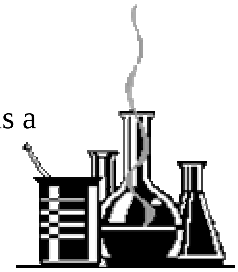
Module 2: Solution Chemistry

15. The ABC's of Solutions



A solution is a homogeneous mixture. By strict definition air is a solution because it is a mixture of basically air and oxygen and the mixture has only one phase. Alloys such as the gold and copper that make up a gold ring or the mixture of copper and zinc that make up bronze are also solutions for the same reason.

In a solution the major part is known as the solvent. So in air (78% nitrogen) nitrogen is the solvent. In most solutions, water is the solvent because water is so common and such a good solvent.

The minor part of the solution is the **solute**. If you dissolve 1 g of sugar in 100 g of water, sugar is the minor component and hence the solute.

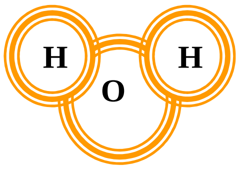
Examples of everyday solutions

Homogeneous Mixture	***Solvent***	***Solute(s)***

If we add more solvent to a solution we are *diluting* it. We lower its concentration of solute. In other words, a given amount of solution we will find less solute and more solvent.

Before venturing more deeply into concentration, let's explain what happens when a substance dissolves in water. Why is for instance that when salt is added to water, it eventually disappears?

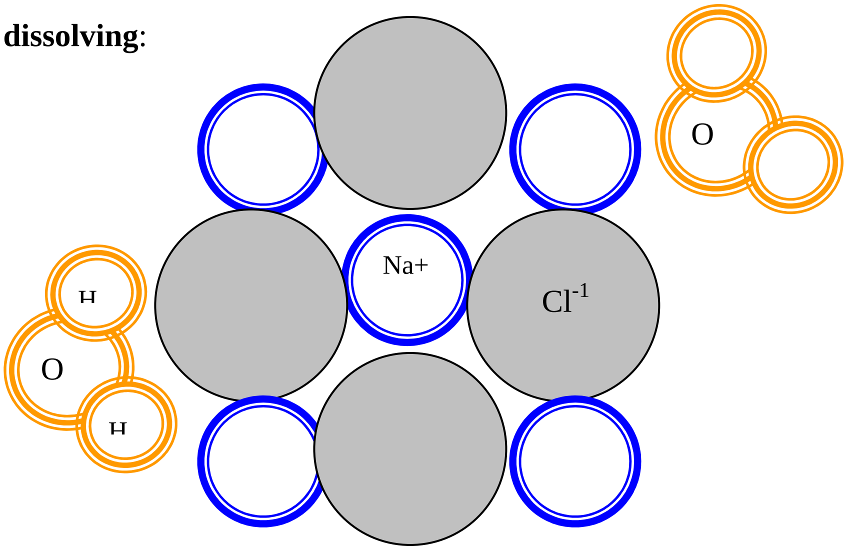
Water is a polar molecule. This does not imply that it has relatives in Northern Canada, but it means that the electronegative (greedy) oxygen atom in water has a partial negative charge, which allows it to attract the positive sodium ion in salt.

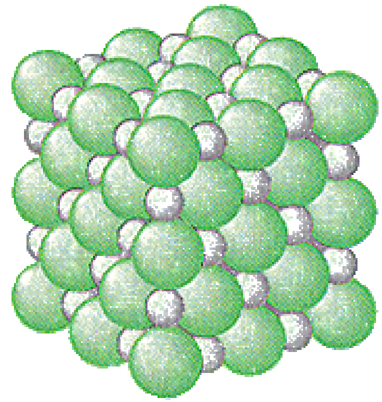


The wimpy hydrogen atoms in water allow the electrons they share to actually move towards the oxygen, and so thee H's carry a partial positive charge. This allows the H's to attract salt's negative chloride ion .The attractions between water and salt are strong enough that they overcome the bonds that keep sodium chloride solid.

