**Kinetics Note Guide: Khan Academy**

https://www.khanacademy.org/science/chemistry/chem-kinetics/reaction-rates/v/introduction-to-kinetics

Introduction to Kinetics (15:26)

1. Draw a Lewis dot and a molecular representation of the hydriodic acid synthesis reaction.
2. What is an activated complex? Draw an example of the hydriodic acid complex and describe it’s stability.
3. Describe what activation energy is, the role it has in reactions, and how it can be reduced.
4. Draw an exothermic energy change diagram for the hydriodic acid synthesis reaction. Label the points at which the reactants are present, the activated complex is present, and the products are present. Also show the activation energy (Ea) and ΔHrxn.
5. Show how the diagram in #4 would change if the reaction was endothermic.
6. Identify the factors that can influence the rate of a reaction and describe how each affects the rate specifically.

Rate of Reaction (9:13)

1. How is the rate of a reaction described mathematically? Provide 2 example equations as demo’d for reactant A and product B in the video.
2. How is rate related to molar ratios from a balanced equation? Transcribe the N2O5 example in the video to supplement your answer.

Rate Law and Reaction Order (10:38)

1. What affect does concentration have on the rate of reaction? Explain why.
2. Transcribe the multiple concentration experiment example below. Highlight when rate should be measured to compare trials and why.
3. What mathematical formula shows the relationship between concentration and rate? Highlight how the power for each reactant is determined (ie: how was [A]1 and [B]2 found?) and what k represents.
4. What does the order of a reaction represent and how is it determined?
5. What unit does the rate constant (k) have in the following scenarios?
   1. Zero order reaction
   2. 1st order reaction
   3. 2nd order reaction
6. Determine the order of the following reaction and the proper units for the rate constant.

**2H2 (g) + O2 (g) → 2H2O (l)**

[H2] [O2] Rate (M/s)

3.54 x 10-2 M 1.03 x 10-3 M 5.56 x 10-5

7.08 x 10-2 M 1.03 x 10-3 M 2.22 x 10-4

3.54 x 10-2 M 3.09 x 10-3 M 5.56 x 10-5

Experimental Determination of Rate Laws (12:27)

1. Follow and transcribe the nitrogen monoxide and hydrogen reaction example below and determine the following:
2. The rate law of the reaction
3. The order of the reaction
4. The value of the rate constant k (with units)
5. The rate of the reaction when [NO] = 0.012 M and [H2] = 0.0060 M
6. Using the values from the synthesis of water experiment, determine:
   1. The rate law of the reaction
   2. The order of the reaction
   3. The value of the rate constant k (with units)
   4. The rate of the reaction when [O2] = 0.098 M and [H2] = 0.0075 M

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3.54 x 10-2 M 3.09 x 10-3 M 5.56 x 10-5

First Order Reaction, w/calculus (7:14)

1. Using the example equation “A → products”, determine:
   1. An equation to describe the rate of reactant A
   2. The rate law of the reaction if it is known to be 1st order
2. A majority of the video will describe the derivation of the differential 1st order rate law, skip ahead to 4:34 and write down the integrated rate law for 1st order reactions.
3. Show how the integrated rate law can be arranged to represent y = mx + b. Identify which components of the rate law represent y, x, m, and b.
4. Draw a graph, with a labeled x and y axis, that would represent the loss of reactant A over time. Label the following points on the graph:
   1. ln[A]0
   2. rate constant, k

Plotting Data for 1st Order Reactions (9:20)

1. Follow the example problem to determine the following for the conversion of cyclopropane into propene:

|  |  |  |
| --- | --- | --- |
| Time (s) | [cyclopropane] (M) | ln[cyclopropane] |
| 0 | 0.099 |  |
| 300 | 0.079 |  |
| 600 | 0.065 |  |
| 900 | 0.054 |  |

1. Use the data to support the order of the reaction as first order.



1. Graph the data
2. What do you look for to support that this reaction is 1st order?
3. Calculate the value of the rate constant (k).
4. Write the rate law for the reaction.

