Kinetics: Second-Order Kinetics

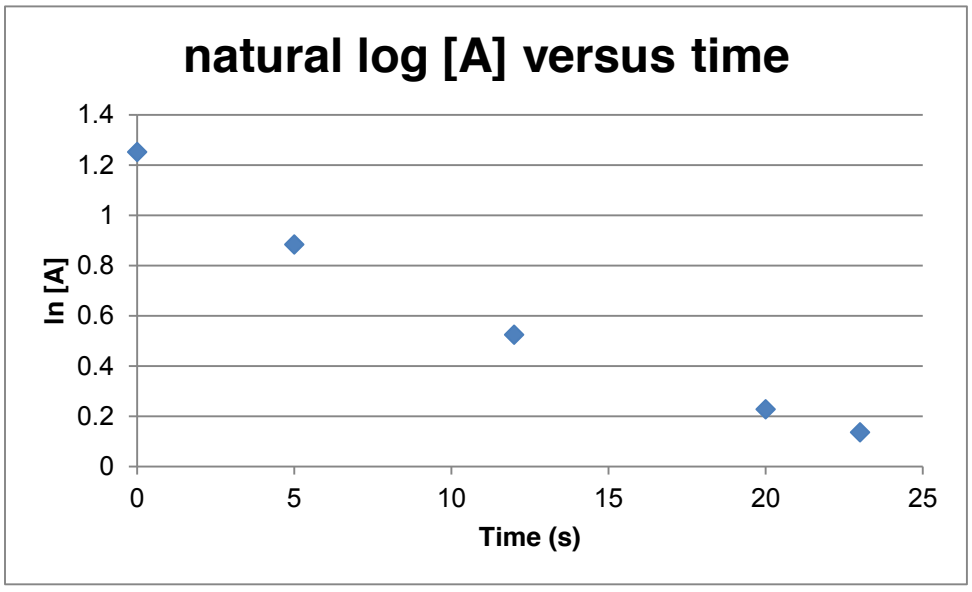
1. Question: Consider the data collected for the reaction

$$A \rightarrow \text{products}$$

[A], M	Time, s
3.50	0
2.42	5
1.69	12
1.26	20
1.15	23

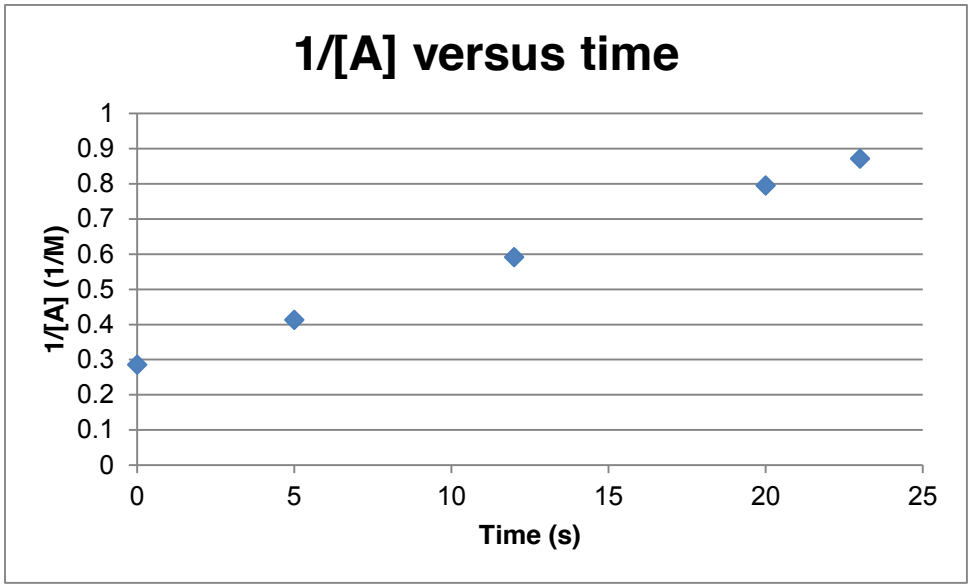
Determine the order of the reaction.

Answer: As with first problem found in module 5 (First-Order Kinetics and the integrated Rate Law) practice problems, a plot of ln A v. t can be produced. If linear, it is first-order.



This plot is curved, not linear. It is not first-order.

Now, produce a plot of 1/[A] v. t.



This plot is linear. The reaction is second-order.

2. Question: A second-order reaction has a rate constant of 2.50×10^{-3} $M^{-1}s^{-1}$. The reaction starts with a concentration of reactant of 1.25 M. What is the concentration of the reactant after 40 seconds?

   Answer: The reaction in this problem is second-order. The second-order integrated rate law is given as:

$$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$$

   To determine $[A]_t$, plug in the values for k, t and the initial concentration, $[A]_0$.

$$\frac{1}{[A]_t} = 2.50 \times 10^{-3} \frac{1}{M\,s} \times (40\ s) + \frac{1}{1.25\ M}$$

$$\frac{1}{[A]_t} = 0.900 \frac{1}{M}$$

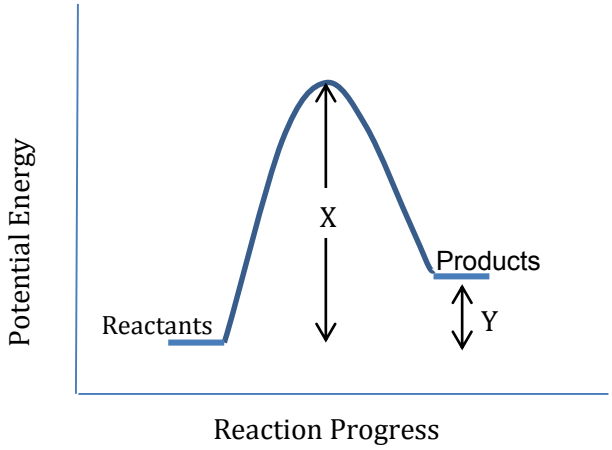
$$[A]_t = \frac{1}{0.900\ 1/M} = 1.11 M$$

Kinetics: Collision Theory

1. Question: Which one of the following statements is ***false*** concerning collision theory of chemical kinetics?
    a. Molecules collide in order to react. As the concentration increases, the number of collisions per second increases, therefore the rate of reaction increases.
    b. Every collision between the correct molecules will result in a reaction.
    c. As temperature increases, the reaction rate increases. This is because more molecules have enough kinetic energy to overcome the activation energy barrier.
    d. In comparing two first-order reactions with different activation energies but the same initial concentrations, the reaction with the greater activation energy will have a slower rate of reaction.

    Answer: Statement b. is false. Only collisions with enough kinetic energy to overcome the activation energy will result in a reaction.

2. Question: Consider the following diagram and select the true statement.



a. The variable X represents activation energy and can be positive or negative, depending upon the reaction.
b. The variable Y represents activation energy and can be positive or negative, depending upon the reaction.
c. The variable X represents activation energy and is always a positive value.

The variable Y represents activation energy and is positive only for endothermic reactions.

Answer: The arrow marked with the “X”, represents the activation energy. It is always a positive value.

The arrow marked with the “Y”, represents the enthalpy change. In this diagram, the value is positive (an endothermic reaction). However, for many reaction, the enthalpy change is negative and the products will have lower energy than the reactants.