Chapter 5 : Water and Solution

Learning Outcomes:

a) To understand water as a precious resource

b) To understand the concentration

c) To make the solution

d) To understand Acid and Base

Essential Vocabulary:

Global Water Cycle, Freshwater and Groundwater, Household Water, Properties of Water, Concentration of Solutions, Solubility, Properties of Water Solution, Acids and Bases

Overview and Introduction

The water on Earth is made up of many different types. The properties of each type of water are thoroughly examined and compared to other types of water. The molecular and solution properties of water are described, as well as acids and bases.

1-1: Where is Earth's water

The majority of people are aware that Earth is known as "the water planet." The name immediately conjures up images of an underwater world. We are aware that the planet is primarily made up of water. Figure 1 depicts how water is distributed in the ocean, with the majority of it saline. The first bar contains only 2.5% of the Earth's water, which is mostly made up of glaciers and ice caps, surface and other freshwater, and groundwater. Only 1.2% of the freshwater in the second bar is usable by humans on a daily basis. In the third bar, rivers make up 0.49% of total surface freshwater. Even though rivers only provide a small amount of freshwater, they are the source of people's drinking water.

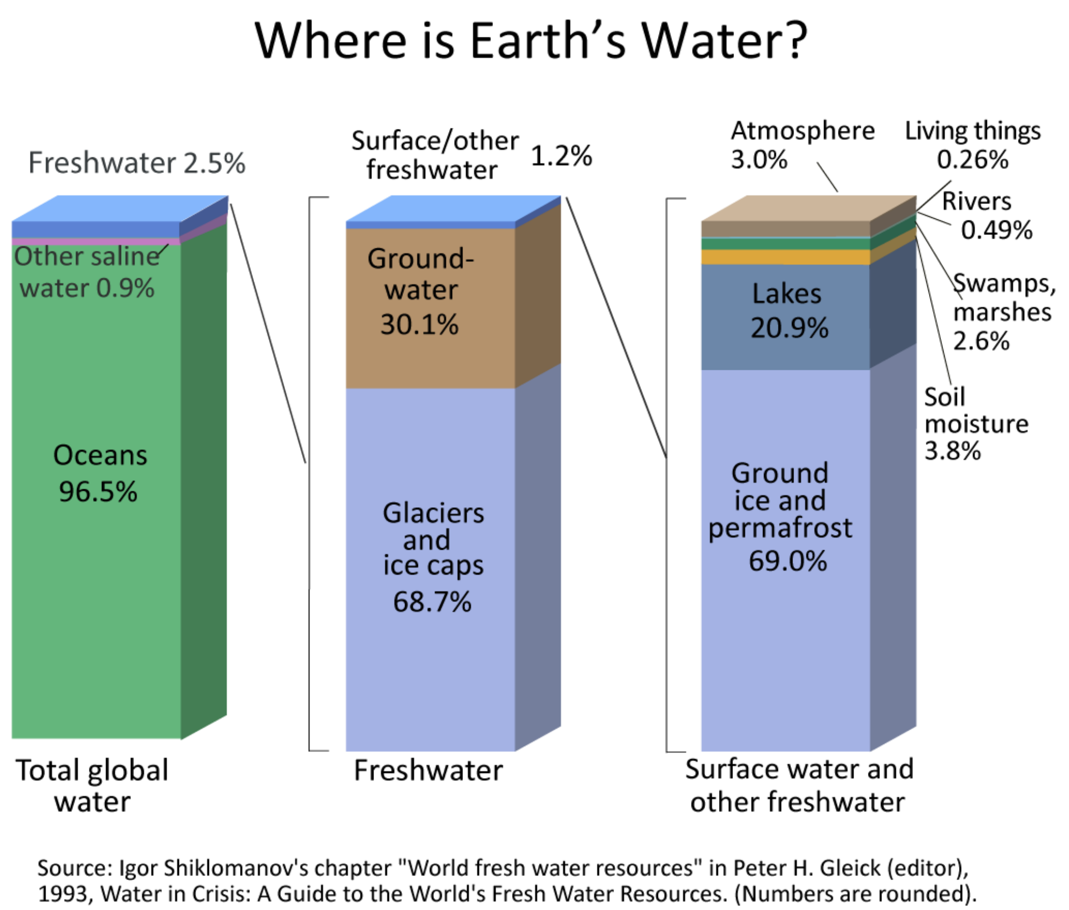

Figure 1: Earth's Water Distribution

Nonetheless, more than 97.5% of the world's water is unfit for human consumption and many other forms of life. The scarcity of water, which is essential for all terrestrial and aquatic life on Earth, is remarkable. This startling insight leads to the realization that we must exercise extreme caution when using this resource. The education of current and future generations of citizens about water is an essential first step. This chapter discusses the global water cycle, salt water, freshwater and groundwater, household water, water properties, water solutions, acids, bases, and salts.

1-2: The Global Water Cycle

Figure 2 illustrates how the global water cycle connects all of the water on Earth. The majority of the processes shown depend on changes in the water phase. Figure 2 illustrates how the main circular cycle of evaporation, condensation, and precipitation complicates the processes. As an illustration, the sun evaporates water from the ocean into the atmosphere, where it condenses back into liquid water that is visible as clouds.

