14.2: Solution Terminology

Learning Objectives

- Learn terminology involving solutions.
- Qualitatively explain the amount of solute dissolved in a solvent.

A **solution** is a homogenous mixture. The component of a solution that does the dissolving is called the **solvent**, while the component that gets dissolved is called the **solute**. Almost always, the solvent is the component that is present in the greatest proportion by mass, moles, or volume.

When one substance dissolves into another substance, we say it is **soluble** in that substance. If a substance does not dissolve into another substance, we say it is **insoluble** in that substance. When two liquids can dissolve into each other in any proportion, we say the liquids are **miscible** with each other. If they cannot dissolve into each other, we say they are **immiscible** with each other.

Figure 14.2.1: Table salt, NaCl, is soluble in water. Salt is the solute. Water is the solvent. (CC-BY-SA 3.0; Chris 73).

Solutions exist for every possible phase combination of solute and solvent. Salt water, for example, is a solution of solid NaCl in liquid water, while air is a solution of a gaseous solute (O_2) in a gaseous solvent (N_2). In all cases, however, the overall phase of the solution is the same phase as the solvent. A solution in which the overall phase is a gas is called a **gaseous solution**. A solution in which the overall phase is a liquid is called a **liquid solution**. A solution in which the overall phase is a solid is called a **solid solution**. Table 14.2.1 lists some common types of solutions, with examples of each.

Table 14.2.1: Types of Solutions

Solute	Solvent	Example
gas	gas	air
gas	liquid	carbonated beverages
liquid	liquid	ethanol (C_2H_5OH) in H_2O (alcoholic beverages)
solid	liquid	salt water
gas	solid	H_2 gas absorbed by Pd metal

Solute	Solvent	Example
liquid	solid	Hg(*l*) in dental fillings
solid	solid	steel alloys

As we have just learned, a solution need not involve water. However, when water is the solvent, it is called an **aqueous solution**. When the solvent is any substance other than water, it is called a **nonaqueous solution**.

In many cases, the relative amounts of solute and solvent may be referenced using the terms dilute and concentrated. A **dilute solution** is one that contains a relatively small amount of solute dissolved in a solvent, while a **concentrated solution** is one that contains a relatively large amount of solute dissolved in a solvent. There is no set cut-off point that distinguishes a dilute solution from a concentrated solution and what constitutes dilute or concentrated may vary with the solute and/or solvent.

Solubility and Saturation

Table salt, NaCl, readily dissolves in water. In most cases, only a certain maximum amount of solute can be dissolved in a given amount of solvent. This maximum amount is specified as the **solubility** of the solute. It is usually expressed in terms of the amount of solute that can dissolve in 100 g of the solvent at a given temperature. Table 14.2.2 lists the solubilities of some simple ionic compounds at 25°C. These solubilities vary widely. NaCl can dissolve up to 36.1 g per 100 g of H_2O at 25°C, while AgCl can dissolve only 0.00019 g per 100 g of H_2O at 25°C.

Table 14.2.2: Solubilities of Some Ionic Compounds

Solute	Solubility (g per 100 g of H_2O at 25°C)
AgCl	0.00019
$CaCO_3$	0.0006
KBr	70.7
NaCl	36.1
$NaNO_3$	94.6

When the maximum amount of solute has been dissolved in a given amount of solvent at a specified temperature, we say that the solution is **saturated** with solute. When less than the maximum amount of solute is dissolved in a given amount of solvent at a specified temperature, the solution is **unsaturated**. These terms are also qualitative terms because each solute has its own solubility. A solution of 0.00019 g of AgCl per 100 g of H_2O may be saturated at 25°C, but with so little solute dissolved, it is also rather dilute. A solution of 36.1 g of NaCl in 100 g of H_2O at 25°C is also saturated, but rather concentrated. Figure 14.2.2 shows the distinction between an unsaturated solution and a saturated solution of NaCl.

