AP Lecture -- Kinetics
Day 1

Objective: The student will be able to differentiate 6 mothodologies to determine the order of a chemical reaction.

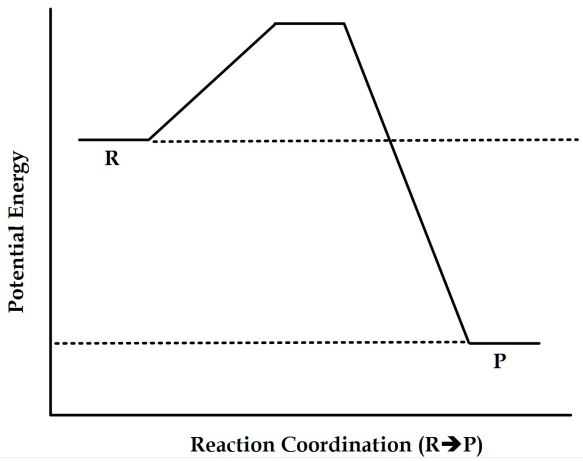
Potential Energy Diagrams

A potential energy diagram plots the changes in potential energy during a chemical reaction.

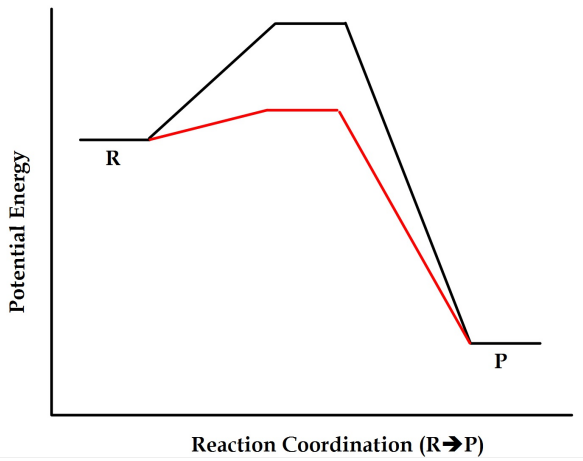
The following vocabulary list is comprised of essential words for understanding potential energy diagrams:

(1) potential energy
(2) activated complex
(3) energy of reactants, products, and activated complex
(4) enthalpy - ΔH
(5) activation energy
(6) catalyzed reaction
(7) uncatalyzed reaction
(8) endothermic and exothermic

PE Diagram for an uncatalyzed reaction



PE Diagram for a catalyzed reaction



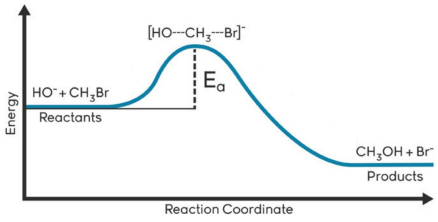
Final Words on PE Diagrams

The relationship between potential energy and kinetic energy.

Relation to bond strength and Bond energy.

Essential Questions:

(1) How do catalysts increase the rate of a chemical reaction?



Determining the Order of a Reaction

What is a reaction order?

Six ways to determine:

1. **from lab data (most important)**
2. **graphically**
3. **if the reaction is a common nuclear decay: all are first order**
4. **if the reaction is known to take place in a single step, order & coefficients are the same**
5. **if the rate mechanism is known, order can be found based on the rate-determining step (RDS)**
6. **the unit of the specific rate constant**

Method #1 -- Lab Data

Experiment	Initial Concentration of Reactants (moles/liter)		Initial Rate of Formation of D (moles/liter/hour)
	[A]	[B]	
1	0.240	0.480	8.000
2	0.240	0.120	2.000
3	0.360	0.240	9.000
4	0.120	0.120	0.500
5	0.0140	1.350	???
6	0.200	???	6.000

Write the Rate Law Expression:

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Rate-law expression: **Rate = $k[A]^2[B]$**

3. Calculate the value of the specific rate constant at 30°C.

rate constants are temperature dependent and must be specified

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Rate-law expression: Rate = $k[A]^2[B]$

4. Calculate the value of the initial rate (at 30°C) of formation of D in experiment #5.

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Rate-law expression: Rate = $k[A]^2[B]$

4. Assume the reaction goes to completion. Under the conditions specified for Exp. #2, what would the final molar concentration of C?

you may have to make that assumption on your own.

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Rate-law expression: Rate = $k[A]^2[B]$

5. What would be the initial concentration of B in trial #6?

6. True of False?

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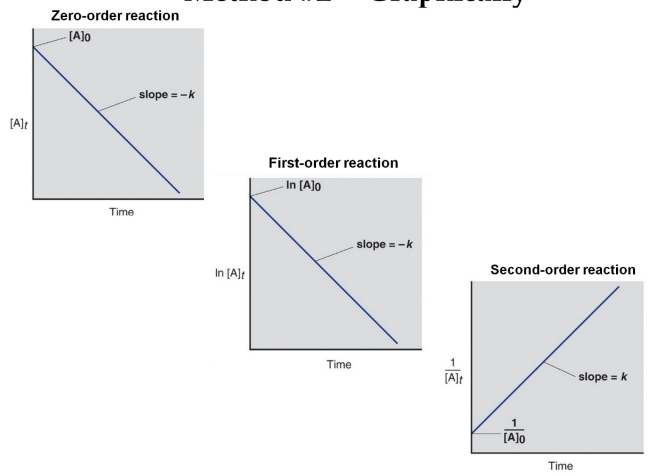
7. At different conditions, what would be the rate expression be for the above reaction if it was found to take these four steps.

Step 1:	$A \rightarrow A^*$	**(medium)**
Step 2:	$A^* + B \rightarrow C^*$	**(slow)**
Step 3:	$3\,C^* + A \rightarrow D^*$	**(medium)**
Step 4:	$D^* \rightarrow 3\,C + D$	**(fast)**

Method #2 -- Graphically



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8. If a different reaction has a specific rate constant of $3.45 \times 10^{3}\ M^{-1} \cdot hr^{-1}$, (a) what is the order of the reaction? (b) what would it take to produce a straight-line graph of the data?

Kinetics In-Class Worksheet

9. What is the half-life (in days) of the radioactive decay of an element if its first-order decay rate constant is 8.57×10^{-6} per second?

Method #1 -- Lab Data

Trial	[A]	[B]	[C]	initial rate of formation of D (in M/hr)
1	0.100	0.200	0.200	2.04×10^{-3}
2	0.100	0.200	0.400	4.08×10^{-3}
3	0.400	0.200	0.400	4.08×10^{-3}
4	0.300	0.600	0.200	1.84×10^{-2}
5	0.100	0.100	0.100	2.55×10^{-4}
6	0.350	0.350	0.350	???
7	0.200	???	0.400	6.04×10^{-4}

Activation Energy

Temp (K)	477	523	577	623
$1/T$, $K^{-1} \times 10^3$	1.33	1.25	1.18	1.11
k, s^{-1}	0.00018	0.0027	0.030	0.26
ln k	−8.62	−5.92	−3.51	−1.35

A general Rule of Thumb

The rate of a formation of a gaseous product is known to be 4.56×10^{-3} M/hr at 30.0°C. What is the rate of formation for this substance at 40.0°C?