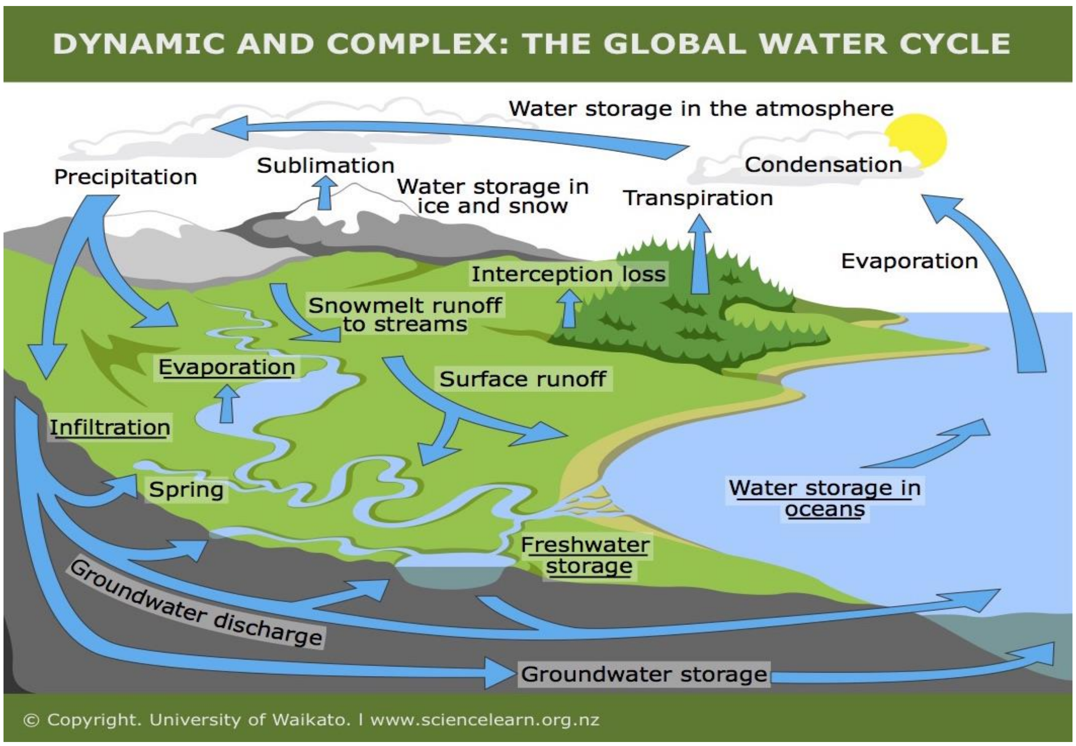

Figure 2: The Global Water Cycle

1-3: Salt Water: Earth's Ocean and Seas

As you are aware, the seawater has a 3.5% mass concentration of salt, making it unsafe for consumption. The mass of dry salts in grams contained in one kilogram of seawater is known as its salinity. The salinity of the world's oceans is typically 35 g/kg of seawater. Rocks on land dissolve most of the salts found in seawater. The carbon dioxide in the air causes the rainwater to become acidic. Acid rainwater erodes rocks and releases ions that travel through rivers and streams before reaching the ocean. In seawater, sodium and chloride ions are the two main ions. Table 1 illustrates that these two ions account for more than 90% of all dissolved ions in seawater.

Table 1. Principal constituents of seawater*

ionic constituent	g/kg of seawater	moles/kg**	relative concentration
chloride	19.162	0.5405	1.0000
sodium	10.679	0.4645	0.8593
magnesium	1.278	0.0526	0.0974
sulfate	2.680	0.0279	0.0517
calcium	0.4096	0.01022	0.0189
potassium	0.3953	0.01011	0.0187
carbon (inorganic)	0.0276	0.0023	0.0043
bromide	0.0663	0.00083	0.00154
boron	0.0044	0.00041	0.00075
strontium	0.0079	0.00009	0.000165
fluoride	0.0013	0.00007	0.000125

*Concentrations at salinity equal to 34.7

https://www.britannica.com/science/seawater

As shown in Figure 3, the temperature of seawater varies with depth. The seawater temperature of a body of water at a given depth can be calculated using the simple formula shown below.

T equals 14,000/D, where T is the Fahrenheit temperature and D is the depth in feet.

This formula is only adequate for depths of 250 to 500 feet. Temperature readings from depths outside of these ranges may be incorrect.

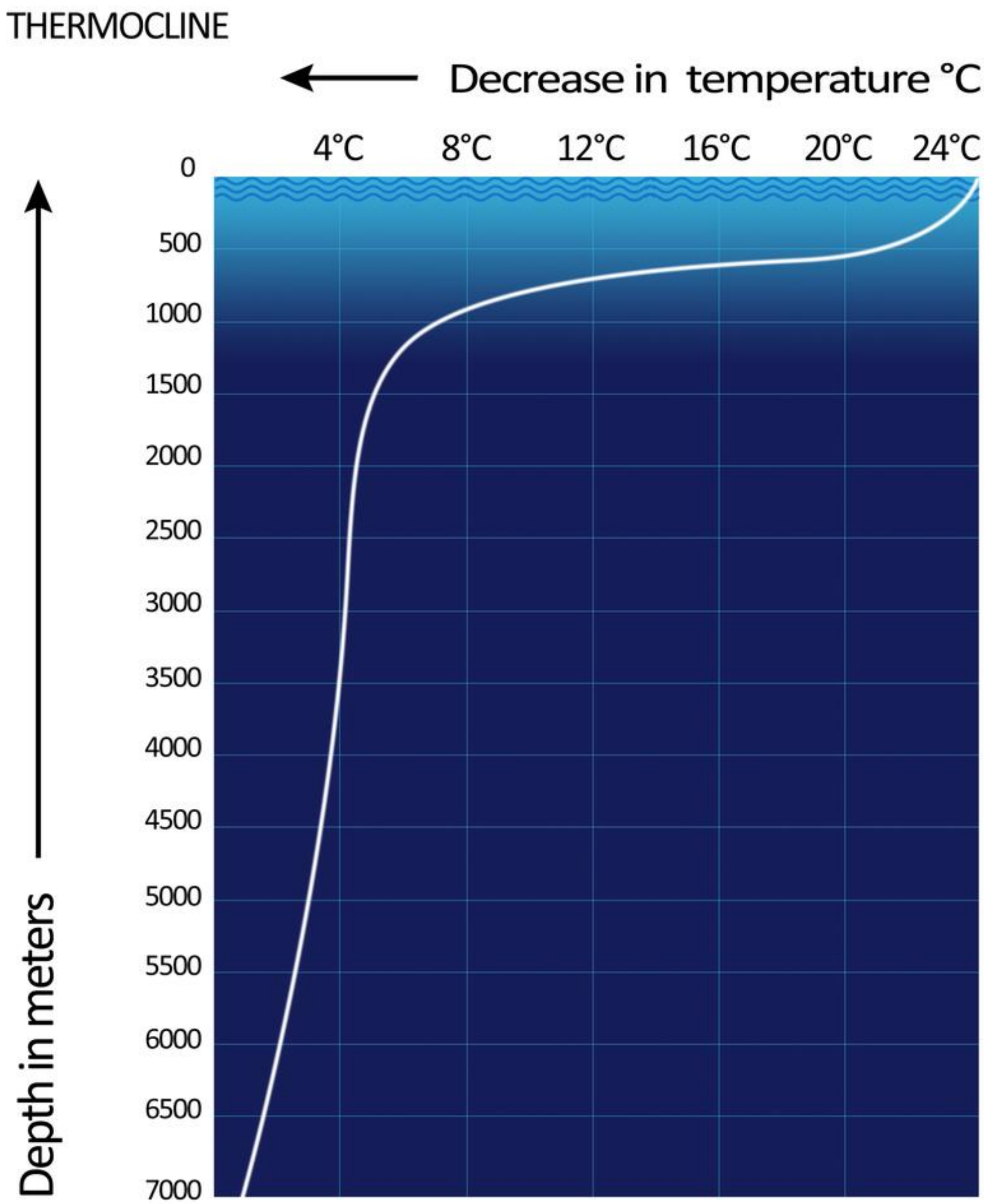

Figure 3: The temperature of seawater varies with depth

https://en.wikipedia.org/wiki/Thermocline#/media/File:THERMOCLINE.png

1-4: Freshwater and Groundwater

Freshwater in rivers, lakes, ponds, and streams has resolved salt concentrations less than 500 ppm. Surface/other freshwater accounts for only 1.2% of total freshwater, as shown in Figure 1. Rivers contain 0.49% of surface/other freshwater, which people can use on a daily basis. The United States is fortunate to have enough freshwater for 1.7×10^{15}L. An estimated 9×10^{11}L is used every day in the United States for agriculture, hydroelectric power, industry, household, and drinking. The average person in the United States uses about 300 liters of fresh water per day for cooking and drinking, cleaning, flushing the toilet, and watering their lawns. One of the current issues facing the world is the scarcity of fresh water. Freshwater scarcity and contamination are major causes of disease in developing countries. As a result, freshwater is one of the most valuable resources, so it must be protected and conserved. Figure 1 shows that groundwater accounts for 30.1% of freshwater. It is found beneath the soil in an aquifer, which is a series of porous rock layers that contain water. The aquifer's water is extremely pure and suitable for human consumption.