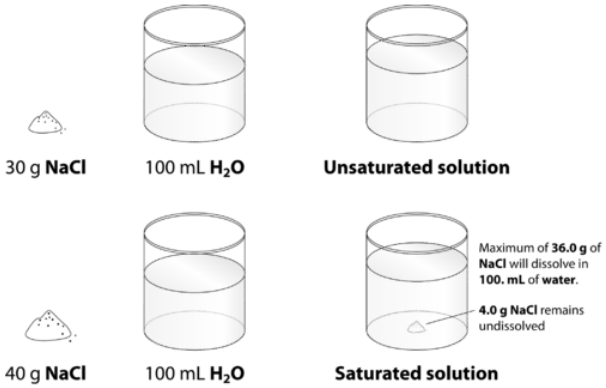

Figure 14.2.2: 30.0 g of NaCl completely dissolves in 100 mL H_2O. When 40.0 g NaCl is added, 36.0 g dissolves and 4.0 g remains undissolved. The end result is a saturated solution.

How can you tell if a solution is saturated or unsaturated? If more solute is added and it does not dissolve, then the original solution was saturated. If the added solute dissolves, then the original solution was unsaturated. A solution that has been allowed to reach equilibrium, but which has extra undissolved solute at the bottom of the container, must be saturated.

This said, it is sometimes possible for a solution to have more solute dissolved than a saturated solution at a given temperature. Such a solution is called a **supersaturated** solution. A supersaturated solution may be formed by heating the solvent, dissolving more solute than would normally dissolve at regular temperatures, then allowing the solution to slowly cool. Supersaturated solutions are not stable. Given the opportunity (such as dropping a crystal of solute in the solution), excess solute will precipitate from a supersaturated solution.

Video 14.2.1 and Video 14.2.2 show some interesting applications of supersaturated solutions. Video 14.2.1 shows supersaturated sodium acetate solution being used in a reusable hand warmer, while Video 14.2.2 shows how to make rock candy from a supersaturated solution of sucrose.

Video 14.2.1: A supersaturated sodium acetate solution may be used to make reusable hand warmers.

Video 14.2.2: A supersaturated sucrose solution may be used to make rock candy.

✅ Example 14.2.1

A solution is made by dissolving 1.00 g of sucrose, $C_{12}H_{22}O_{11}$, in 100.0 g of liquid water. Identify the solute and solvent in the resulting solution.

Solution

Either by mass or by moles, the obvious minor component is **sucrose**, so it is **the solute**. **Water** – the majority component – is **the solvent**. The fact that the resulting solution is the same phase as water also suggests that water is the solvent.

✅ Example 14.2.2

Indicate whether gasoline and ethanol, CH_3CH_2OH, are miscible or immiscible with water.

Solution

Gasoline is a mixture of hydrocarbons. Hydrocarbons are nonpolar, while water is polar. Therefore, gasoline and water are immiscible with each other. Ethanol, CH_3CH_2OH, has a polar —OH grouping that makes ethanol a polar compound and one in which hydrogen bonds exist. Therefore, ethanol and water are miscible with each other.

✏️ Exercise 14.2.1

A solution is made by dissolving 3.33 g of HCl (*g*) in 40.0 g of liquid methyl alcohol, CH_3OH. Identify the solute and solvent in the resulting solution.

Answer

solute: HCl (*g*); solvent: CH_3OH

✏️ Exercise 14.2.2

Which solution is an example of an aqueous solution and which is an example of a nonaqueous solution?

A. Sugar dissolved in water.
B. Naphthalene dissolved in ethanol.

Answer

Sugar dissolved in water is an example of an aqueous solution.

Naphthalene dissolved in ethanol is an example of a nonaqueous solution.

Summary

- Solutions are composed of a solvent (major component) and a solute (minor component).
- Solvents and solutes can be any phase of matter combined together.
- A saturated solution has the maximum amount of solute possible at a given temperature. An unsaturated solution will have less solute than a saturated solution and, in certain cases, a supersaturated solution can be made which has more solute.

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