RATES REVIEW ANSWER SHEET

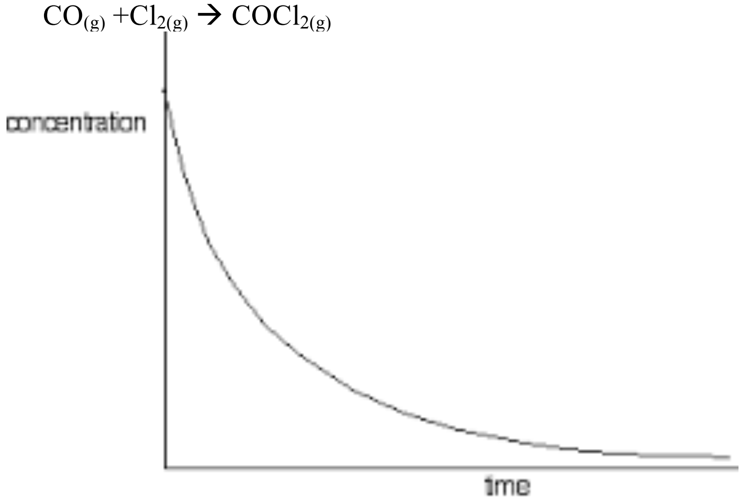
We will take up the multiple choice questions and some of the short answers (theoretical concepts) from the review package in class. Below are some of the answers to the Application Type Problems.

Problem

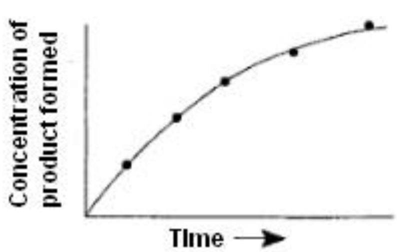
Graphics

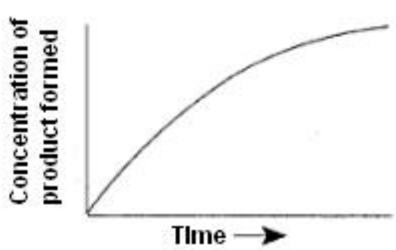
For the following questions, use the graphics provided to review terms or skills. Add any missing labels, draw any missing parts, or use the graphics to help you answer a question.

1. a) Sketch a graph to show the change in concentration of $CO_{(g)}$, with respect to time, during the following reaction.
   $CO_{(g)} + Cl_{2(g)} \rightarrow COCl_{2(g)}$



b) Sketch a graph to show the change in concentration of $COCl_{2(g)}$, with respect to time, during the same reaction.





RATES REVIEW ANSWER SHEET

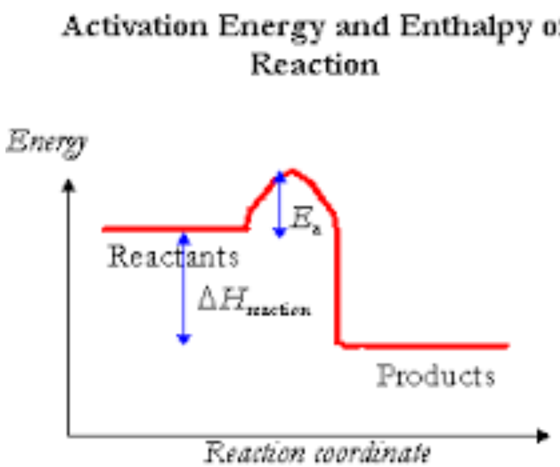
c) On the first graph, show and explain how you would determine the average rate of reaction.

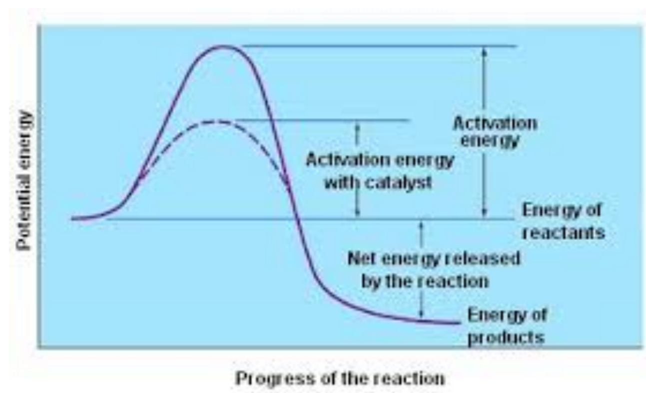
Determine the slope of the secant line from the beginning of the reaction to the end of the reaction.

d) On the first graph, show and explain how you would determine the instantaneous rate of reaction.

