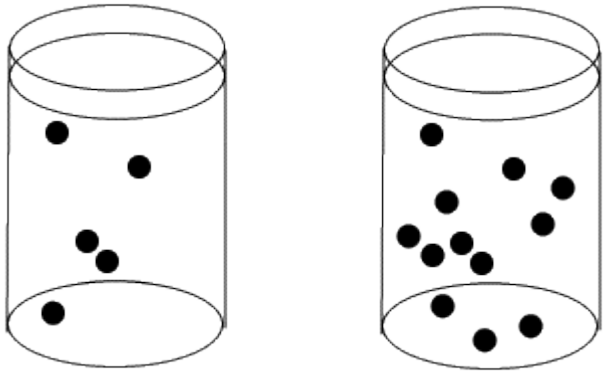
RATE LAWS

So far, we have talked about changes in the number of molecules over time as a reaction progresses. The number of reactant molecules decreases as the number of product molecules increases.

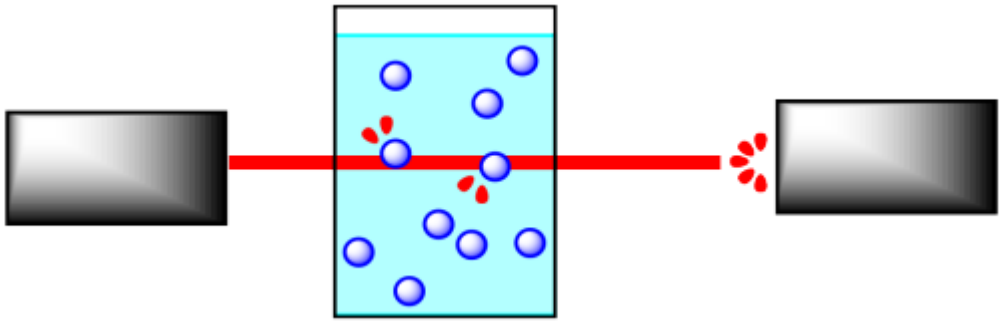
Practically, the easiest way to measure the speed of a reaction is to measure the concentration over time. We can measure either the concentration of the reactants or the products.

Remember, concentration refers to how densely populated a solution is with a particular compound.

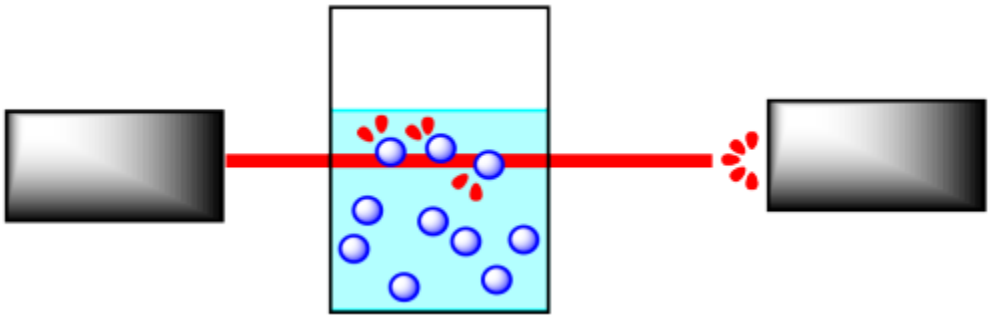


The concentration of black dots is higher in the beaker on the right than in the beaker on the left.

Reactions are often monitored by some sort of spectroscopy. In spectroscopy, "light" or some other frequency of electromagnetic radiation shines through a sample in which a reaction is taking place. The light can interact with the molecules in the sample. The molecules absorb particular frequencies of light, so if the light encounters the molecules on its way through the sample, a little of the light at those frequencies is absorbed. Less light makes it all the way through the sample; the amount that does make it through is measured by a detector on the other side.



If the concentration of the sample is different, a different amount of light from the spectrometer will be absorbed. For instance, suppose the sample is more concentrated. The more molecules there are, the more light is absorbed. And because the beam of light travels through the sample in a straight line, the more concentrated the solution, the more molecules it will encounter.



It is pretty simple to calibrate the instrument to be able to determine concentration from the amount of light absorbed. In addition, the light may interact with the reactant molecules and product molecules in different ways. That means you can monitor the absorption of a frequency that you know is absorbed by reactant molecules, but not by product molecules, and you can detect changes in reactant concentration. You could also do the same thing to detect changes in product concentration.

We sometimes write the rate of the reaction as:

Rate = d[product]/dt

Meaning, the rate is the change in concentration of product with change in time.

Concentration could be measured in any units. Frequently, we are dealing with a solution, and we use units such as grams per liter or, much more commonly, moles per liter. The change in time is most often measured in seconds.

We could also write the rate of the reaction as:

Rate = -d[reactant]/dt

Meaning, the rate is the change in concentration of reactant with change in time. The minus sign just means that the reaction is getting consumed over time as it turns into product, so its concentration is decreasing.

Kinetic studies are important in understanding reactions. Not only are they important in industry, but they are also used to understand biological processes, especially enzyme-catalyzed reactions. They also play a role in environmental and atmospheric chemistry, as part of an effort to understand a variety of issues ranging from the fate of prescription pharmaceuticals in wastewater to the cascade of reactions involved in the ozone cycle.

Source: http://employees.csbsju.edu/cschaller/Reactivity/kinetics/rkratelaw.htm