1-5: Household Water

As mentioned earlier, the typical American uses 300 liters of freshwater per day for a number of uses, such as drinking, cooking, cleaning dishes, doing laundry, taking a bath, using toilets, and tending to their lawn and gardens. Freshwater is therefore a precious resource in the modern world. Lakes, streams, reservoirs, ponds, and rivers are the sources of freshwater. Furthermore, subterranean groundwater is extracted and pumped. After contaminants are removed through pollution removal procedures, treatment to eradicate bacteria, and filtering to remove sediment particles, freshwater should be utilized. Table 2 lists the five main categories of pollution that can be found in US drinking water, along with their sources and possible health risks.

Table 2. Five main categories of pollution in drinking water

https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

Contaminant	Potential Health Effects	Sources of Contaminant in Drinking Water
Lead	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits
Total Trihalomethanes (TTHMs)	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection
Chloramines	Eye/nose irritation; stomach discomfort, anemia	Water additive used to control microbes
Polychlorinated biphenyls (PCBs)	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals
Viruses and Bacteria	Gastrointestinal illness (such as diarrhea, vomiting, and cramps)	Human and animal fecal waste

1-6: Properties of Water

Water, as you are aware, is essential to human survival. Our bodies are composed of 70% water by weight. Food and vegetables contain up to 95% water, while meat contains 50% water by weight. Water is a major component in living things and is necessary for our survival, so understanding water properties can help us better understand life. Water can act as a solvent because most compounds dissolve in water and transport solutes via diffusion or a circular system. In addition to these characteristics, there are numerous other useful physical properties. For example, liquid phase water is denser than solid phase water (ice). Also, water has a unusual high specific heat of 4.186 J / g ^{o}C, and high heat of vaporization of 540 cal / g at 100 ^{o}C.

1-7: Structure of Water Molecules

The molecular formula is H_2O with two bonds (O-H) between H atom and O atom that is called as a polar covalent bond. In the O-H bond, electrons are not equally shared by H and O, and shared electrons spend more time in Oxygen side than Hydrogen side because electronegativity of Oxygen is larger than Hydrogen, as a result, partially negative on Oxygen atom and partially positive on Hydrogen atom as you can see at the figure 4. The electrons are shared equally to make bonds, these bonds are called to covalent bonding. But the electrons are not equally shared in the bond, these bonds are said to be polar covalent bond such as O-H bond in water.

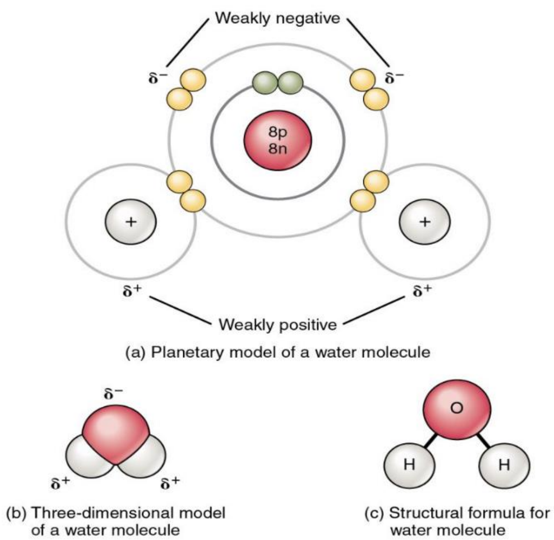

Figure 4. Polar Covalent Bonds in a Water Molecule

https://open.oregonstate.education/aandp/chapter/2-2-chemical-bonds/

In water, the water molecules have a strong intra- molecular interaction because negative charge on Oxygen and positive charge on Hydrogen. This interaction is the strong interaction between molecules and is cold as hydrogen bonding between H and O indicated by dot lines.

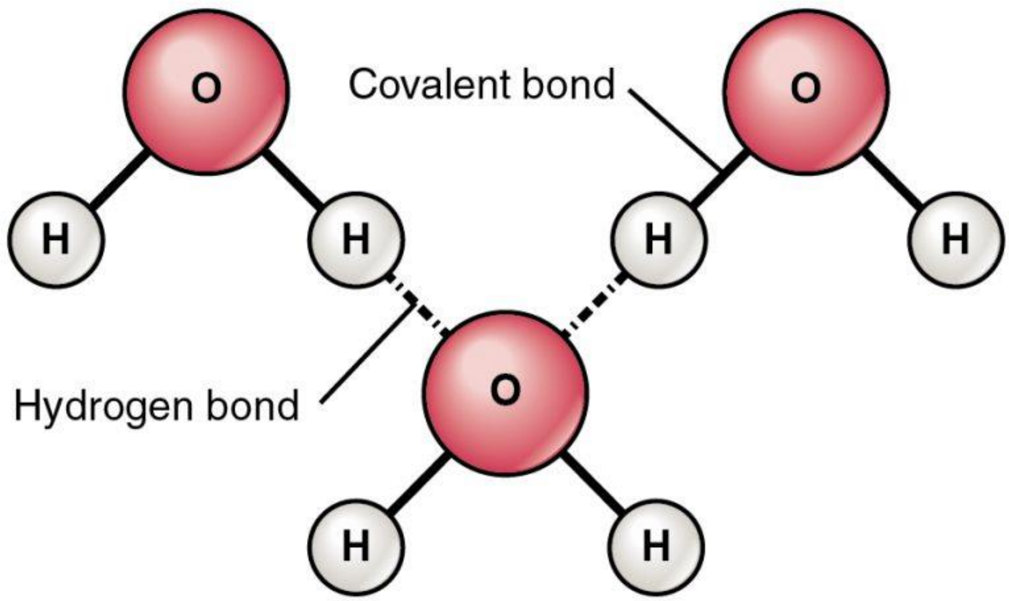

Figure 5. Hydrogen Bonds between Water Molecules:

https://open.oregonstate.education/aandp/chapter/2-2-chemical-bonds/

The hydrogen bond can explain the unusual properties of water, which include: a) higher density in liquid water than solid water (ice), b) unusually high heat of fusion, and c) specific heat and heat of vaporization. Figure 6 shows the regular hexagonal bonded structure of ice, which is less dense than liquid water due to the open holes in the ice structure. The pattern of open holes in liquid water is very similar to that of ice, but the hydrogen bonds are not as rigid, so the open holes collapse, resulting in a higher density of liquid water. Other properties are unusually high due to the extra energy required to break the hydrogen bonds in water.

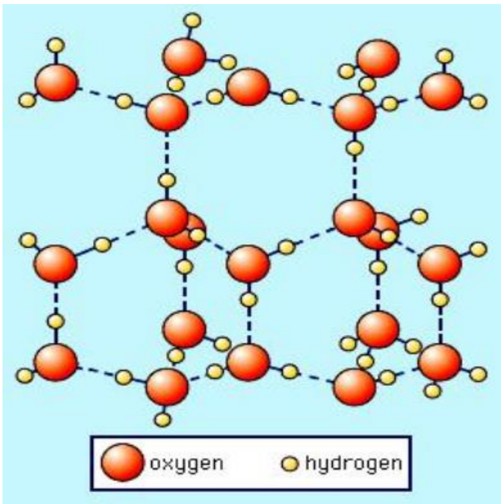

Figure 6. This figure shows the hexagonal ice structure with Hydrogen bonds

https://chemistry.stackexchange.com/questions/73664/why-is-ice-less-dense-than-water?noredirect=1&lq=1

1-8: Concentration of Solutions

The ratio of solutes and solution is called as the concentration, which have various ways to define concentration. For an example, when you cook, you need to add numerous table spoons of salt in water to make 100 g salt solution as shown in the table 3. Here, salt is solute, and water is solvent because water is much larger amount. As you can see at the table, the concentration of percent by weight is defined by the weight of solute in 100 g of solution.

