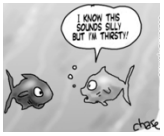
Section 1
Understanding Solutions

- On a hot day, you may think that a cool glass of plain water would be refreshing.
- However, if the glass were actually filled with "plain" water, it would taste stale.
- This is because plain water is distilled water, meaning that there is nothing in the liquid but water.
- The water you are used to drinking has a variety of other substances in it, including chloride, fluoride, and several metallic ions.



Solutions and Suspensions

- I'm going to mix water with pepper and water with salt in two different containers.
- What do you observe?

- The pepper did not mix very well with the water while the salt dissolved.


- You can still scoop out the pepper.
- **Definition:** Suspension – a mixture in which particles can be seen and easily separated by settling or filtration.

Solutions and Suspensions

- Suspensions are not mixed evenly.
- One mouthful of the pepper-water suspension may not taste too much like pepper while another may taste more like pepper.
- The salt disappeared.

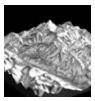
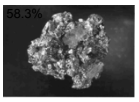
- **Definition:** Solution – a well-mixed mixture.
- Each sip of the salt water will be just as salty as the last and the next.

Solutions and Suspensions

- Unlike a suspension, a solution has the same properties throughout.
- Solutions and suspensions also differ in the size of their particles and the way the parts of the mixtures can be separated.
- The components of a suspension can be separated using a filter.
- The components of a solution cannot be separated using a filter, however, the solvent can be evaporated away to separate the components.

Solvents and Solutes

- **Definition:** Solvent – the part of a solution present in the largest amount.
- The solvent dissolves the other substances in a solution.
- **Definition:** Solute – a substance present in a solution in a smaller amount and dissolved by the solvent.


- For each of the pairs above, identify the solute/solvent.

Water as a Solvent

- In many common solutions, water is the solvent.
- Sugar water, for example, is the basis for flavored soft drinks.
- Dissolving carbon dioxide in sugar water produces soda.
- Because water dissolves so many substances, it is often referred to as the "universal solvent."

Water as a Solvent

- Water-based solutions are important for life.
- For example, nutrients for plants are dissolved in water in the soil.
- Sap is a solution that carries sugar to tree cells.
- Water is the solvent in saliva, blood, and tears.
- Reactions take place in solution in cells.

Solutions Without Water

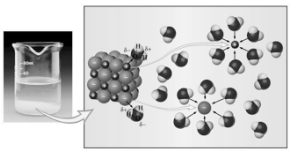
- Many solutions are made with solvents other than water.
- The table below has several examples of solutions both with and without water.

Solute	Solvent	Solution
Gas	Gas	Air (oxygen and other gases in nitrogen)
Gas	Liquid	Soda water (carbon dioxide in water)
Liquid	Liquid	Antifreeze (ethylene glycol in water)
Solid	Liquid	Dental filling (silver in mercury)
Solid	Liquid	Ocean water (sodium chloride and other compounds in water)
Solid	Solid	Brass (zinc in copper)

Particles in a Solution

- **Whenever a solution forms, particles of the solute leave each other and become surrounded by particles of the solvent.**
- Recall that water molecules are polar, meaning that they have a partially positive end and a partially negative end.
- These partial charges are attracted to the full charges of the ions in an ionic compound.
- As a result, the partial charges of several water molecules will surround the ions of an ionic compound, separating them from one another.

Ionic Solids in Water



- The water will continue this process as each new layer of ions is exposed to the solvent.
- The ions are being *hydrated* in this process.

Molecular Solids in Water

- Not all substances break apart into ions in solution.
- A molecular solid, such as sugar, will break up into individual, neutral molecules.
- The polar water molecules will surround the sugar molecules, separating them from one another.
- The more polar the molecular solid, the easier it will be for water to break apart and hydrate.

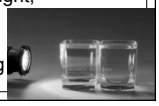
Solutions and Conductivity

- One way to distinguish between ionic and molecular solutions is to test the conductivity of the solutions.
- Ionic compounds, when dissolved in water, are good conductors of electricity.
- Molecular compounds, when dissolved in water, are not usually good conductors of electricity.
- Therefore, if a solution conducts electricity, it most likely has an ionic solute.

