Unit 1 - Pure Substances and Mixtures
Chapter 2: Solutions

2.1 Solutes & Solvents

Vocabulary:

solvent – the larger part of a solution
- the part of a solution into which the solutes dissolve

solute – the smaller part of a solution
- the part of a solution that dissolves in the solvent

dissolve – to mix one type of matter into another type of matter to form a solution
dissolving – mixing completely with a solvent to form a solution
alloy – a solid solution that is a mixture of two or more metals
pollution – contaminants in the environment that could harm living things

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Ocean water is a solution - water is the solvent
- salt and other minerals are the solutes

Steel is a solution - iron is the solvent
- carbon, manganese, vanadium, chromium, tungsten are the solutes

Tea is a solution- water is the solvent
- tea particles are the solutes

Air is a solution - nitrogen is the solvent
- oxygen, carbon dioxide, argon, water vapour and other gases are the solutes

Soda water is a solution – water is the solvent (it is present in the greatest amount)
- carbon dioxide gas is the solute

Water is used in the body to dissolve substances that the body needs, such as salts, sugars, and other nutrients. Once in a liquid solution, these solutes can be easily transported to the parts of the body where they are needed.

Pollution is a term for any contaminant in an environment – whether a pure substance or a mixture – that could harm the living things in that environment. Pollution can get into the water from the run-off of fertilizers and pesticides, from waste created by mining and industrial activity, from sewage, and from household products poured down the drain.

2.2 Dissolving & the Particle Theory

Vocabulary:

soluble – able to dissolve in a specified solvent (e.g. salt is soluble in water)
insoluble – unable to dissolve in a specified solvent (e.g. sand is insoluble in water)

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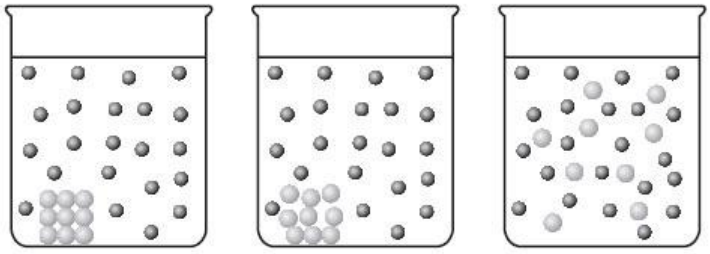
1. **What happens when solutes dissolve – using Particle Theory**

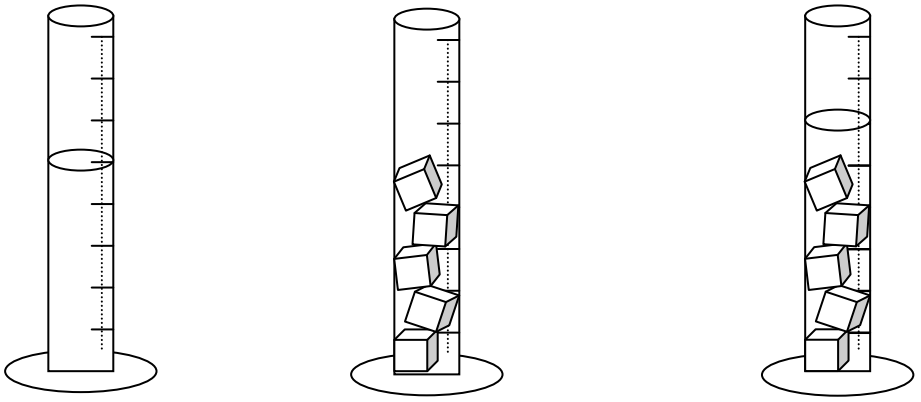
The attractions between the solvent particles and the solute particles are stronger than the attractions between the solute particles. The attractions between the solute and solvent particles pull the solute particles apart. The random motions of the particles cause the solute particles to spread throughout the solution, as shown below



2. In a sugar & water solution with 300mL of water and 100mL of sugar, the total volume of the sugar and water mixture will be less than 400mL. As the sugar particles separate, the smaller water particles fit into the spaces between the larger sugar particles.