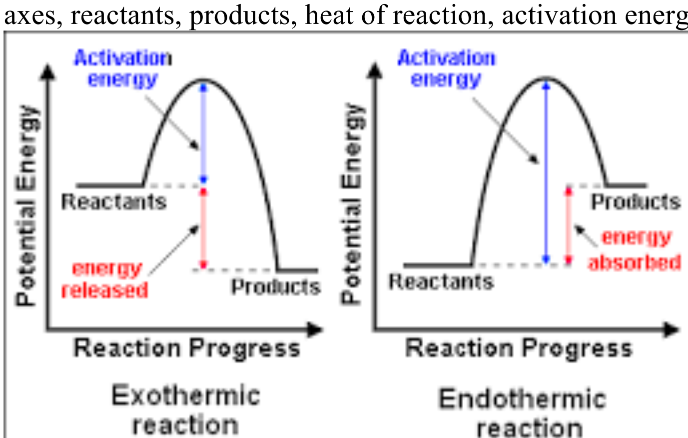
Determine the slope of the tangent line at a given point (moment in time).

2. The forward activation energy of a reaction is 25 kJ/mol, and the heat of reaction is - 286.4 kJ/mol.
   a) Sketch a potential energy diagram for the reaction. Label the axes, the forward activation energy, the heat of reaction, the transition state, and the reactants and products.
   b) Indicate the numerical values of the forward activation energy and the enthalpy change on your diagram.
   c) Show and label the effect of a catalyst.





3. Sketch a potential energy diagram for an exothermic reaction and for an endothermic reaction. Label the axes, reactants, products, heat of reaction, activation energy, and transition state on each diagram.

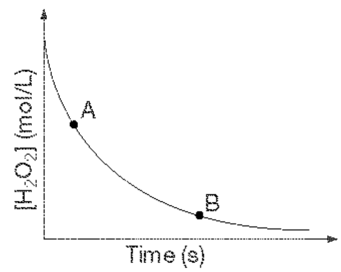


Source: Milton Beychok

Energy level diagrams of exothermic and endothermic reactions.[4][5][6]

RATES REVIEW ANSWER SHEET

4. The following graph represents the concentration of $H_2O_{2(aq)}$ over time for the decomposition of hydrogen peroxide into water.
$2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$

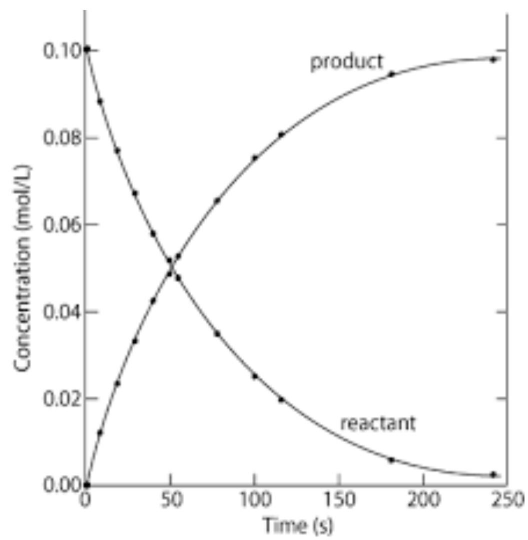


a) What would you do to determine the rate of reaction at A? Determine instantaneous rate at point A by determining the slope of the tangent line.

b)

b) Compare the rate of reaction at A with the rate of reaction at B. Explain the difference in terms of the collision theory. The slope of the tangent line is more steep at point A so the rate of the reaction will be faster.

c) Sketch the general shape of the curve, showing the concentration of H_2O versus time on the same graph. Since water is a product is which gradually slope upwards starting a concentration of 0.



RATES REVIEW ANSWER SHEET

5. The experimental data in the table below were collected for the following reaction of nitrogen monoxide and hydrogen.

   i) What is the rate law for this reaction?
   ii) Solve for rate law constant k with proper units

$2NO_{(g)} + 2H_{2(g)} \rightarrow N_{2(g)} + 2H_2O_{(g)}$

Trial	Initial concentration (mol/L)		Initial rate of disappearance of NO (mol/Ls)
	[NO]	$[H_2]$	
1	0.10	0.10	1.23×10^{-3}
2	0.10	0.20	2.46×10^{-3}
3	0.20	0.10	4.92×10^{-3}

$r = k\,[NO]^x[H_2]^y$

Effect of NO
Experiment 1&3

$[0.20 / 0.10]^x = [4.92 \times 10^{-3} / 1.23 \times 10^{-3}]$

$2^x = 4$

$X = 2$ Therefore 2nd order for NO

Effect of H_2
Experiment 1&2

$[0.20 / 0.10]^y = [2.46 \times 10^{-3} / 1.23 \times 10^{-3}]$

$2^Y = 2$

$y = 1$ Therefore 1st order for H_2

Therefore this reaction is 3rd order overall.