(Mass of solute/mass of solution) X 100% solution = % solute (g/g)
Equation 1

Table3. Making salt solutions in % by weight

Beaker number	**Table Spoon**	**Weight (g)**	**% by weight**
1	**1**	**2**	**(2g/100g) X100 % = 2 %**
2	**3**	**6**	**(6g/100g) X100 % = 6 %**
3	**5**	**10**	**(10g/100g) X100 % = 10 %**
4	**7**	**14**	**(14g/100g) X100 % = 14 %**
5	**9**	**18**	**(2g/100g) X100 % = 18 %**

One table spoon = 2 g of salt.

Table 4 shows that the volume of solute and total solution can also be used to express the percentage of solute by volume in a 100 ml solution.

(Volume of solute/Volume of solution) X 100% solution = % solute (v/v)   Equation 2

Table 4. Making Rubbing Alcohol Solutions in % by Volume

Beaker number	**Table Spoon**	**Volume (mL)**	**% by Volume**
1	**1**	**2**	**(2mL/100mL) X100 % = 2 %**
2	**3**	**6**	**(6mL/100mL) X100 % = 6 %**

3	**5**	**10**	**(10mL/100mL) X100 % = 10 %**
4	**7**	**14**	**(14mL/100mL) X100 % = 14 %**
5	**9**	**18**	**(18mL/100mL) X100 % = 18 %**

One table spoon = 2 mL of rubbing alcohol.

Another way to express concentration is in parts per million (PPM), which is widely used in science. The ppm is defined as 1mg of solute in a total solution of 1000g (1 kg), as shown in equation 3. Examples of PPM solutions with calculations are described in table 5.

PPM= (mg solute /1000 g solution) X1000,000 (10^6) equation 3

Table 5. Making salt solutions in PPM

Beaker number	Table Spoon	Weight (mg)	PPM
1	**1**	**2**	**(2mg/1000g) X 10^6 = 2 ppm**
2	**3**	**6**	**(6mg/1000g) X 10^6= 6 ppm**
3	**5**	**10**	**(10 mg/1000g) X 10^6 = 10 ppm**
4	**7**	**14**	**(14mg/1000g) X 10^6 = 14 ppm**
5	**9**	**18**	**(18mg/1000g) X 10^6 = 18 ppm**

One table spoon = 2 mg of salt

Example 1. 3 % (v/v) vinegar is the mixture of acetic acid in water which usually used in the table. How much mL of acetic acid is in 3% vinegar.

% Solute = 3% (v/v), solution=100 mL, Volume of solute=?

According equation 2,

(Volume of solute/100 mL solution) X 100 % = 3 % (v/v) ,

Then, Volume of solute = (3 % X100 mL solution)/100%,

Volume of solute = 3 mL.

Example 2. If there is 0.6 g of Pb present in 300 g of solution, what is the Pb concentration in parts per million (ppm)?

Example 3. If there is 0.5 mg of Pb in 350 g of solution, what is the Pb concentration in ppm?

The most used concentration term is molarity (M) in chemistry, the molarity is defined mole solute over liter of solution.

Molarity (M) = moles of solute / liters of solution Equation 4

One mole is defined as the amount of solute that contains Avogadro's number (6.02×10^{23}), which is the number of atoms in 12 grams of Carbon 12. As a result, the molar mass of any substance is the mass in grams of one mole of its representative particles. For example, carbon has a molar mass of 12 grams per mole. Molar mass is extremely useful for converting weight units to moles or vice versa. In everyday life, one dozen eggs equals twelve eggs. To convert 24 eggs to a dozen, multiply 24 eggs by (dozen/12 eggs) = 2 dozen. So, 24g of carbon can be converted to moles using equation 5: 24 g carbon multiplied by (mole/12 g) equals 2 moles.

Mole: weight in grams x (mole/molar mass) equation 5

After obtaining the mole of solute, the molarity can be calculated by dividing by the liter of solution, as shown in the table 6 below.

Table 6. Making salt solutions in Molarity

Beaker number	Table Spoon	Weight (g)	Moles of Solute	Molarity (M)
1	1	2	(2g x (mole/58.5g) =0.034	0.034 moles /1L = 0.034
2	3	6	(6g x (mole/58.5g) = 0.102	0.102 moles /1L = 0.102
3	5	10	(10g x (mole/58.5g) =0.171	0.171 moles /1L =0.171
4	7	14	(14g x (mole/58.5g) =0.239	0.239 moles /1L =0.239
5	9	18	(18g x (mole/58.5g) =0.308	0.308 moles /1L =0.308

One table spoon = 2 g of salt, total solution: 1 liter

Examples 4. Determine the molarity for each of the following solutions:

a. 0.5 mol of NaCl in 0.5 L of solution

b. 98.0 g of NaCl in 1.00 L of solution

c. 20.0 g of Sodium Chloride, NaCl in 400.00 mL of solution

1-9: Solubility:

If you continue to add tea spoons of salt to the solution, you will eventually see the salt at the bottom, which will not dissolve any further. That point is known as saturated solution, and it occurs when the concentration of salt exceeds the maximum at a specific temperature. The maximum concentration that can be dissolved at a given temperature is known as a substance's solubility. As shown in Figure 7 for solids and 8 for gases, solubility increases as temperature increases. At 25 degrees Celsius, Sodium Chloride (NaCl) has a solubility of 360 g/L. As shown in equation 6, Henry's law is used to explain how pressure affects gas solubility. Solid solubility is unaffected by pressure, whereas gas solubility is affected.

Solubility = k × P. Equation 6

In the equation, k is the Henry's law constant, which has a different value for each gas, and P is the pressure of the gases. The solubility is directly proportional to the pressure. Solubility increases proportionally with pressure.