Colloids

- Some mixtures are neither solutions nor suspensions.
- Jell-o, for example, is a colloid.

- **Definition:** Colloid – a mixture with small undissolved particles that do not settle out.
- **Solutions and colloids differ in the size of their particles and how they affect the path of light.**
- Colloid particles are big enough to scatter light, unlike those in a solution.
- Other colloids include mayonnaise, shaving cream, and whipped cream.



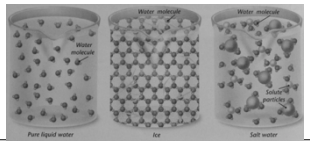
Effects of Solutes on Solutions

- When ice cream is made, it cannot be frozen using just ice.

- This is because the solute particles lower the freezing point to below 0°C.
- Therefore, rock salt must be added to the ice-water solution used to freeze the ice cream.
- The salt lowers the freezing temperature to a point where the ice is able to solidify the ice cream.

Lower Freezing Points

- **Solutes lower the freezing point of a solvent.**
- A glass of pure water will freeze into ice without anything to impede its progress.
- Salt water, however, has bulky ions in the way of the water molecules coming together to form the structure of ice.



Higher Boiling Points

- **Solutes raise the boiling point of a solvent.**
- As a liquid vaporizes, it gains enough energy to break free from the liquid state.
- As the temperature increases, so does the vaporization.
- Eventually, the vaporization will change from just evaporation to boiling.
- Solute particles allow fewer solvent particles to be exposed to the surface of a liquid.

Higher Boiling Points

- It also requires energy to overcome the attraction of the solvent particles for the solute.
- Therefore, it will take more energy for the solvent to boil.
- In the case of water, this would happen at a higher temperature than 100°C.
- Car manufacturers utilize these concepts to prevent a car from freezing and overheating.
- Antifreeze is capable of preventing both by lowering the freezing point to -13°C and raising the boiling point to 176°C.

Section 2
Concentration and Solubility

- Note that solutions have strengths.
- A weak tea, for example, is lighter than a dark tea, as seen in Figure 8 on page 184.
- These two teas differ in concentration of solute.
- **Definition:** Dilute Solution – a mixture that has only a little solute dissolved in it.
- **Definition:** Concentrated Solution – a mixture that has a lot of solute dissolved in it.

Concentration

- The concentration of a solution can be altered by adding more solute or solvent to a solution.
- For example, fruit juice concentrates are made by removing the water from the juice, making the solution more concentrated.

- When you add water back to the concentrate, you are diluting it into a drinkable mixture.

Measuring Concentration

- **To measure concentration, you compare the amount of solute to the amount of solvent or to the total amount of solution.**
- The method used to determine the concentration of a solution will vary dependant on the type of solution.
- For example, you can measure the solute in grams and the solvent in mL or L. You could measure the solute in mL or L instead.
- Concentrations can also be given as percents.

Solubility

- **Definition:** Solubility – a measure of how well a solute can dissolve in a solvent at a given temperature.
- Different temperatures will yield different solubilities.
- In order to compare the solubility of two solvents, the same units must be used.
- Often, solubility is given in grams of solute per 100g of solvent.

Saturated and Unsaturated Solutions

- Just because you can dissolve a certain amount of solute in a solvent doesn't mean you have.
- In the case where the amount of solute in the solvent matches the solubility, the solution is considered to be saturated.
- **Definition:** Saturated Solution – a solution containing as much dissolved solute as possible at a given temperature.
- Adding more solute to a saturated solution will not change the concentration.

Saturated and Unsaturated Solutions

- The solute added to a saturated solution will fall to the bottom of the container unaltered.
- If a solution has less solute than the solubility allows for, it is considered to be unsaturated.
- **Definition:** Unsaturated Solution – a solution that does not hold as much solute as possible at the given temperature.
- If more solute is added to an unsaturated solution, the concentration will increase until saturation has occurred.

Working with Solubility

- Solubility will be given for a specific solvent at a given temperature.
- Let's have a look at Figure 10 on page 186.
- The table compares the solubility of four common household chemicals in water at 0°C.
- Which of these four chemicals is the most soluble? The least?
- Figure 11 shows the difference in the amount of sugar vs. baking soda able to be dissolved in water at 0°C.

