04

CHEMICAL KINETICS

EFFECTS OF TEMPERATURE & CATALYSTS

CHEMISTRY 136L // FALL 2019

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REACTION OF INTEREST

$$2\,I^- (aq) + S_2O_8^{2-} (aq) \rightarrow I_2 (aq) + 2\,SO_4^{2-} (aq)$$

How is the rate of change of each reactant and each product related to each other?

$$\text{Rate} = +\frac{\Delta[I_2]}{\Delta t} = +\frac{1}{2}\frac{\Delta[SO_4^{2-}]}{\Delta t} = -\frac{1}{2}\frac{\Delta[I^-]}{\Delta t} = -\frac{\Delta[S_2O_8^{2-}]}{\Delta t}$$

THE RATE LAW

The reaction is first order with respect to both reactants: I^- and $S_2O_8^{2-}$.

$$\text{Rate} = k[\text{I}^-]^1[\text{S}_2\text{O}_8^{2-}]^1$$

which means the rate constant (*k*) is

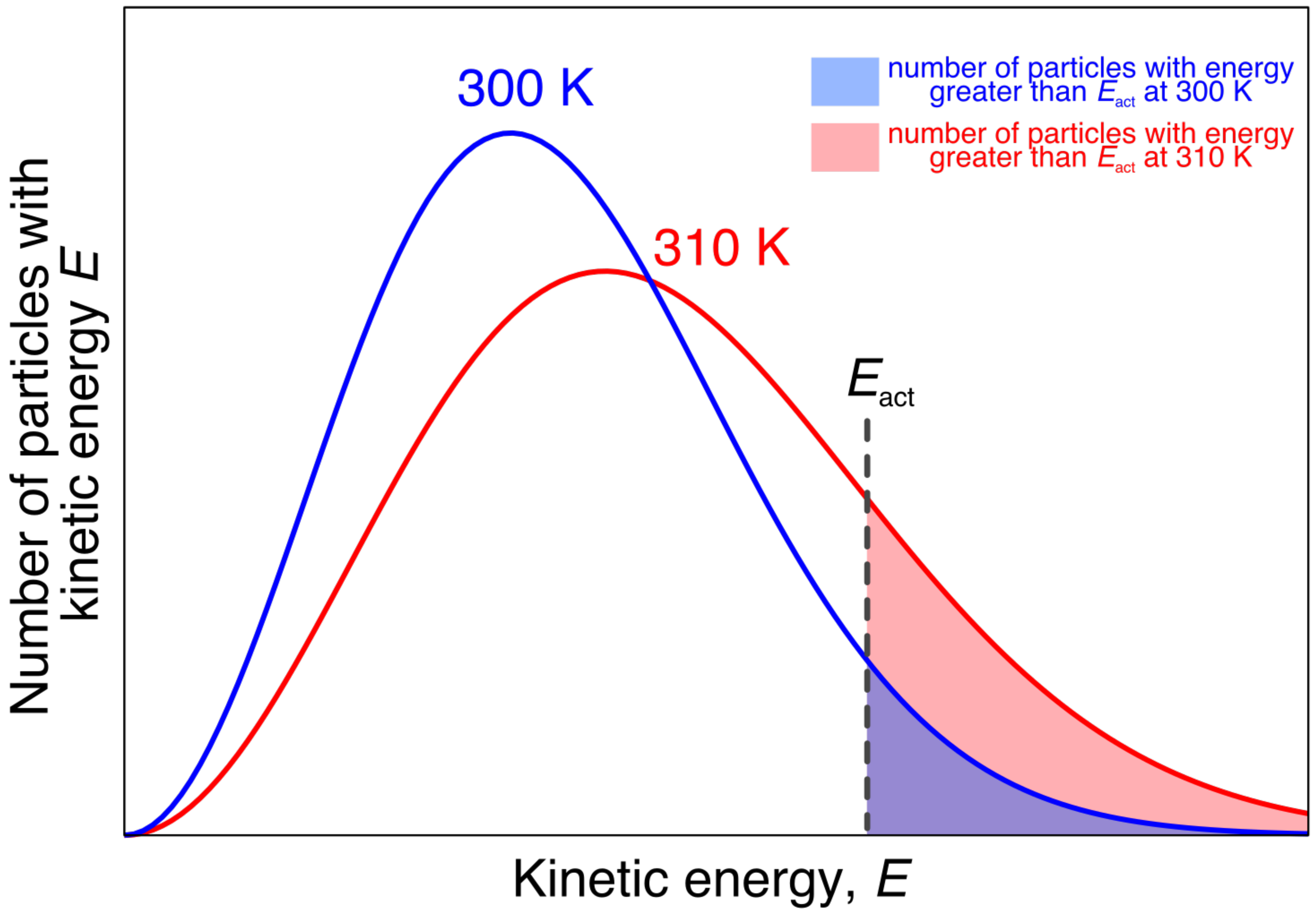
$$k = \frac{\text{Rate}}{[\text{I}^-][\text{S}_2\text{O}_8^{2-}]}$$

