Concentration

The term **concentration** refers to the amount of reactants present in a particular volume of liquid or gas during the reaction. For example, if you put 20 teaspoons of sugar in a litre of water, then the concentration of sugar is high. The solution is concentrated. However, if you put 1 teaspoon of sugar in a litre of water, then the concentration of sugar is low. The solution is dilute. Concentrated and dilute solutions are shown in Figure 5.3.5.

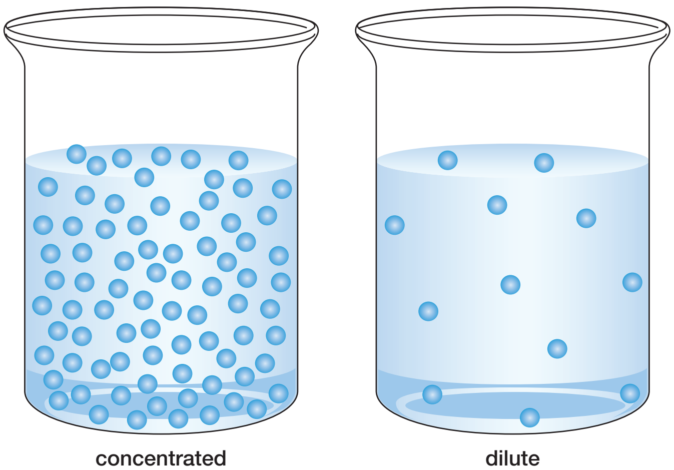

Figure 5.3.5 A concentrated solution has a large number of sugar molecules in the beaker of water. A dilute solution has very few sugar molecules in the same volume.

Increasing the concentration of the reactants will increase the rate of reaction. This is because the particles are more likely to collide and react when they are highly concentrated. Collisions between particles are necessary to allow the bonds to break and new bonds to form.

Increasing the concentration of reactants is a very common way of increasing the rate of reaction. You concentrate the reactants whenever you turn up the gas knob on a heater or stove like in Figure 5.3.6, add more wood to a fire, add more sugar to a breadmaker or drink 20 mL instead of 10 mL of antacid to relieve heartburn.

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Figure 5.3.6 When you increase the flow of gas on a gas stove, you increase the concentration of reactants to produce a bigger flame and more heat.

It is also common to reduce the concentration of reactants in order to slow the rate of some reactions. When you place food in a zip-lock bag or air-tight container, you are limiting the concentration of oxygen and therefore limiting how quickly the food can go stale. A similar principle is used to protect some iron structures from rusting. Iron is often coated with paint to limit the amount of oxygen that can react with the surface to form iron(II) oxide (rust).

Agitation

Stirring reactants can also increase the rate of reaction. Stirring is known scientifically as **agitation**. Agitation ensures that the reactants are kept in contact, by removing build-up of products around the reactants. For example, if a solid piece of calcium carbonate is dropped into the bottom of a beaker of sulfuric acid, it will react with the acid to produce calcium sulfate, water and carbon dioxide gas. The word equation for this reaction is:

calcium carbonate + sulfuric acid → calcium sulfate + water + carbon dioxide

and the formula equation is:

$$CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(aq) + H_2O(l) + CO_2(g)$$

Although the carbon dioxide bubbles off as a gas, the other products—calcium sulfate and water—build up around the calcium carbonate as shown in Figure 5.3.7. The products surround the calcium carbonate, which means less sulfuric acid contacts the calcium carbonate to react. Agitating the reaction flushes the products away from the calcium carbonate, and allows the sulfuric acid to attack the surface of the calcium carbonate. Magnetic stirrers (Figure 5.3.8) are used in the laboratory to constantly agitate reactions and ensure the maximum rate of reaction.

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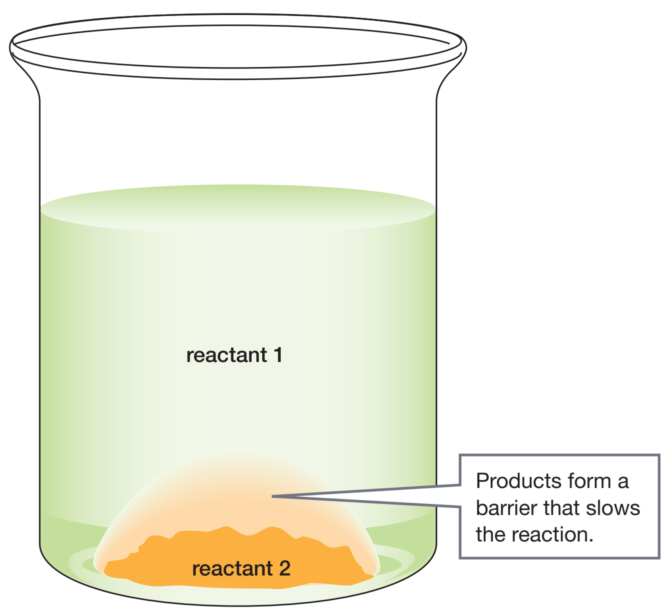

Figure 5.3.7 When a solid reacts with a liquid, the products build up around the solid, slowing down the rate of reaction. Agitation removes the build-up of products to maximise the rate of reaction.