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With the aid of relevant chemical and mathematical equations, show whether the half-life of a second order reaction is concentration dependent or not.

Half-Life

Another characteristic used to determine the order of a reaction from experimental data is the [half-life](https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Kinetics/Reaction_Rates/Half-lives_and_Pharmacokinetics) (t1/2t1/2). By definition, the half life of any reaction is the amount of time it takes to consume half of the starting material. For a second-order reaction, the half-life is inversely related to the initial concentration of the reactant (A). For a second-order reaction each half-life is twice as long as the life span of the one before.

Consider the reaction 2A→P2A→P:

We can find an expression for the half-life of a second order reaction by using the previously derived integrated rate equation.

1[A]t−1[A]o=kt(32)(32)1[A]t−1[A]o=kt

Since,

[A]t1/2=12[A]o(33)(33)[A]t1/2=12[A]o

When,

t=t1/2(34)(34)t=t1/2

Our integrated rate equation becomes:

112[A]o−1[A]o=kt1/2(35)(35)112[A]o−1[A]o=kt1/2

After a series of algebraic steps,

2[A]o−1[A]o=kt1/2(36)(36)2[A]o−1[A]o=kt1/2

1[A]o=kt1/2(37)(37)1[A]o=kt1/2

We obtain the equation for the half-life of a second order reaction:

t1/2=1k[A]o(38)(38)t1/2=1k[A]o

This inverse relationship suggests that as the initial concentration of reactant is increased, there is a higher probability of the two reactant molecules interacting to form product. Consequently, the reactant will be consumed in a shorter amount of time, i.e. the reaction will have a shorter half-life. This equation also implies that since the half-life is longer when the concentrations are low, species decaying according to second-order kinetics may exist for a longer amount of time if their initial concentrations are small.

Note that for the second scenario in which A+B→PA+B→P, the half-life of the reaction cannot be determined. As stated earlier, [A]o[A]o cannot be equal to [B]o[B]o. Hence, the time it takes to consume one-half of A is not the same as the time it takes to consume one-half of B. Because of this, we cannot define a general equation for the half-life of this type of second-order reaction.