Half-Life of a First Order Reaction (8:15)

1. Re-write the integrated rate law for a 1st order reaction.
2. Watch the derivation of the half-life equation; define what half-life represents and write the equation for the half-life of a 1st order reaction below.

First Order Example Problem (10:19)

1. Walk through the example problem to determine the following:

The conversion of cyclopropane into propene is a first order reaction with a rate constant of 6.7 x 10-4 1/s at 500⁰C.

Second Order Reaction, w/calculus (7:14)

1. Using the example equation “A → products”, determine:
   1. An equation to describe the rate of reactant A
   2. The rate law of the reaction if it is known to be 2nd order
2. A majority of the video will describe the derivation of the differential 2nd order rate law, skip ahead to 4:50 and write down the integrated rate law for 2nd order reactions.
3. Show how the integrated rate law can be arranged to represent y = mx + b. Identify which components of the rate law represent y, x, m, and b.
4. Draw a graph, with a labeled x and y axis, that would represent the loss of reactant A over time. Label the following points on the graph:
   1. 1/[A]0
   2. rate constant, k

Plotting Data for 2nd Order Reactions (8:07)

1. Follow the example problem to determine the following for the decomposition of nitrogen dioxide:

|  |  |  |
| --- | --- | --- |
| Time (s) | [NO2] (M) | 1/[ NO2] |
| 0 | 0.00800 |  |
| 50 | 0.00660 |  |
| 100 | 0.00560 |  |
| 150 | 0.00485 |  |

1. Use the data to support the order of the reaction as first order.



1. Graph the data
2. What do you look for to support that this reaction is 2nd order?
3. Calculate the value of the rate constant (k).
4. Write the rate law for the reaction.

Second Order Example Problem (8:09)

1. Walk through the example problem to determine the following:

The decomposition of nitrogen dioxide into nitrogen monoxide and oxygen is a second order reaction with a rate constant of 0.54 1/Ms at 300⁰C.

* 1. Skip, the half-life equation for 2nd order is not on the AP equation sheet and therefore would not need to be applied. (plug and chug if given in a problem anyways)

Zero Order Reaction, w/calculus (9:53)

1. Using the example equation “A → products”, determine:
   1. An equation to describe the rate of reactant A
   2. The rate law of the reaction if it is known to be 2nd order
2. A majority of the video will describe the derivation of the differential zero order rate law, skip ahead to 3:18 and write down the integrated rate law for zero order reactions.
3. Show how the integrated rate law can be arranged to represent y = mx + b. Identify which components of the rate law represent y, x, m, and b.
4. Draw a graph, with a labeled x and y axis, that would represent the loss of reactant A over time. Label the following points on the graph:
   1. [A]0
   2. rate constant, k

**Summary**

1. Rate of reaction (R) can be described as change in concentration of reactant over change in time.

***R = Δ[A]/Δt***

1. Rate changes over the progression of the reaction until equilibrium is reached.
2. Reactants decrease quickly, then level out
3. Products increase quickly, then level out
4. A rate law can be written to describe how the concentration of reactants changes over time. It includes the order of each reactant, which represents the affect that reactant has on the rate of the reaction, respectively. It also includes a rate constant (k) value.

***R = k[A]a[B]b***

1. Order can be determined for each reactant by identifying how changing concentration affects the rate of the reaction.

Ex: If [A] is doubled and the rate quadruples… 2n = 4, so n = 2 (Reactant is 2nd order)

1. Order is usually determined experimentally, but if no concentration and rate data is provided, assume the order of each reactant is equal to the coefficient of the balanced equation.

Ex: 2HC2H3O2 (aq) + Na2CO3 (s) → 2NaC2H3O2 (aq) + H2O (l) + CO2 (g)

Rate Law: R = k[HC2H3O2]2[Na2CO3]

1. The order of a reaction can be determined experimentally using reactant concentration data.
2. If [A] vs. time is linear = zero order Integrated Rate Law = ***[A]t – [A]o = -kt***
3. If ln[A] vs. time is linear = 1st order Integrated Rate Law = ***ln[A]t – ln[A]o = -kt***
4. If 1/[A] vs. time is linear = 2nd order Integrated Rate Law = ***1/[A]t – 1/[A]o = kt***