2.3 Concentration and Solubility

Key Question: What are concentration and solubility, and how do they change solutions?

You know that certain substances are good for you. Others are bad for you. Some substances can be both good and bad for you.

In small amounts a substance can be good. If you have too much, the substance can hurt you.

Foxglove Leaves

Foxglove is a common plant (Figure 1). The medicine digitalis comes from foxglove leaves. It can help people with weak hearts.

Figure 1 Digitalis comes from the leaves of a foxglove plant. Small amounts can help people with weak hearts. Too much can be very harmful.

People used to make tea with foxglove. They soaked parts of the plant in hot water. The digitalis mixed with the water.

A small amount of the tea helped people with weak hearts. The tea made their hearts beat stronger. However, people had to be careful with foxglove tea. Tea that was too strong made their hearts beat much too fast.

Concentrated and Dilute Solutions

You may have heard people use the words "concentrated" or "dilute." These words describe how much solute is in a solution.

concentrated solution
a solution with a large number of solute particles in a given volume of solution

dilute solution
a solution with a small number of solute particles in a given volume of solution

A solution with a large amount of solute is a **concentrated solution**. A solution with a small amount of solute is a **dilute solution** (Figure 2). Very dilute foxglove tea could help people. Very concentrated foxglove tea could hurt people.

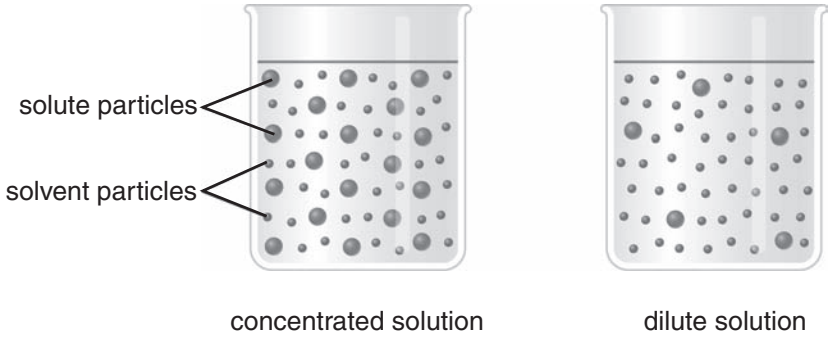

Figure 2 A concentrated solution contains more solute particles (large particles) than the same volume of a dilute solution.

Imagine you have a glass of water. Your friend has a glass with the same amount of water. You add one spoonful of fruit drink powder to your glass. Your friend adds three spoonfuls to his glass.

Your fruit punch solution will be dilute. Your friend's fruit punch solution will be concentrated. Look at Figure 3 to see the difference.

Figure 3 You can make a concentrated solution by adding a lot of solute. You can make a dilute solution by adding less solute to the same volume of solvent.

The volume of the solvent can also change. Imagine you have two glasses with different amounts of water in them. You add the same amount of solute. The glass with less water will be more concentrated.

Calculating Concentration

concentration
the amount of solute present in an amount of solution

The amount of solute in a solution is the **concentration** of the solution: the more solute, the greater the concentration.

The equation for concentration is

$$\text{concentration} = \frac{\text{mass of solute (in grams)}}{\text{100 mL of solution}}$$

For example, in a sugar/water solution you might have

1. 100 mL of solution
2. 5.0 g of sugar

$$\text{concentration} = \frac{\text{mass of solute (in grams)}}{\text{100 mL of solution}}$$

$$\text{concentration} = \frac{\text{5.0 g sugar}}{\text{100 mL of solution}}$$

The concentration of the sugar/water solution is 5.0 g/100 mL.

In a baking soda/water solution you might have

- 50 mL of solution
- 4.5 g baking soda

$$\text{concentration} = \frac{\text{mass of solute (in grams)}}{\text{100 mL of solution}}$$

Remember that concentration is always described per 100 mL of solution. We divide the amount of solution (50 mL) into 100 mL. In this case that is 2. Then we multiply the amount of solute by that number.

$$\frac{\text{100 mL}}{\text{50 mL}} = 2$$

$$2 \times 4.5 \text{ g} = 9.0 \text{ g}$$

$$\text{concentration} = \frac{\text{9.0 g baking soda}}{\text{100 mL of solution}}$$

The concentration of the baking soda/water solution is 9.0 g/100 mL.

Saturated and Unsaturated Solutions

Think back to the powdered fruit drink. What do you think would happen if your friend kept adding powder to the fruit punch? At some point, the drink would be saturated. The powder would not dissolve into the water.

saturated solution
a solution in which no more solute can dissolve

unsaturated solution
a solution in which more solute can be dissolved

A solution that cannot dissolve any more solute is a **saturated solution**. A solution that can still dissolve more solute is an **unsaturated solution**.

Solubility

There is a limit to how much solute a solvent can dissolve.

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

There are three parts to solubility. **Solubility** is

1. the largest amount of a solute that can dissolve
2. in a certain volume of a solvent
3. at a certain temperature

Solubility can be measured in grams of solute per 100 mL of solvent at room temperature (g/mL at 20 °C). The equation is

$$\text{solubility} = \frac{\text{maximum mass of solute that will dissolve (in grams)}}{\text{100 mL solvent at given temperature}}$$

Different substances have different solubility. Look at Table 1 to see the solubility of sugar and salt.

Table 1 The Solubility of Sugar and Salt in Water

Solute	Solubility in water at 20 °C
sugar	204 g/100 mL of water
salt	36 g/100 mL of water

Name: _____ Date: _____

CONCENTRATION VS. SOLUBILITY

Concentration and solubility may seem alike, but there is a difference.

- Concentration is solute (grams) per 100 mL of *solution*.
- Solubility is solute (grams) per 100 mL of *solvent*.

In other words:

- concentration = g/100 mL solution
- solubility = g/100 mL solvent

CHECK YOUR UNDERSTANDING

1. Use your own words to define "concentrated" and "dilute."

2. Use your own words to define "saturated" and "unsaturated."

3. How are "solubility" and "saturated" similar? How are they different?

4. Think back to the Key Question. Describe how concentration and solubility change solutions.

END