A Model for a Solution

150 mL water + 120 mL dice = 160 mL dice/water



4. Drink crystals dissolved in water: solute is drink crystals
solvent is the water

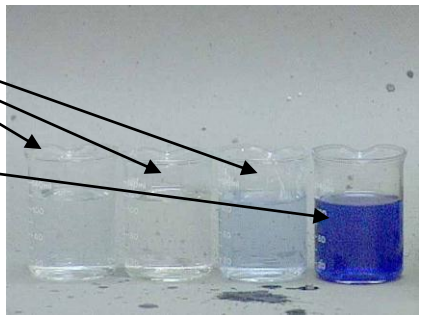
As the drink crystals dissolve in water, the different particles are pulled apart. They spread throughout the water to form the solution.

2.3 Concentration & Solubility

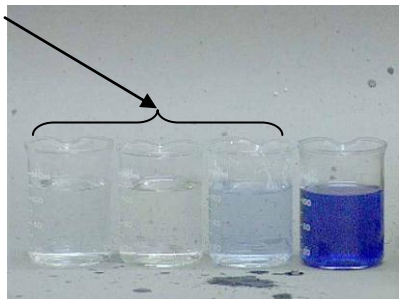
Concentration: the amount of solute present in an amount of solution

Dilute Solutions: small amount of solute dissolved ("weak")

Concentrated Solutions: large amount of solute ("strong")



Unsaturated Solutions: still contain unfilled spaces between the solvent particles



Saturated Solutions: the maximum amount of solute dissolved in the solution (all the spaces in solvent are filled). If you try to strengthen a saturated solution, the solute will simply sink to the bottom of the solvent without dissolving.

Solubility – a measure of how much solute can dissolve in a certain solvent to form a saturated solution at a particular temperature and volume

Solubility *(demonstration/experiment)*

Question: What has the greater solubility: salt or sugar?
Hypothesis: I think sugar will be more soluble than salt because the text says so.
Materials: salt, sugar, beakers, stir stick, water, measuring spoon
Method: - fill 2 beakers with same amount of water each
- put spoonful of salt in one beaker and spoonful of sugar in other
- stir until completely dissolved
- keep track of how many spoons are going into each
- repeat until solute remains at the bottom, even after stirring (saturated)

Observations - ___ spoonfuls fit into the salt & water solution
- ___ spoonfuls fit into the sugar & water solution (more than salt)

Conclusion – more sugar was needed to make a saturated solution than salt, therefore sugar is more soluble in water than salt
Application – solubility of salt and sugar will be needed when making food (e.g. making syrup, you don't want sugar crystals floating in it, or if making a sauce, you don't want salt crystals floating in it.

2.5 Dissolving Solutes Faster

Question:

What affects the speed of a solute dissolving into a solvent?

1. volume of solvent
2. temperature of solvent
3. surface area of solute (crushing)
4. agitation of mixture (stirring or shaking)

Hypothesis:

1. Volume of Solvent: I think _____
   because _____
2. Temperature of Solvent: I think _____
   because _____
3. Surface area of Solute: I think _____
   because _____
4. Agitation of Mixture: : I think _____
   because _____

Materials:

- Sugar cubes
- Beakers
- Graduated cylinder
- Water
- Kettle
- Spoon
- Stopwatch
- Paper towels
- Hammer

Method:

Volume of Solvent:

Fill one graduated cylinder with 100mL of water and fill the other with 500mL of water.
Drop a sugar cube in each at the same time.
Begin timing on stopwatch.
Record which one dissolves first (or if they both dissolve at the same rate)

Temperature of Solvent:

Fill one beaker with regular tap water and one with the same amount of boiling water.
Drop a sugar cube in each at the same time.
Begin timing on stopwatch.
Record which one dissolves first (or if they both dissolve at the same rate)

Surface are of Solute:

Wrap one sugar cube in a paper towel and hammer it until it is entirely crushed.
Fill two beakers with regular tap water.
Drop a sugar cube in one and crushed sugar cube into other at the same time.
Begin timing on stopwatch.
Record which one dissolves first (or if they both dissolve at the same rate)

Agitation of Mixture:

