CHEMICAL KINETICS : RATE OF REACTION

3. Chemical kinetics

Kinetics - Study of factors that affect how fast a reaction occurs and the step-by-step processes involved in chemical reactions.

Factors that Affect Reaction Rate

A. Concentration of reactants - higher reactant concentrations increase the rate of reaction.
B. Catalyst – substance that accelerates the reaction rate without being transformed.
C. Temperature - higher temperatures usually increase the rate of reaction.
D. Surface area of solid - smaller particles have more surface area so the rate increases.

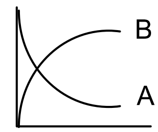
13.1. THE RATE OF A REACTION

Rate of reaction: The change in the amount of a reactant or product per unit time. (Analogy: speed of an automobile = ΔDistance/Δtime.)

$$\text{Average Rate} = \frac{\Delta\text{concentration}}{\Delta\text{time}}$$

[ ] = concentration

E.g. For a reaction A → B



Average Rate for B = = ; Average Rate for A = =

- The reaction rate is a measure of how fast a reaction occurs.
- Rate can be expressed as the rate of formation of products or the rate of disappearance of reactants.
- Reaction rate is always positive, so a (-) sign is used for reactant rate expressions. (Because the concentration of reactants decreases with time, Δ[Reactants] is a negative quantity.)
- Reaction rate decreases with time ⇒ slope of curve decreases as reaction progresses.

Experimental Determination of Rate

We can find the rate of reaction by measuring the concentration of a reactant or product during the course of the reaction. Concentration can be obtained by different methods including titration, spectroscopy, and by taking manometer pressure readings.

Spectrometer Measurements

E.g. $Br_2 + HCO_2H \rightarrow 2Br^- + 2H^+ + CO_2$

A colored species, Br_2, is consumed during this reaction, so we can use a spectrophotometer to measure the absorbance of light over a series of time intervals. (The absorbance is proportional to the concentration of Br_2.) The concentration of Br_2 vs. time can then be plotted as shown in Figure 13.5.

Example. Calculate the average rate from t = 50.0 s to 100.0 s

instantaneous rate: Rate at a specific point in time. Analogy: the speed a car is traveling when a photo radar camera snaps the picture.

To calculate instantaneous rate - draw a line tangent to the curve at a given instant in time & find the slope of the line.

Example. Instantaneous Rate at t = 200.0 s:

*Due to estimating the values used in determining the slope of the line, the value that you obtain for the instantaneous rate may differ from the instantaneous rates given in your text book.

Gas Phase Reactions

If one of the substances in the reaction mixture is a gas, manometer readings can be taken to monitor the pressure of the gas.

e.g. $2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$

The rate of oxygen evolution can be measured with a manometer. The pressure of oxygen can then be converted to concentration by using the ideal gas law:

$$PV = nRT$$

Concentration can be expressed as: $\frac{n}{V} = \frac{\text{moles}}{L} = M$

By substitution: P = MRT or $M = \frac{P}{RT}$

Reaction Rates & Stoichiometry

Consider the reaction: $2N_2O_5 \rightarrow 4NO_2 + O_2$

- For this reaction, the rate of disappearance of N_2O_5 is twice the rate of formation of O_2.
- To make the rates equal, divide rates by their stoichiometric coefficients:

$$\text{Rate} = -\frac{1}{2}\frac{\Delta[N_2O_5]}{\Delta t} = \frac{1}{4}\frac{\Delta[NO_2]}{\Delta t} = \frac{\Delta[O_2]}{\Delta t}$$

Example. For the reaction, $3H_2 + N_2 \rightarrow 2NH_3$, write the rate expressions in terms of the disappearance of the reactants and the appearance of the products.

Example. For the reaction, $2N_2O_5 \rightarrow 4NO_2 + O_2$, if the rate of decomposition of N_2O_5 is 4.2×10^{-7} mol/(L·s), what is the rate of appearance of (a) NO_2; (b) O_2?

Source : http://ciseche10.files.wordpress.com/2013/12/3-chemical-kinetics.pdf