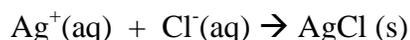


Factors Influencing the Rate of Reactions

Some reactions are very fast and some are very slow, no matter what every chemical reaction requires certain amount of time for its completion. Reaction between ions in solution is usually fast provided there is no change in oxidation state, for example, the neutralization of an acid by base, which proceeds as fast as solutions are mixed together due to high number of collisions. This is probably due to the fact that every time a hydrogen ion collides with a hydroxide ion reaction occurs, leaving little delay in the reaction. On the other hand, precipitation reaction, such as, formation of silver chloride when solutions containing a silver ion is mixed with a solution containing chloride ion, may require a few seconds to allow the ions to diffuse towards each other to form the precipitate(crystalline grain):

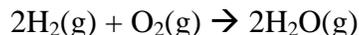


Ionic oxidation-reduction reactions are sometimes very slow, for example, the oxidation of Sn^{2+} ion by Fe^{3+} ion:



Here the reaction does not occur every time a Sn^{2+} ion collides with one or two Fe^{3+} ions. In order for the reaction to take place, the collision should be effective enough to transfer the electrons from Sn^{2+} ions to Fe^{3+} ions. Such collisions may not be of great number.

Some reactions are extremely slow at room temperature like the reaction between hydrogen gas and oxygen gas:



A mixture of these two gases can be kept for years without any appreciable reaction.

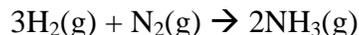
The factors that influence the rate of chemical reaction are numerous. Some of these are

- Composition of reacting substances
- Concentrations of reactants
- Physical form of reacting mixture
- The intimacy of their mixture
- The temperature and pressure
- Any special circumstances such as irradiation with visible light, ultraviolet light, x-rays, neutrons, or other wave or particles
- The presence of catalyst

Homogeneous and Heterogeneous Reactions

A reaction that takes place in a single phase (homogenous system) is known as *homogenous reaction*. The most important of these reactions are those in gaseous and

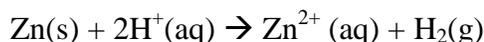
liquid solutions. For example, formation of ammonia gas from hydrogen and nitrogen gases:



A reaction that takes place in two or more phases (heterogeneous system) is called *heterogeneous reaction*. For instance, the oxidation of carbon by potassium perchlorate involves two phases, solid and gas.



Another example is the reaction between solid zinc and acid solution:



This reaction involves three phases, namely, the solid zinc phase, the solution phase(acid), and the gaseous phase formed by the evolved gas (H_2).

The Rates of Heterogeneous and Homogeneous Reactions

A heterogeneous reaction takes place at the interfaces (surfaces) of reacting substances that can be made to go faster by increasing the surface area. Thus, finely divided zinc reacts more rapidly with acid than coarse zinc.

Question: Why the laundry detergents are always in powdered form instead of solid like cake or bath soap?

Answer: Powdered form provides a greater surface area as oppose to cake form thereby increasing the rate of reaction. This illustrates the influence of the physical form.

Catalysts may also accelerate the rate of homogeneous as well as heterogeneous reactions, for example, the enzymes in the living bodies. The rates of almost all the chemical reactions greatly depend on the temperature. **It is generally true that rates can be accelerated by increase in temperature.**

Temperature plays an important role in making our life comfortable; higher the temperature higher the rate of chemical reaction and lower the temperature lower the rate of chemical reaction. We keep the food in the refrigerator to prolong its self-life or to lower the rate of spoilage (the spoilage is nothing but the chemical reaction). Otherwise, the food left outside in the room will spoil quickly because the rate of spoilage increases at room temperature as the room temperature is higher than the refrigerator temperature.

Sometimes a reactant may exhaust in the neighborhood of the interface that slows down the reaction. In that case, stirring the mixture will speed up the reaction. This is the reason why we stir tea or coffee after we put the sugar in it.

Question: When you want to dry cloths in a dryer after laundry, which takes less time, folded cloths or non-folded cloths? And why?

Most actual chemical processes are very complicated and the analysis of their rates is not that easy. As reaction proceeds, the reacting substances are used up and new ones are created. The process becomes further complicated if heat is evolved or absorbed during the course of the reaction. In addition, other effects may occur that may even further complicate the reaction.

Chemists have attempted to simplify the problem as much as possible in an effort to understand the rate of reactions. A good understanding has been acquired for homogeneous reactions- in a gaseous or liquid solution- that take place at constant temperature. Experimental studies are conducted by placing the reacting system in a constant temperature device known as *thermostat*. Theoretically, the quantitative theories have been developed, which are discussed in separate sections in this chapter.