intermingled with those of another and stay that way permanently. E.g. skimmed milk, tea.

In solutions, the substance being dissolved (usually the substance of smaller quantity) is called the solute and the substance doing the dissolving (usually the substance of larger quantity) is the solvent.

Techniques for Separating Mixtures

Mixtures can be separated, some more easily than others. There are several techniques that can be used to separate them. The method used depends on the kind of mixture and the properties of the substances in the mixture:

A. Mixture of Solid and Solid

1. Sieves- various gauges of sieves can be used to separate different sizes of solid particles.
2. Magnets- magnetic substances can be separated
3. Wind—substances that can be moved by a light breeze can be separated from heavier substances that fall straight down in the breeze.
4. Water—floating materials can be separated from materials that sink in water.

**B. Mixture of Solid and Liquid**

1. **Evaporating**—Soluble or insoluble solids can be recovered by evaporating the water. The water is lost into the air as it evaporates, while the solid, whether dissolved or not, remains behind forming a residue.
2. **Decanting**—insoluble solids that settle out in water can be recovered by pouring off the water and letting the wet residue dry out.
3. **Filtering**—insoluble solids can be stirred up to form a suspension, which can be poured into a filtering system. The water will pass through the filter, but the insoluble substance will collect on the filter.

**Mixture of Liquid and Liquid**

4. **Decanting**—where two liquids do not mix, the top liquid is paired off or removed with an eyedropper.
5. **Distilling**—heat the mixture of liquids in a distilling apparatus. The temperature will rise to, and remain at, the boiling temperature of one liquid until all of it boils off. Then, it will rise to the boiling temperature of the next liquid, and so on. The vapours of each substance are collected in a tube which passes through a cooling system condensing the vapours back to a liquid in a container.

**C. Mixture of a Liquid and a Gas**

1. **Heating**—cold liquids including water will dissolve more gas than warm liquids.

**D. Mixture of Gas and a Gas**

1. **Liquefying**—cool the mixtures of gases down until one becomes a liquid. This requires cooling to a very low temperature (-200 °Celsius). The liquid can easily be separated from the gas.

**Saturation**

If a soluble solid is stirred into water until the water cannot dissolve any more of that substance, then the solution formed is known to be saturated at that temperature.

**Matter and Change**
Matter does not always remain the same. It undergoes change depending on conditions. Some of these changes are reversible, while others are not (irreversible).

In a **reversible change** that matter can be brought back to its original form. **Irreversible change** is where the change is very difficult, or even impossible to reverse.

There are also **physical changes** that happen to matter. In a physical change the matter is still what it was originally, but its appearance has changed. E.g. paper and crumpled paper… both are still paper.

In **chemical changes** the matter is no longer what it was originally. It has changed so that it has become something else. Usually another indicator of a chemical reaction is that there has been **heat, energy, or light produced**. E.g. paper and burned paper… the paper is no longer paper. It is now something completely different … it is now carbon.

**How Does Temperature Affect the Speed of Molecules?**

Hot water molecules move more rapidly than cold water molecules. The dissolving sugar molecules are therefore dispersed more completely throughout the liquid and a greater amount of sugar is dissolved in the hot water.

As temperatures increase, molecules move faster. The food coloring should diffuse noticeably more rapidly in the hot water than in the cold water.

**Acids and Bases and pH**

Solutions are usually tested for their **pH levels** which indicate whether the solution is an **acid** or a **base**. The pH scale ranges from 0 to 14 with 7 being the neutral point. A pH above 7 shows us that the solution is basic and a pH below 7 indicates that it is acidic. In order to test for pH we use blue and red litmus paper. Blue = basic Red = acid. When both red and blue strips retain their original colour after testing one item, that item is said to be neutral.

**Mixture, Mixture, Where’s the Mixture?**

Pure substances are difficult to find in nature and often are expensive to produce through a refining process. Sugar and salt are fairly pure substances although salt is generally iodized so it is a mixture.

A mixture results when the particles of one substance are mixed with those of another substance in any proportion. A number of natural and man-made substances around us are mixtures including soil, air, rocks, wood, steel, fresh and salt water, paints and even blood.

When one substance is mixed in another so that it is evenly dispersed throughout, the mixture is called a homogeneous mixture. If one substance is unevenly mixed with the other, the mixture is known as a heterogeneous mixture. A solution is a special homogeneous mixture formed when one substance is dissolved in another. Dissolving is a process by which the particles of one substance become completely intermingled with those of another and stay that way permanently.

**Using Sieves**

The size of solid particles decides which size of sieve is the most effective at separating different solids.

**Using Magnets**
Only materials containing iron, cobalt, nickel or neodymium are attracted to a magnet. Magnets are used to separate metal from non-metal objects. A magnetic field is able to pass through plastic.