Solution Intro, Concentration and Dilution

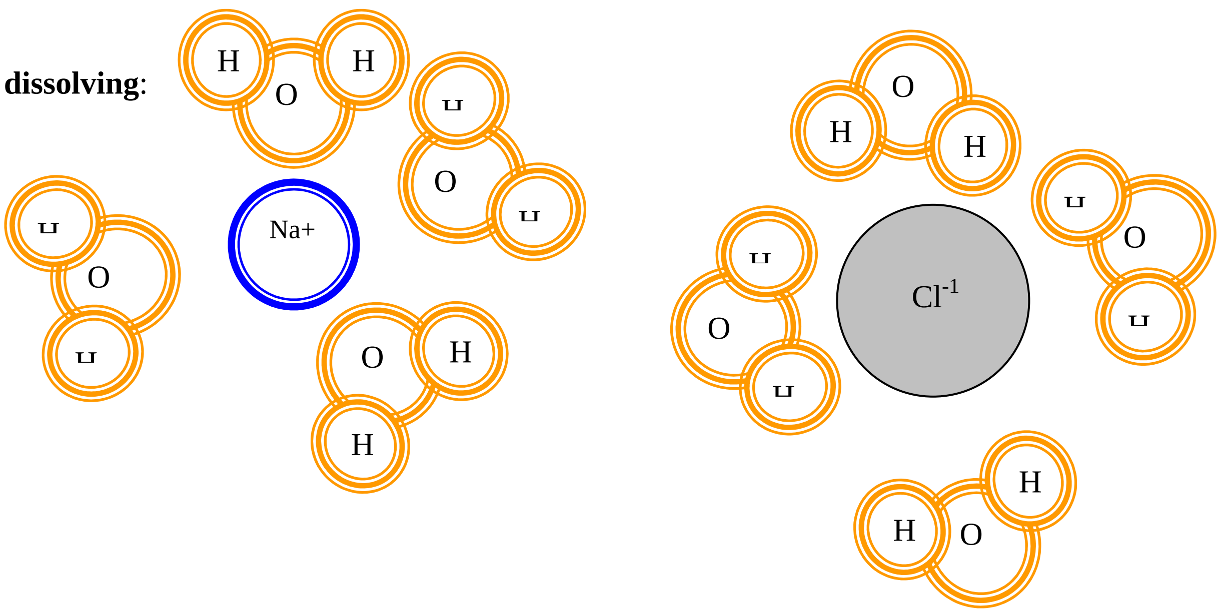
Before dissolving:





As salt's ions come apart and find themselves trapped among water molecules, we no longer see them.

After dissolving:



<u>Example:</u> Draw what is going on when KI dissolves.

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Ionic Equations:

When an ionic solid dissolves in water, positive and negative ions appear in solution. The subscripts (little numbers) in the compound's formula reveal the number of each ion that will form on the right hand side of the equation.

Example 1: $Na_2S_{(s)} \rightarrow$???

Answer:

If a polyatomic group appears in the compound, the *subscripts do* ***not*** *become coefficients unless brackets appear*.

Example 2: $CaSO_{4(s)} \rightarrow$????

Example 3: $Mg(NO_3)_{2\,(s)} \rightarrow$

Exercises

1.

Homogeneous Mixture	***Solvent***	***Solute(s)***
a. 18 K gold (24 K is pure)		
b. Air		
c. ocean water		
d. 7up		

2. Why does salt seem to disappear as it dissolves in water?

3. What part of the water molecule faces a dissolved Mg^{+2} ion? Draw it.

4. Complete and balance the following ionic equations:

a. $KBr \rightarrow$

b. $CaCl_2 \rightarrow$

c. $(NH_4)_2S \rightarrow$

d. $Na_2CO_3 \rightarrow$

e. $AlPO_4 \rightarrow Al^{+3} +$ ______

f. $AlCl_3 \rightarrow$

g. $AgNO_3 \rightarrow$

h. $ZnCl_2 \rightarrow$

i. $KOH \rightarrow$

j. $HF_{(g)} \rightarrow$

k. $\rightarrow Rb^{+1} + Br^{-1}$

l. $\rightarrow Ca^{+2} + NO_3^{-1}$

m. $\rightarrow Al^{+3} + S^{-2}$

4. If 4.0 grams of Na_3N dissolved in water, what mass of ions would be created in solution?

5. **(430 only)** How many moles of sodium would appear in solution for every gram of sodium nitride (Na_3N) that dissolved? First write an equztion!

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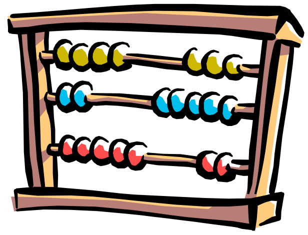

16. Concentration

A. Mass Percent:

$$mass\% = \frac{mass\ of\ solute}{mass\ of\ solute + mass\ of\ solvent} \times 100\%$$

Example 1 Two grams(2.0 g) of salt are mixed with 50 grams of water. Find the mass % of the solution.

Example 2 How many grams of salt must be added to 10 grams of water to create a 10% solution**?**

Example 3 How many grams of NaBr are needed to make 30 g of a 2.0% solution?