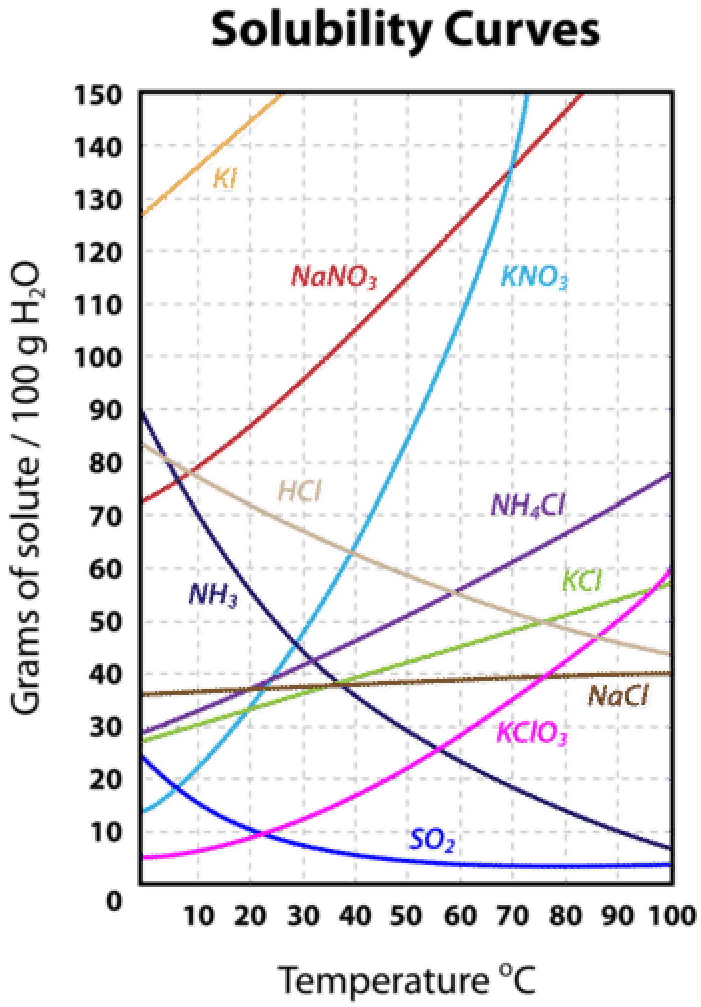

Figure 7. A solubility curve is a graph of the solubility of a substance as a function of temperature.

https://chem.libretexts.org/Courses/Saint_Francis_University/CHEM_113%3A_Human_Chemistry_I_(Muino)/09%3A_Solutions/9.04%3A_The_Effect_of_Temperature_on_Solubility

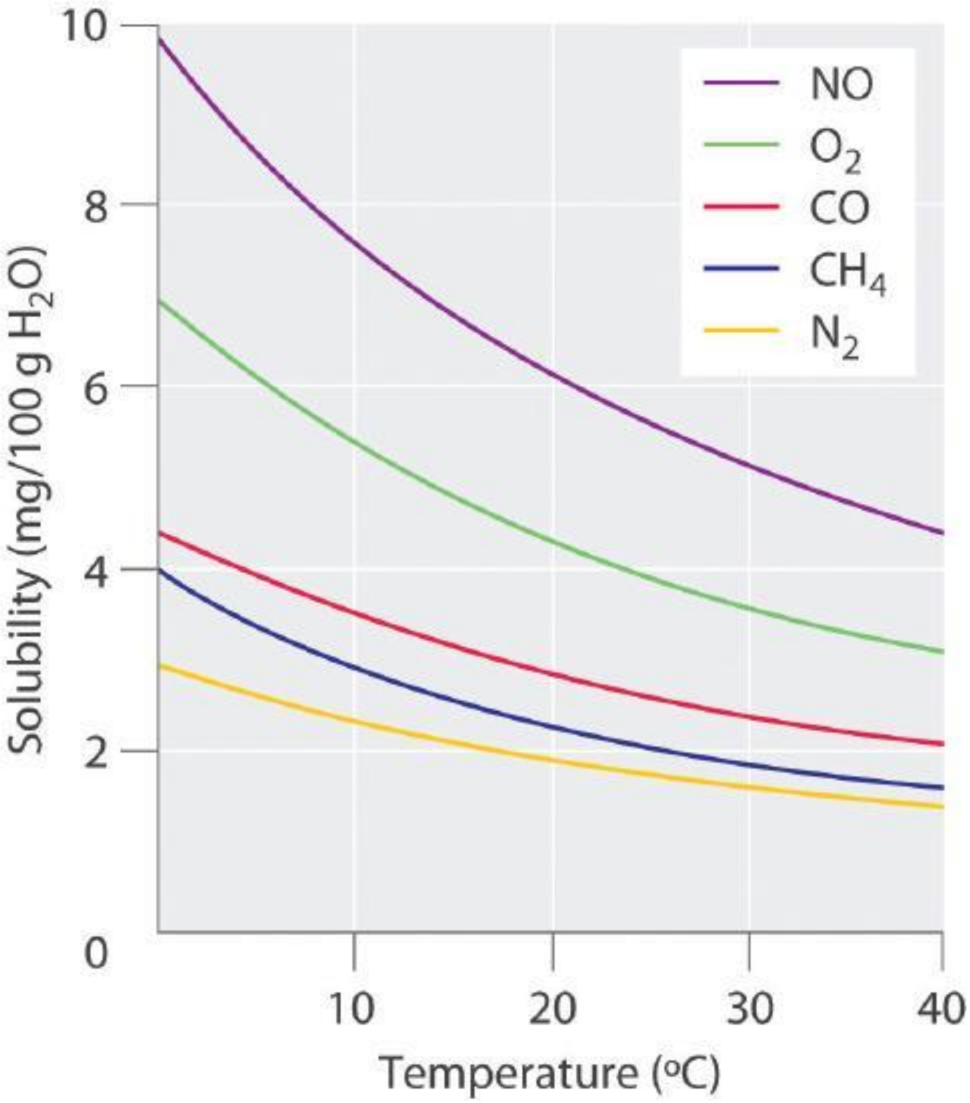

Figure 8. Solubilities of Several Common Gases in Water as a Function of Temperature at Partial Pressure of 1 atm. The solubilities of all gases decrease with increasing temperature. (CC BY-SA-NC; anonymous)

https://chem.libretexts.org/Bookshelves/General_Chemistry/Book%3A_General_Chemistry%3A_Principles_Patterns_and_Applications_(Averill)/13%3A_Solutions/13.04%3A_Effects_of_Temperature_and_Pressure_on_Solubility

1-10: Properties of Water Solution

Pure solvents such as water have a specific and chemical properties, but these properties are changed by the presence of the solute in solution. In this section, these changes is described including some examples.

A) Electrolytes and Nonelectrolytes

Pure water does not conduct electricity, but a salty NaCl solution does, as shown in Figure 9, due to the presence of sodium and chloride ions in the salty solution. These ionic solutions, known as electrolytes, conduct electricity. Sugar solution in water does not conduct electric current because sugar does not produce ions in solution. Sugar is a covalent compound and is referred to as a nonelectrolyte.