**Using Air**

When a fan is used to separate solids, the larger/heavier particles fall closer to the fan. Smaller/lighter particles are carried farther away from the fan by the moving air. The greater the difference in the masses of the two solids, the easier they are to separate.

**Using Water**

If something is able to float (is buoyant) that is a useful property for separating some solids in a mixture. Mixing sawdust and sand works extremely well because the sawdust clearly floats while the sand sinks. This makes it much easier to separate. Mixing solids such as aquarium rocks and sand are more difficult to separate using flotation because both sink. Peat moss immersed in water tends to float. Peat moss becomes saturated much faster in hot water.

**Sweet and Sour**

*****Safety Note: Never taste anything in Science unless you are told to do so by the teacher. Tasting things in Science can be very dangerous. In solutions involving solids and liquids, the molecules of the substance dissolved become permanently dispersed in the liquid forming a homogeneous mixture. The substance doing the dissolving is the solvent and the substance being dissolved is called the solute. Separating a mixture of a soluble solid and a liquid is most easily accomplished through evaporation of the solvent. In the lemonade activity, the lemon juice is also a mixture. The liquid component will evaporate. The solid component from the lemon juice will remain with the sugar.

**Mixing Liquids**

Some liquids, such as alcohol and water, mix completely forming a solution that can only be separated by distillation. Some liquids do not mix. If they do mix, they will separate according to density. The more dense liquid will settle to the bottom. Liquid mixtures that do not form solutions can be separated by decanting, using an eyedropper, or by distilling.

**Layering Liquids**
Liquids form distinct layers with the heaviest (densest) layers at the bottom and the least dense liquid at the top. The order from the bottom to the top of the following liquids would be: glycerin, water, cooking oil and alcohol.

When pouring liquids it is important that the cylinder be tilted, so that the liquids can slide carefully down the side of the cylinder. This way there is less turbulence or disturbance of the liquids within the cylinder.

**Dissolving Lifesavers**

Some factors affect the rate at which dissolving happens: size of particles, the temperature of the water, stirring/shaking, and the type of solvent.

The more kinetic energy (speed of moving particles) the particles of solvent have, the faster they will dissolve the solid. Thus, the rate of dissolving increases with temperature. It also increases when the surface area of the solute increases because more particles of solute can be bumped.

**The Solution to Recovery**

Use small amount of powder. If too much powder is used, some will settle out even though much of it has dissolved and you may think that no solution was formed. If the powder is not soluble, it will first make a suspension (the water will become cloudy), but eventually the powder will settle out on the bottom of the container.

**Techniques for Recovering Powders (Solutes) from Solutions and Powders from Suspensions**

A. **Pouring off the Water (Decanting)**

Let the solid (powder) settle to the bottom of the container and pour the water off. Suspensions of cornstarch and calcium carbonate can be separated this way.

B. **Filtering**

Use a coffee filter/paper towel to filter the powder out of the water. A second filtering may be required if the liquid that passes through the filter is cloudy. This technique will work for cornstarch, baking powder, baking soda, calcium carbonate, and talc. When you filter a solution and a suspension, only the components of a suspension can be separated this way. It does not work for a solution.

C. **Evaporating the Water**

One way to recover the solid from a solution is to evaporate the water. Note: a solution when poured through the filter does not separate the powder from the water. Therefore, it is necessary to evaporate the water by pouring the solution into a Petri dish (labeled with the name of the solution e.g. salt solution) Leave it overnight (possibly two nights) in a warm room. You should use a magnifying glass to examine the Petri dish after the water has evaporated.

When you recover the solute by evaporation, you will produce crystals.
Crystals Galore

A crystal is a solid unit in which the molecules have been arranged in repeating patterns or networks. Crystals can grow in a solution by accretion (an increase in size by gradual growth or additions). The slower the rate of evaporation, the larger the crystal formation will be.

When you are working on an experiment where you are making crystals, please be sure that when you increase one of the substances, that you do not exceed doubling the amount. There should also be proper ventilation or an open window when working with ammonia. There is a concentrated odor, so it would be best to make the crystals in a place where they can be left undisturbed for several days.

Crystals which grow up on the sides of the jar or container may be recycled by pushing them back into the solution with a stick.

Salt Crystals

When a solid dissolves in a liquid, a solution has been made. If the solution cannot dissolve any more of the solid, it is said to be saturated.

Larger crystals require more time and slower evaporation. To slow down the rate of evaporation, we use a tall jar (less surface area is exposed to be evaporated).

A small seed crystal on a thread helps the crystal to grow.

Since warm to hot water is used to dissolve the salt, wrap a cloth around the jar to slow down the rate at which the water in the jar will cool. This will help to form larger crystals.