B. Grams per Liter (g/L) = grams of solute per liter of solution

implied: **mass = CV** **C = concentration in g/L**
V = volume in L

Example 1 If 30 grams of NaOH are dissolved and then diluted to 2.0 L with water, what is the concentration of the solution?

Example 2 What mass of salt is needed to make 300 mL of a 2 g/L solution?

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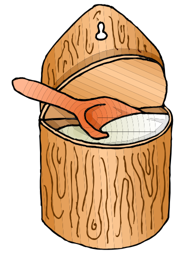
<u>Example 3</u> How would ex 2 actually be done in the lab? Outline a procedure. Hint: you will need a beaker, the actual salt, a balance, a stirring rod, a graduated cylinder or volumetric flask and water.

Exercises (**Mass Percent and g/L)**



1. 5.0 grams of sugar are dissolved in 150 g of water What is the mass percent of sugar in the solution?

2. A 200-gram solution of alcohol contains 180 mL of water. What is the mass percent of alcohol? (Remember water's density.)

3. How many grams of NaBr are needed to make 50 g of a 5.0% solution?

4. You are using 150 mL of ether as a solvent. What mass of sulfanilamide crystals should be added to create a 10% m/V solution. (m/V means mass of solute in g over *mL of solution*)

5. How many grams of LiOH are needed to make 25 g of a 4.0 % solution?

6. What mass of NaF must be mixed with 25 mL = 25 g (because of water's density) of water to create a 3.5% solution.

7. An 800 g solution of Kool Aid contains 780 g of water. What is the mass percent of solute in this solution?

8. What is the mass percent of a solution created by adding 10 g of olive oil to 90 g of vegetable oil?

9. If a 4000g solution of salt contains 40g of salt, what is its mass percent?

Concentration in g/L

1. Find the concentration in g/L for each of the following:

a. 20 g of NaCl dissolved in 500 L of solution
b. 2.8 g of NaBr dissolved in 200 mL of solution
c. 200 mg of KCl dissolved in 75 mL of solution

2. How many grams of Br_2 are needed to make 250 mL of a 4.5 g/L solution?

3. How many grams of HCl are needed to make 500 mL of a 2 g/L solution?

4. How many grams of LIF are needed to make 2.0 L of a 5 g/L solution?

5. Step by step, explain how you would actually prepare 2.0 L of a 5 g/L solution of NaCl in the lab.

C. *Molarity (430 only) (M)

Molarity = Moles per Liter (moles/L) = moles of solute per liter of solution

<u>Example1</u> If 30 grams of NaOH are dissolved and then diluted to 2.0 L with water, what is the molar concentration (molarity) of the solution?

Starting Material	Preliminary Calculation	Procedure
Solute and water have to be turned into a solution of known concentration.	Mass = CV, if C is in g/L for 430 : moles = CV, if C is in mol/L	1. **W**eigh the calculated amount of solid. 2. **D**issolve in beaker containing less than the desired amount of solvent. 3. **T**ransfer to a volumetric flask. 4. **A**dd water to dilute to the mark with solvent and mix. Remember **WDTA**= We don't trust adults.

<u>Example 2</u> How do you prepare 250 mL of a 3.0 mole/L solution of NaCl?

Solution Intro, Concentration and Dilution

17. Preparing a Solution from Another Solution Using Dilution

Starting Material	Preliminary Calculation	Procedure
An already prepared solution has to be diluted to create a less concentrated solution	$C_1V_1 = C_2V_2$ C_1= concentration of original solution V_1 = volume actually used from original C_2 = final concentration of the newly prepared solution V_2 = volume of the new solution (*it is total of the original volume and the volume of water added*)	1. **P**ipette the calculated amount (V_1)into a volumetric flask of size V_2. 2. **T**ransfer to a volumetric flask of volume V_2. 3. **A**dd water and mix. **Remember:** **PTA= Parents' Teachers Association**

Example 1 A student needs to make 300 mL of a 2.0 g/L solution of HCl from a 5.0 g/L solution. How does he go about doing it?

Example 2 You want to prepare 500 mL of a 0.60 g/L solution. Only a 10.0 ml pipette is available. To use that volume, how concentrated should your original solution be?

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Example 3 0.25 L of a 3 g/L solution are on the counter. How much of the solution should he dilute to 0.30 L to make a 2 g/L solution?

Exercises

1. A technician needs 2.0 L of a 1.8 g/L solution of HNO_3. Sitting on the counter is concentrated HNO_3 (10 g/L). How much of the 10 g/L solution should he carefully dilute to 2.0 L ?