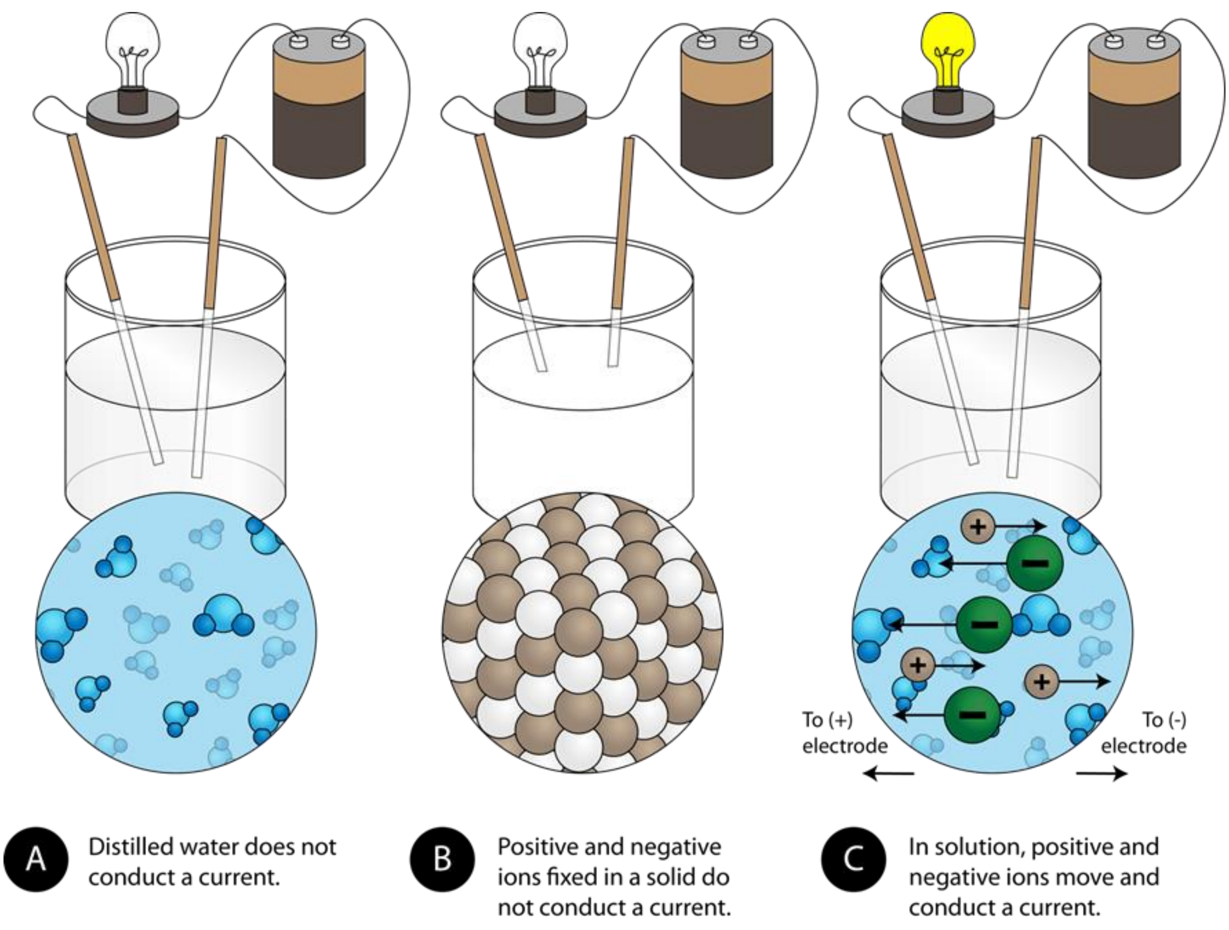

Figure 9. Pure water (A) and solid ionic compounds (B) are electrical noncondutors, but the solution of ionic compounds in water is an electrical conductor. Source: https://www.hiclipart.com/free-trans...cmeih/download

B) Boiling Point Evaluation

As you are aware, water boils at 100 degrees Celsius, but a salty water solution boils at a higher temperature. Boiling occurs when the vapor pressure of liquids equals atmospheric pressure at sea level. The boiling point of solution is higher than that of pure solvent because the vapor pressure of solution is lower, requiring more heat to equal the pressure of the external atmosphere. The boiling point of the solution is higher than that of the pure solvent. As a result, salty water has a higher boiling point than water. Figure 10 shows the boiling point elevation (ΔT_b), which can be calculated using the following equation. The magnitude of the boiling point elevation is also directly proportional to the molality (m) of the solution.

$\Delta T_b = K_b \times m$ equation 7

The proportionality constant, K_b, is known as the molal boiling-point elevation constant. For water, the value of K_b is 0.512 $^{o}C/m$.

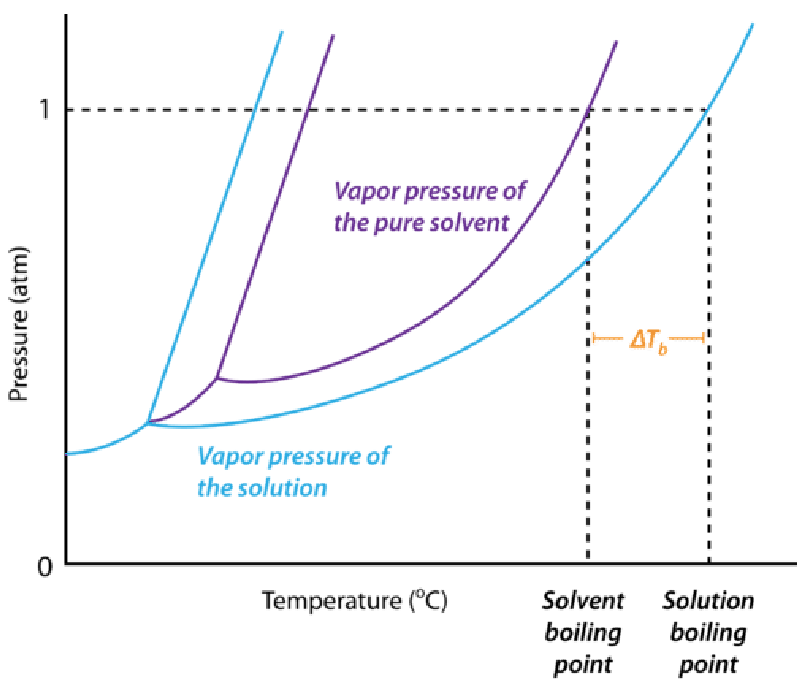

Figure 10. The lowering of the vapor pressure in a solution causes the boiling point of the solution to be higher than that of the pure solvent.

https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introductory_Chemistry_(CK-12)/16%3A_Solutions/16.14%3A_Boiling_Point_Elevation

C) Freezing Point Depression

As you are aware, the freezing point of water is 0 degrees Celsius under normal pressure. The solute in the water solution interferes with the crystal structure of the ice. As a result, water solutions have a lower freezing point than pure water. For example, salt ($CaCl_2$) is spread on ice roads to reduce the freezing point of the ice. In figure 11, the freezing point depression is represented by ΔT_f, which can be calculated using equation 8. The freezing point depression is proportional to both the molality (m) of the solution and the proportionality constant (K_f)

$\Delta T_f = K_f \times m$ equation 8

K_f is called the molal freezing-point depression constant. For water, the value of K_f is $-1.86\ ^{o}$ C/m.