Crystals can be made with various substances, such as Epsom salts, pickling salt, etc. Some of these crystals may take weeks or months to grow.

Water Droplets

Drops of water are shaped like balloons (round and 3-dimentional). The film that forms on the surface of a liquid is called surface tension. Surface tension is due to cohesion (cohesion is the force of attraction between the particles (molecules) of a substance). Water is extremely cohesive and has strong surface tension.

The Great Bulge

The surface of water is rounded and is able to hold the water above the rim of the cup. Instead of overflowing, the water seems to be held together by an invisible skin. Although there is not a skin (such as the kind you would find on boiled milk or mushroom soup), there is still a surface tension (cohesion of molecules).

Challenge: Using an eyedropper, water and a penny, see how many water droplets you can place on the surface of a penny before it overflows.

Floating a Paper Clip

The paper clip must be completely flat to float. The large and small bends in the paper clips must be in the same plane (completely flat, not bent).

All particles of matter including those of liquids have attractive forces or cohesive forces that draw the particles of the substance together. These forces are relatively strong in water, but weak in others such as alcohol and oil.
The way you are able to see evidence of cohesive forces are the beading effects of water when it is placed on a sheet of waxed paper or when droplets of water fall through the air. The attraction of water particles to each other results in surface tension.

This property of water can be explained this way: In a glass of water, the water particles in the centre of the glass distribute their attractive forces for one another in all directions. The particles at the surface, however, don’t have any articles above them to attract, so the attractive forces exerted on the particles below and beside them can be stronger. The result is that the particles on the surface attract each other so strongly it is difficult to break through them.

The surface tension of water can support objects that normally should sink as long as the attractive forces are not disturbed by the object. This is why the object must be placed gently on the water surface so that the mass of the object does not drive the object through the surface and why the object must be dry to begin with. If the object is wet the water on the object will join with the water in the container and the attractive forces will form on top of the object rather than underneath. As a result, the object will sink.

The weight of the object will depress the skin of the water much like a person depresses a trampoline when lying on it. When viewed from the side, the attractive forces would look like the sketch below.

Detergent molecules have one end that likes water and binds to it. The other end does not like water and thus repels it. Therefore, when added to water, detergent molecules will mix with water, but in the process, they interfere with the cohesive forces among water molecules, weakening the surface tension.

When a drop of detergent is placed on the surface, the paper clip presses into the water (the soap breaks the tension). When the tension breaks, the clip sinks to the bottom of the cup.

Gas in a Bag

When vinegar and baking soda mix, a chemical reaction takes place and a gas, carbon dioxide (CO2) is produced.

The generation of CO2 happens quickly. Take care not to pour any of the vinegar solution out of the bag onto the candle. When the CO2 is poured out of the bag onto the candle flame, the flame is extinguished.

A chemical reaction has taken place when a substance changes colour, odor, temperature or produces a gas. In a chemical reaction a new substance is created.

Carbon dioxide is odorless, tasteless, colourless, is heavier than air and does not burn. It is used to put out certain types of fires and also used in carbonated drinks.

CO2 can also be generated by putting 10 mL of yeast, 10 gm of sugar and 60 mL of warm water in a medium Ziploc bag. Remove the air from the bag and seal. Wait several minutes. Test for CO2 by pouring the gas onto a tea light candle in a jar. NEVER do this experiment unsupervised.

Baking yeast is a fungus that lives on sugar. It produces CO2. In baking, the CO2 forms gas bubbles that cause muffins or bread to rise.

Testing Powders

A chemical reaction has occurred when a substance changes colour, an odor is generated, the temperature changes, or a gas is produced. In a chemical reaction, a new substance is created. Chemical changes are generally irreversible. In a reversible change the chemicals can be brought back to their original form. An irreversible change occurs in a
chemical reaction where one or more substances interact to form new molecules and substances and cannot return to their original structure.

**Basically Acidic**

The pH scale measures the degree of acidity in an item. If red (pink) litmus paper remains red and the blue litmus paper turns red, the item being tested is an acid. When the red litmus paper turns blue and the blue litmus paper remains blue, the item is a base. If there is no change on either strip then the item is said to be neutral.

******Note:****** Blue indicates a base. Both words begin with “b”.

**Cabbage Chemistry-Acid/Base Indicator**

You can make a home-made acid/base indicator. It is made using red cabbage. Chop the cabbage into 2-3 cm cubes and place into a large pot with 3 litres of water. Bring to a boil and simmer 30 minutes. Strain off the cabbage and keep the liquid. Discard the cabbage pulp. You should also add 50 ml of rubbing alcohol to the cabbage liquid (the alcohol is used to keep the cabbage from going bad). The alcohol does not affect the indicator in any way, but is necessary if you intend to keep the indicator more than a few days. Refrigerate the cabbage indicator until ready to use.