Fill two beakers with regular tap water.
Drop a sugar cube in each at the same time.
Stir one with a spoon and let the other stand still.
Begin timing on stopwatch.
Record which one dissolves first (or if they both dissolve at the same rate)

Observations:

	hours	minutes	seconds
Control 400 mL water			
Less water 100 mL water			
Greater surface area (crushed)			
Temperature (boiling water)			
Agitation (stirring)			

- sugar dissolved faster with more water
- sugar dissolved faster when crushed up
- sugar dissolved faster when using hot water
- sugar dissolved faster when mixture was stirred

Conclusions: *(e.g.)*

- Sugar dissolves faster with more water because there are more spaces for the sugar particles to spread out into.
- Sugar dissolves faster when crushed up because there is more surface area for the solvent to access the sugar particles.
- Sugar dissolves faster when using hot water because the solvent particles are already moving faster and spread far apart for the sugar particles to spread out quickly.
- Sugar dissolves faster when the mixture is stirred because it allows the particles to find spaces to fit more quickly.

Applications: *(e.g.)*

- Using boiling water will dissolve solutes like coffee or Jell-O faster.
- If your chocolate milk powder is not dissolving, add more milk.
- Break apart any clumps before pouring solute (like brown sugar) into solvent.
- Stir fruit punch crystals in water to dissolve them more quickly.

The Rate of Dissolving

Many factors affect the speed at which one substance dissolves in another, for example:

- the surface area of the solute particles
- size of the solute particles

Breaking up the solute particles into smaller pieces increases the overall surface area of crystals exposed to solvent, thereby accelerating the dissolving process.

- temperature

As temperature increases, the particles move faster and spread out with greater chances for mixing of the solute and solvent particles.

- amount of solute
- amount of solvent
- amount of shaking/stirring

The greater the amount of solvent relative to the solute, the greater the opportunity for interactions and attractions between the solute and solvent particles, and the more uniform the distribution of the particles.

- type of solvent

The level of attraction changes with the types of particles. Dissolving will happen faster when the solute's and solvent's particles are highly attractive.

2.5 Dissolving Solutes Faster

See handout.

What did you observe?

- The sugar dissolved faster with more water (than less)
- The sugar dissolved faster when crushed up (than cube)
- The sugar dissolved faster when using hot water (than cold or room temp)

p 49 c, d, e

(c) In the first experiment, there were more water particles in the second beaker than there were in the first beaker. The larger number of water particles collided with the sugar particles more often. That made the sugar cube dissolve more quickly in the larger volume of water. In the second experiment, the sugar cube in the second beaker was broken into small pieces. That exposed more sugar particles to the water, which made it easier for the sugar particles to dissolve in less time.

(d) e.g. If I were going to repeat the experiment, I would add more trials to each experiment. That way, I could see if my data were approximately the same for each condition.

(e) e.g. How does the temperature of the water used affect the speed at which a sugar cube dissolves?

Name: _____ Date: _____

2.5 Dissolving Solutes Faster

In "Conduct an Investigation 2.5", you will explore factors that may affect the dissolution rate of a solute. The following sample procedure explores two such factors, solvent volume and solute size, in order to answer the following testable questions:
How does the volume of water used affect how quickly a sugar cube dissolves?
How does crushing a sugar cube affect how quickly it dissolves in water?

Equipment and Materials: per pair:

4 250 mL glass beakers	250 mL graduated cylinder	spoon
4 labels; pen or marker	tap water	paper
4 sugar cubes	stopwatch	

Part A: The Effects of Solvent Volume on the Rate of Dissolving

1. Obtain two clean, dry 250 mL beakers. Label one beaker "A" and the other beaker "B." Place one whole sugar cube on the bottom of each beaker.

2. Use a 250 mL graduated cylinder to measure 100 mL of water, and pour it into beaker A. Begin timing with a stopwatch as soon as you add the water.

3. Use the spoon to slowly stir the water. Do not allow the spoon to hit the sugar cube and break it apart.

4. Use the stopwatch to measure the amount of time (in minutes and seconds) it takes for the sugar cube to dissolve completely. Record your observation in Table 1 below.