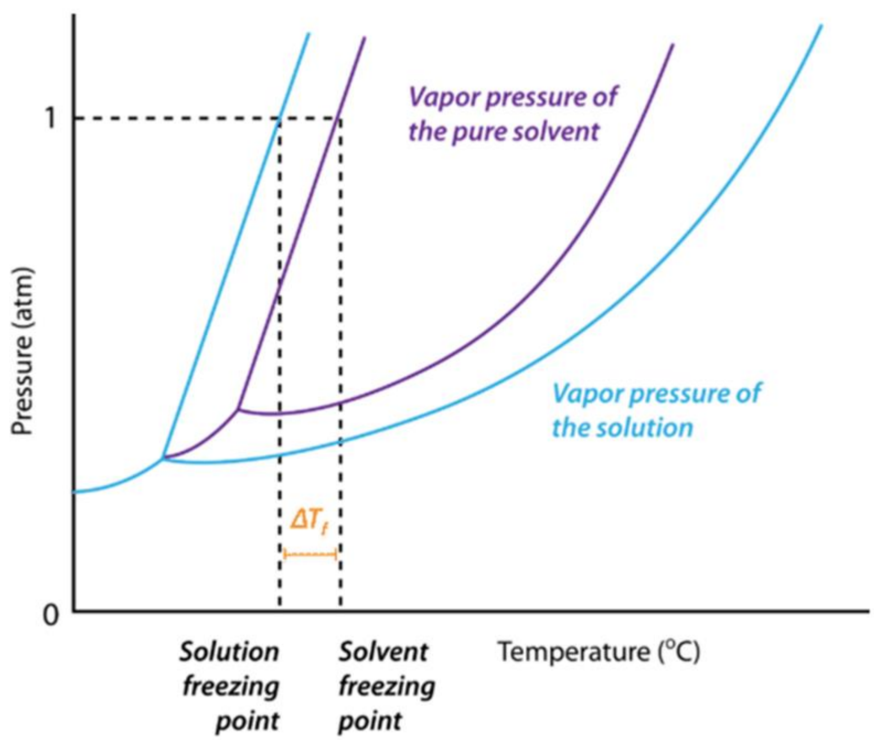

Figure 11. The vapor pressure of a solution (blue) is lower than the vapor pressure of a pure solvent (pink). As a result, the freezing point of a solvent is lower when any solute is dissolved into it.

https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introductory_Chemistry_(CK-12)/16%3A_Solutions/16.13%3A_Freezing_Point_Depression

1-11: Acids, Bases and Salts

As we use a lot of vinegars which are used in culinary arts as a flavorful, acidic cooking ingredient, pickling. Vinegar is called an acid because when vinegar is added to water, release hydrogen ion (H^+) in water solution by Arrhenius definition. Arrhenius classified the substance as an acid and bases. Acid is released hydrogen ion (H^+) which makes low in pH range. Base is released hydroxide ion (OH^-), which makes high in pH range. Hydrogen ions bonds with water to make hydronium ion $H_3O^+(aq)$ in water solution. You are likely familiar with a number of common acids and their uses. Several common acids and their uses are described below.

Table 7: Common Acids and Their Uses

Compound Name and Chemical Formula	Common Name (if applicable)	Uses
hydrochloric acid, HCl	muriatic acid (used in pools) and stomach acid is HCl	Used in cleaning (refining) metals, in maintenance of swimming pools, and for household cleaning.
sulfuric acid, H_2SO_4	none	Used in car batteries, and in the manufacture of fertilizers.
nitric acid, HNO_3	none	Used in the manufacture of fertilizers, explosives and in extraction of gold.
acetic acid, $HC_2H_3O_2$	vinegar	Main ingredient in vinegar.
carbonic acid, H_2CO_3	responsible for the “fizz” in carbonated drinks	As an ingredient in carbonated drinks.
citric acid, $C_6H_8O_7$	none	Used in food and dietary supplements. Also added as an acidulant in creams, gels, liquids, and lotions.
acetylsalicylic acid, $C_6H_4(OCOCH_3)CO_2H$	aspirin	The active ingredient in aspirin.

Table 8: Common Bases and Corresponding Uses

Compound Name and Chemical Formula	Common Name (if applicable)	Uses
sodium hydroxide, $NaOH$	(lye or caustic soda)	Used in the manufacture of soaps and detergents, and as the main ingredient in oven and drain cleaners.
potassium hydroxide, KOH	(lye or caustic potash)	Used in the production of liquid soaps and soft soaps. Used in alkaline batteries.
magnesium hydroxide, $Mg(OH)_2$	(milk of magnesia)	Used as an ingredient in laxatives, antacids, and deodorants. Also used in the neutralization of acidic wastewater.
calcium hydroxide, $Ca(OH)_2$	(slaked lime)	Used in the manufacture of cement and lime water. Also, added to neutralize acidic soil.
aluminum hydroxide, $Al(OH)_3$	none	Used in water purification and as an ingredient in antacids.
ammonia, NH_3	none	Used as a building block for the synthesis of many pharmaceutical products and in many commercial cleaning products. Used in the manufacture of fertilizers.

https://ecampusontario.pressbooks.pub/enhancedchemistry/chapter/acids-bases/

1-12: pH Scale

When you taste lemons, grapes, or tomatoes, you feel sour because the pH of these fruits is extremely low, as shown in the figure. The low pH value indicated a high concentration of hydrogen ion (H^+), as pH is calculated using equation 9. The pH is calculated as the log of the reciprocal of the molar concentration of hydrogen [H^+].

$pH = -\log[H^+]$ Equation 9

The concentration of hydrogen is calculated using equation 10 from equation 9.

$[H^+] = 10^{-pH}$ Equation 10

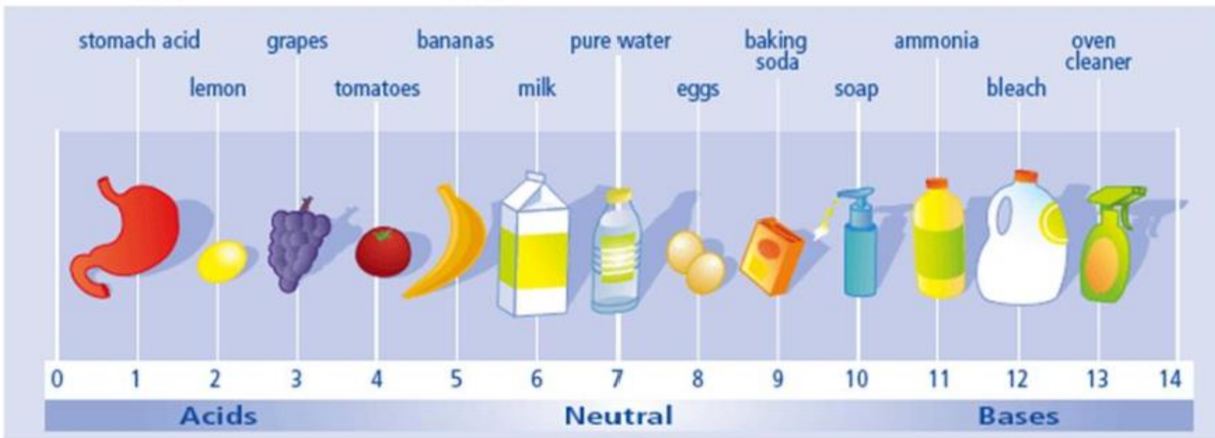

Figure 12. The pH scale.

https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Chemistry_for_Changing_Times_(Hill_and_McCreary)/07%3A_Acids_and_Bases/7.06%3A_The_pH_Scale

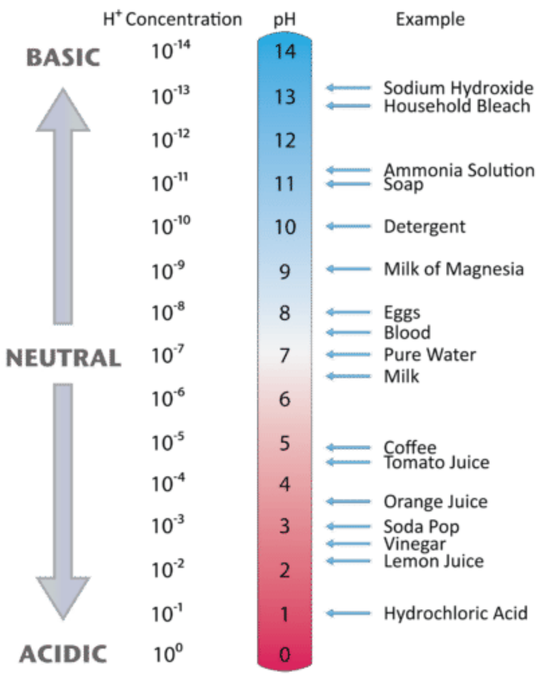

Figure 13. The pH values for several common materials with corresponding hydrogen ion concentration, [H+] .