Now solve for the rate constant.

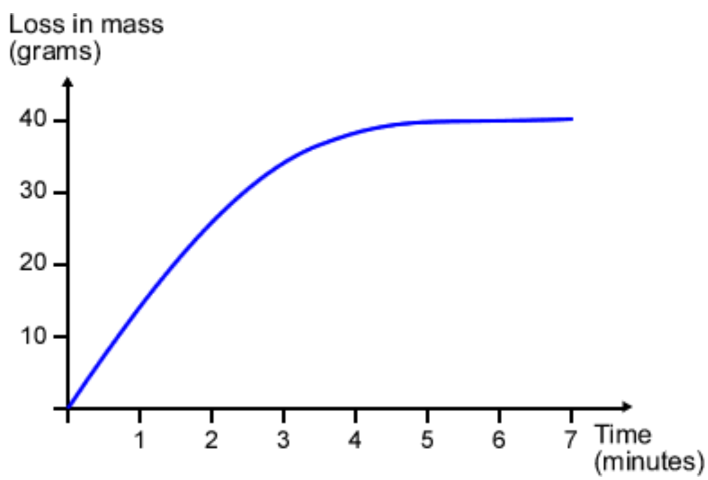
$k = 1.23 \;\; mol^{-2} \bullet L^2 \bullet s^{-1}$

$k = 1.23\ L^2 / mol^2 \bullet s$

<u>RATES REVIEW ANSWER SHEET</u>

Rates of Reaction Review: Part 2

1. Here is a rate graph for a reaction involving 0.5 mol/L hydrochloric acid and magnesium



a. Write a balanced equation for the single displacement reaction between HCl and Mg. $2HCl + Mg \rightarrow MgCl_2 + H_2$

b. Is the above rate graph representing the formation of product or the consumption of a reactant? Formation of product

c. Describe what the graph shows you about the rate of reaction. (Why is the curve flat at the end?) As time increases, the rate of production of hydrogen gas decreases until it starts to plateau at which time the reaction has stopped and the rate is 0.

d. How you think the curve would look if you repeated the experiment: (i) at a lower temperature (ii) at a higher temperature *and* with a catalyst present.

Volume of H_2 produced mL

Refer to explanations of factors affecting rate and collision theory.

RATES REVIEW ANSWER SHEET

e. Calculate the average rate of reaction from 1 – 7 minutes. Be careful of units.

r = Δ volume (since graph is based on volume not concentration) / Δ time (min) = (40-10) / 7-1

= 30/ 6 = 5 mL/min

2. State the collision theory. Now the theoretical effects that temperature, concentration, surface area, pressure and catalysts have on the rate of a reaction.

3. Determine the rate law and calculate the rate constant for the following data.

trial	initial [A]	initial [B]	rate
#1	1.00×10^{-3}	0.25×10^{-3}	0.26×10^{-9}
#2	1.00×10^{-3}	0.50×10^{-3}	0.52×10^{-9}
#3	1.00×10^{-3}	1.00×10^{-3}	1.04×10^{-9}
#4	2.00×10^{-3}	1.00×10^{-3}	4.16×10^{-9}
#5	3.00×10^{-3}	1.00×10^{-3}	9.36×10^{-9}
#6	4.00×10^{-3}	1.00×10^{-3}	16.64×10^{-9}

RATES REVIEW ANSWER SHEET

$r = k[A]^x [B]^y$

$[A]^x$ Exp 4/3

2.00×10^{-3} 1.00×10^{-3}

$2^x = 4$ $x= 2$

$=4.16\times10^{-9}$ 1.04×10^{-9}

$[B]y$ = Exp 2/1

$2^y =2$ $y = 1$

$r = k [A]^2 [B]^1$ $k = 1.04\ mol^{-2} \cdot L^2 \cdot sec^{-1}$

4. Definitions to know: activation energy, activated complex, rate determining step, reaction mechanisms, elementary steps.

See Reaction Mechanism Package for last lesson and practice on reaction mechanisms.