Working with Solubility

- Solubility is a characteristic property of a compound.
- Is it a physical property or chemical property?
- It can be used to help determine the difference between two otherwise seemingly identical substances.
- For example, since you would not taste the difference, how would you tell the difference between salt and sugar?

Changing Solubility

- **Among the factors that affect the solubility of a substance are temperature, pressure, and type of solvent.**
- Ever notice how it is easier to dissolve sugar into hot tea than into ice tea?
- Sugar crystals may form if I saturate hot tea with sugar and then cool it down. Why?
- By cooling the solution, I have decreased the solubility of the sugar.

Temperature

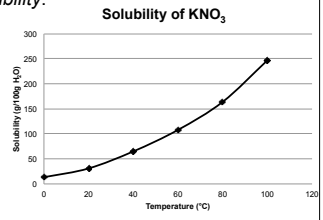
- For most solids, solubility increases as temperature increases.
- This is why temperature must be reported with a solubility.
- Cooks use this principle to dissolve enough sugar into candies, fudge, or peanut brittle.

- Because the exact temperature can affect the results, most cooks use a candy thermometer to ensure the correct solubility.

Sharpen Your Skills

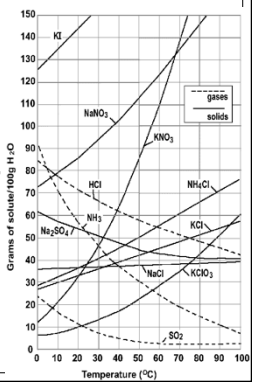
- Use the data table below to graph the solubility of potassium nitrate in 100g of water. The horizontal axis should be labeled *Temperature* and the vertical axis should be labeled *Solubility*.

Temperature (°C)	Solubility (g/ 100g water)
0	13
20	31
40	65
60	108
80	164
100	247



Solubility Graphs

- Solubility is often found by reading a graph such as the one you just made.
- However, for the sake of space, several compounds may be found on a single graph, as seen to the right.
- Try using your handouts to determine the solubility of NH_4Cl at 80°C.



Temperature

- When heated, a solution can hold more solute than it could before.
- Sometimes, when a heated saturated solution cools slowly, the extra solute will stay in solution.
- **Definition:** Supersaturated Solution – a solution that has more dissolved solute than is predicted by its solubility at the given temperature.
- If a crystal of the solute is added to a supersaturated solution, the extra solute will come out of solution.

Temperature

- Unlike most solids, gases become less soluble when the temperature goes up.
- Notice on your solubility curves that the solids (solid lines) have increasing slopes as the temperature increases but that gases (dashed lines) have decreasing slopes as the temperature increases.
- For example, carbon dioxide will dissolve more in cold water than in warm water.
- A warm soda will fizz more than a cold soda when opened.

Pressure

- Pressure will affect the solubility of gases.
- A higher pressure will lead to more gas dissolving.
- To increase the solubility of carbon dioxide in sodas, they are packaged under increased pressure.
- Opening the bottle or can reduces the pressure, allowing for the gas to come out of solution quickly.

Pressure

- Scuba divers use this principle when diving.
- Air is 80% nitrogen gas.
- The further a diver descends into the water, more nitrogen dissolves into the diver's blood.
- This is because pressure increases with depth.
- If the diver returns too quickly to the surface, the nitrogen will bubble out of his/her blood and block the blood flow.
- This condition is called the bends.

Solvents

- Some solvents dissolve solutes better than others.
- For example, oil will not dissolve water very well, nor will it dissolve food coloring.

- This is because water and food coloring are polar while oil is very nonpolar.
- Polar and nonpolar substances do not mix well.
- This principle is used in your body daily.

Solvents

- You need vitamins to keep your body working.
- There are two types of vitamins: those soluble in fat and those soluble in water.
- The water-soluble vitamins are not stored in your body, but rather are removed with other waste.
- In order to get these vitamins, you may eat certain foods or take a vitamin supplement.
- Too much of a vitamin can be almost as harmful as not enough.