Example 5. Indicate each solution as acidic, basic, or neutral with pH

a) milk of magnesia, pH = 10.5

b) pure water, pH = 7

c) wine, pH = 3.0

Example 6. What is the [H^+] for water, pH = 7?

Example 7. What is the pH of an aqueous solution whose hydrogen ion concentration is 2.0 x 10^{-5} M?

Lab: Making Solutions

Objectives:

One of basic skills in science is to make solutions with various ways of concentration of solution.

As a basis for understanding of concentration of solutions, students will:

1) To understand of concentration of solution

2) To know the mathematic procedures to make the various solutions

3) To prepare various solutions.

Part 1: Weight Percent (%) and Volume (%) Solution

The ratio of solutes and solution is called as the concentration, which have various ways to define concentration. For an example, when you cook, you need to add numerous table spoons of salt in water to make 100 g salt solution as shown in the table 1. Here, salt is solute, and water is solvent because water is much larger amount. As you can see at the table, the concentration of percent by weight is defined by the weight of solute in 100 g of solution. Table 2 shows that the volume of solute and total solution can also be used to express the percentage of solute by volume in a 100 ml solution.

(Mass of solute/mass of solution) X 100% solution = % solute (g/g) Equation 1

(Volume of solute/Volume of solution) X 100% solution = % solute (v/v) Equation 2

Table1. Making salt solutions in % by weight

Beaker number	Table Spoon	Weight (g)	% by weight
1	**1**	**2**	**(2g/100g) X100 % = 2 %**
2	**3**	**6**	**(6g/100g) X100 % = 6 %**

3	**5**	**10**	**(10g/100g) X100 % = 10 %**
4	**7**	**14**	**(14g/100g) X100 % = 14 %**
5	**9**	**18**	**(2g/100g) X100 % = 18 %**

One table spoon = 2 g of salt.

Based on table 1, please fill out the table below to fully understand the weight percent solution calculation procedures.

Table 1A. Making salt solutions in % by weight

Beaker number	Table Spoon	Weight (g)	% by weight
1	**2**		
2	**4**		
3	**6**		
4	**8**		
5	**10**		

One table spoon = 2 g of salt. Total solution =100 g.

Table 2. Making Rubbing Alcohol Solutions in % by Volume

Beaker number	Table Spoon	Volume (mL)	% by Volume
1	**1**	**2**	**(2mL/100mL) X100 % = 2 %**
2	**3**	**6**	**(6mL/100mL) X100 % = 6 %**
3	**5**	**10**	**(10mL/100mL) X100 % = 10 %**
4	**7**	**14**	**(14mL/100mL) X100 % = 14 %**
5	**9**	**18**	**(18mL/100mL) X100 % = 18 %**

One table spoon = 2 mL of rubbing alcohol.

Based on table 2, please fill out the table below to fully understand the volume percent solution calculation procedures.

Table 2A. Making Rubbing Alcohol Solutions in % by Volume

Beaker number	Table Spoon	Volume (mL)	% by Volume
1	2		
2	4		
3	6		
4	8		
5	10		

Part II. PPM Solution

Another way to express concentration is in parts per million (ppm), which is widely used in science. The ppm is defined as 1mg of solute in a total solution of 1000 g (1 kg), as shown in equation 3. Examples of ppm solutions with calculations are described in table 3.

PPM= (mg solute /1000 g solution) X1000,000 (10^6) Equation 3

Table 3. Making salt solutions in PPM

Beaker number	Table Spoon	Weight (mg)	PPM
1	1	2	(2mg/1000g) X 10^6 = 2 ppm
2	3	6	(6mg/1000g) X 10^6= 6 ppm
3	5	10	(10 mg/1000g) X 10^6 = 10 ppm
4	7	14	(14mg/1000g) X 10^6 = 14 ppm
5	9	18	(18mg/1000g) X 10^6 = 18 ppm

One table spoon = 2 mg of salt

Based on table 3, please fill out the table below to fully understand the ppm solution calculation procedures.

Table 3A. Making salt solutions in PPM

Beaker number	Table Spoon	Weight (mg)	PPM
1	2		
2	4		
3	6		
4	8		
5	10		

One table spoon = 2 mg of salt

Part III: **Molarity (M) Solution**

The most used concentration term is molarity (M) in chemistry, the molarity is defined mole solute over liter of solution.

Molarity (M) = moles of solute / liters of solution Equation 4

A mole is defined as the amount of solute with Avogadro's number (6.02 X 10 23), which is the number of atoms in 12 grams of carbon 12. As a result, the molar mass of any substance is the mass in grams of one mole of its constituent particles. For example, carbon has a molar mass of 12 grams per mole. Molar mass is extremely useful for converting weight units into moles and vice versa. In everyday life, a dozen eggs equals twelve. To convert 24 eggs to a dozen, multiply them by (dozen/12 eggs), which equals 2 dozen. So, equation 5 can be used to convert 24g of carbon into moles: 24 g carbon multiplied by (mole/12 g) yields 2 moles.

Mole: weight in grams x (mole/molar mass) Equation 5

After obtaining the mole of solute, the molarity can be calculated by dividing by the liter of solution, as shown in the table 4 below.

Table 4. Making Solutions in Molarity

Beaker number	Table Spoon	Weight (g)	Moles of Solute	Molarity (M)
1	1	2	(2g x (mole/58.5g) =0.034	0.034 moles /1L = 0.034
2	3	6	(6g x (mole/58.5g) = 0.102	0.102 moles /1L = 0.102
3	5	10	(10g x (mole/58.5g) =0.171	0.171 moles /1L =0.171
4	7	14	(14g x (mole/58.5g) =0.239	0.239 moles /1L =0.239
5	9	18	(18g x (mole/58.5g) =0.308	0.308 moles /1L =0.308

One table spoon = 2 g of salt, total solution: 1 liter

Based on table 4, please fill out the table below to fully understand the molarity solution calculation procedures.

Table 4A. Making Solutions in Molarity

Beaker number	Table Spoon	Weight (g)	Moles of Solute	Molarity (M)
1	2			
2	4			
3	6			
4	8			
5	10			

One table spoon = 2 g of salt, total solution: 1 liter

Part IV: Preparing 100 mL of 1 M NaCl Solution

Step

1. Obtain a 100 mL volumetric flask.
2. Determine the mass (grams) of solid NaCl required to make 100 mL of a 1 M NaCl aqueous solution. Showcase your work in the calculations section.
3. Fill the dry volumetric flask with the NaCl solute using a funnel.
4. Fill the flask approximately halfway with tap water. Swirl to dissolve the solute.
5. Carefully add solvent along the marked line on the flask's neck.
6. Invert the flask a few times to finish mixing.
7. Present your solution and calculations to the instructor for approval.

Calculations: 1.

Calculate the mass (in grams) of solid NaCl necessary to prepare 100 mL of a 1 molar aqueous solution of NaCl.