If the initial rate of the reaction can be measured/determine experimentally, then the value of *k* can be calculated as

$$k = \frac{\text{Initial Rate}}{[\text{I}^-]_0[\text{S}_2\text{O}_8^{2-}]_0}$$

PURPOSES OF EXPERIMENT

Reaction rates



1. Temperature dependence
2. Activation energy
3. Effect of catalyst (Cu^{2+})

Axiom

Reaction rate double for a 10 °C rise.

THE ARRHENIUS EQUATION

What is it?

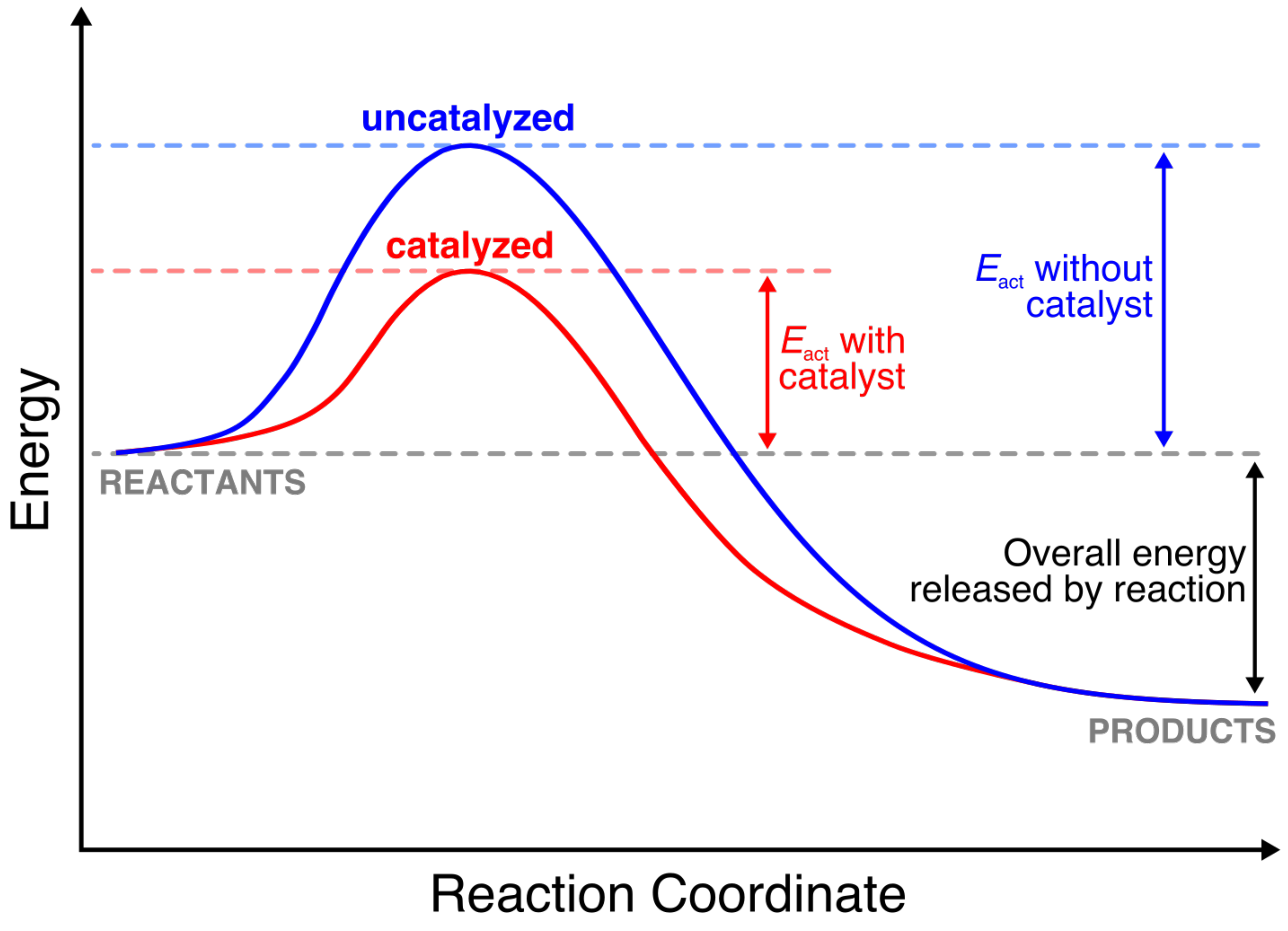
$$k = A\,e^{-\frac{E_a}{RT}} \qquad \ln k = \ln A - \frac{E_a}{RT}$$