5. Repeat steps 2–4 with beaker B, but add 200 mL of water to the beaker instead of 100 mL of water. The water you use should be from the same source as the water you used the first time.

Table 1: Results of Procedure A

Beaker	Volume of water (mL)	Time required for sugar cube to dissolve
A	100	
B	200	

Name: _____ Date: _____

Dissolving Solutes Faster: Sample Procedure *(continued)*

Part B: Effects of Solute Size on the Rate of Dissolving

6. Obtain two clean, dry 250 mL beakers. Label one beaker "C" and the other beaker "D." Place one whole sugar cube in the bottom of beaker C.

7. Place a whole sugar cube on a small piece of paper. Use the back of a spoon to crush the sugar cube into smaller pieces. Make sure none of the sugar sticks to the spoon or falls off the paper.

8. Carefully use the paper to pour the pieces of crushed sugar cube into the bottom of beaker D.

9. Use a 250 mL graduated cylinder to measure 100 mL of water, and pour it into beaker C. Begin timing with a stopwatch as soon as you add the water.

10. Use the spoon to slowly stir the water. Do not allow the spoon to hit the sugar cube and break it apart.

11. Use the stopwatch to measure the amount of time it takes for the sugar cube to dissolve completely. Record your observation in Table 2 below.

12. Repeat steps 9–11 with beaker D. Make sure the water you use is from the same source as the water you used the first time.

Table 2: Results of Procedure B

Beaker	Size of sugar cube	Time required for sugar cube to dissolve
C	whole	
D	crushed	

Example results:

Table 1: Results of Procedure A

Beaker	Volume of water (mL)	Time required for sugar cube to dissolve
A	100	2 min. 15 sec.
B	200	2 min. 6 sec.

Table 2: Results of Procedure B

Beaker	Size of sugar cube	Time required for sugar cube to dissolve
C	whole	2 min. 18 sec.
D	crushed	45 sec.

p 52 #1-6 - **SAMPLE ANSWERS**

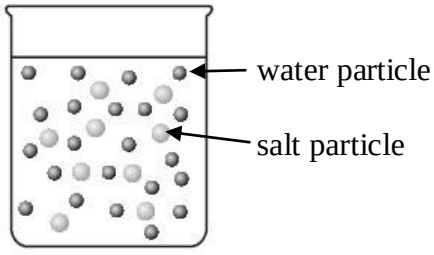
WHAT DO YOU REMEMBER?

1. (Use given terms appropriately in a sentence.)
(a) When the particles of a solute dissolve, the solute cannot be seen anymore.
(b) A solute dissolves in a solvent to form a solution.
(c) Water is the solvent in ocean water.
(d) Concentrated solutions contain a lot of solute particles in a given volume.
(e) Dilute solutions have relatively few solute particles in a given volume.
(f) The solubility of sugar in water is higher than the solubility of salt in water.

2. (a) Water, ethanol, and oil are three common solvents.
(b) Sugar, salt, and juice powder are three common solutes.

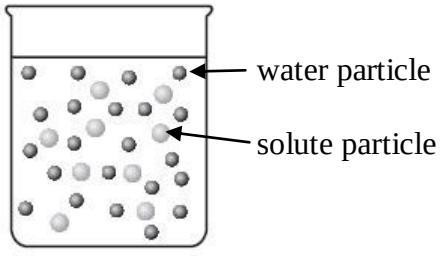
3. Solution (a) is dilute, and solution (b) is concentrated. The solute particles give the solutions their colour. Therefore, the darker the colour of the solution, the more solute particles there are in it. Since solution (b) is darker, it must be more concentrated.

4. (a) A sample drawing is shown below.



(b) When the salt dissolved in the water, the salt particles in the solid split apart and mixed evenly with the water particles. My drawing shows the salt particles evenly mixed with the water particles.
(c) The spaces between the particles are empty.

5. (a) A sample drawing is shown below.



(b) After the solute dissolves, its particles are evenly mixed with the water particles. My drawing shows that the solute particles are evenly mixed with the water particles.

6. To get the sugar cubes to dissolve faster, Ling should break them into pieces, mix them with hot water, and stir the mixture.