2. You want to prepare 250 mL of a 0.50 g/L solution from a 2.0 g/L solution. How many mL should you pipet from the 2.0 g/L solution?

3. a. 0.75 L of a 4 g/L solution are on the counter. How much of the solution should he dilute to 0.10 L to make a 1 g/L solution?

   b. *Outline the lab procedure.*

4. A 25.0 mL pipette is available. You want to end up with 300 mL of a 3.0 g/L solution. How concentrated should your original solution be if 25.0 mL will be used for dilution.

5. To 50 ml of a 3g/L solution, a student added 250 ml of water. What was the final concentration of the solution?

6. How much water should be added to 20 .0 mL of a 6.5 g/L solution in order to create a 2.8 g/L solution?

7. **(430 only)** What is the concentration of a solution created by adding 200 mL of water to 1.5 L of a 3.0 mole/L solution?

8. **(430 only)** In 100 mL of a solution, there are 3.0 g of NaCl. Find the molarity.

9. How many grams of KBr are needed to prepare 2.5 L of a 0.25 g/L solution?

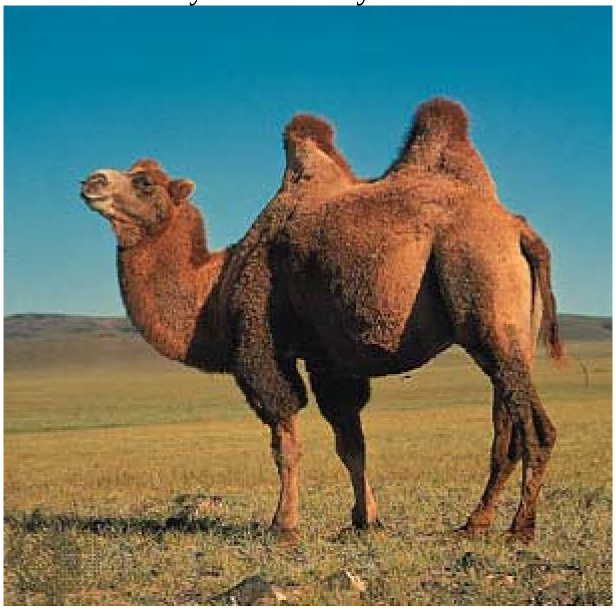
10. How many grams of $Ca(ClO)_2$ are needed to prepare 2.0 L of a 0.45 g/L solution?

11. Explain how you would actually prepare 3.0 L of a 0.2 g/L Na Br solution in the lab.

Solution Intro, Concentration and Dilution

Use of Concentration to Discover Why Camels Can Go Weeks Without Water

There are many reasons why camels can survive the desert's arid conditions:



1. Instead of wasting water on disposing urea, their bodies recycle part of it. The nitrogen can be used to make amino acids, the building blocks of protein.
2. Although they are warm-blooded, they still adjust their body temperature to the environment from about 37 to 40^{o}C.
3. Their fat is concentrated in their hump(s), so they have less insulation throughout the rest of the body. Contrary to popular belief, a camel does ***not*** store water in its hump(s) or anywhere else.
4. Whereas the blood of most water-deprived mammals becomes thicker, leading to poor circulation and dangerously high body temperatures, a camel's blood vessels retain most of their water. How was this discovered?

   In the 1950's, Knut Schmidt-Nielsen and his wife injected a harmless dye in to a camel's bloodstream. They waited a while for the dye to distribute itself evenly. Then they took a blood sample and measured the concentration of the dye. Then the camel went 8 days without drinking in the desert heat. Although it lost a lot of weight (over 40 litres of water), the concentration of the dye in the blood revealed that the blood had only lost about 1 litre of water. In other words the rest of the water had been lost from tissues.

This is the kind of calculation that the Nielsens used:

Suppose that the original concentration of the dye had been 0.0495 g/L in 100 L* of blood. If the concentration of the dye had then increased to 0.0500 g/L, using $C_1V_1 = C_2V_2$, $0.0495(100) = 0.0500V_2$, would reveal V_2 to be 99 L, a change of only 1 L.

*How did they know that the camel had a 100L of blood? Let's say they had originally injected 8.0 mL of 619 g/L of dye. After even distribution of the dye(*before* the camel went 8 days without drinking), the concentration became diluted to 0.0495 g/L, then $C_1V_1 = C_2V_2$ or $619(0.0080) = 0.0495(0.008+V_2)$, would reveal V_2 to be about 100 L.

Reference:

Scientific American. **The Physiology of the Camel**. December, 1959.
Picture from George Holton, The National Audubon Society Collection/Photo Researchers