Plot ln k vs. $1/T$

How does a catalyst increase the speed of a reaction?

1. It is not consumed in the reaction.
2. It lowers the activation energy (E_a).
3. It catalyzes in both directions.
4. It speeds up attainment of equilibrium.

Energy Diagram



GENERAL PROCEDURE

How do we measure the speed of our reaction?
What is the role of the thiosulfate ion?

$$2\,I^- (aq) + S_2O_8^{2-} (aq) \rightarrow I_2 (aq) + 2\,SO_4^{2-} (aq)$$
$$I_2 (aq) + 2\,S_2O_3^{2-} (aq) \rightarrow 2\,I^- (aq) + S_4O_6^{2-} (aq)$$

This is an extremely fast reaction compared to the reaction of interest.

Note: speed of reaction 2 is essentially speed of reaction 1!

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As long as there is $S_2O_3^{2-}$ in the reaction mixture, $[I_2] = 0$

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When all $S_2O_3^{2-}$ is consumed, I_2 will accumulate and reaction mixture turns **BLUE** with starch indicator.

GENERAL PROCEDURE

How do we measure the speed of our reaction?
What is the role of the thiosulfate ion?

$$I_2\,(aq) + 2\,S_2O_3^{2-}\,(aq) \rightarrow 2\,I^-\,(aq) + S_4O_6^{2-}\,(aq)$$

Now we can determine the rate as:

$$\text{Rate} = -\frac{\Delta[I_2]}{\Delta t} = -\frac{1}{2}\frac{\Delta[S_2O_3^{2-}]}{\Delta t} = \frac{1}{2}\frac{[S_2O_3^{2-}]_0}{t_{\text{blue}}}$$

because

$$\begin{aligned}
\Delta[S_2O_3^{2-}] &= [S_2O_3^{2-}]_{\text{blue}} - [S_2O_3^{2-}]_0 \\
&= 0 - [S_2O_3^{2-}]_0 \\
\Delta[S_2O_3^{2-}] &= -[S_2O_3^{2-}]_0
\end{aligned}$$

Notes

1. Use ice-water mixture to control temperature.
2. Make table for uncatalyzed and catalyzed runs.
3. Be careful with pipetting and buretting.
4. Calibrate the temperature probe with melting point of ice.
5. Measure time to the 1 s. Collect data every second.
6. Set time duration to 600 s.