

## NMSI Super Problem: Kinetics Collision Theory and Differential Rate Laws

 $\mathbf{X}(g) + 2\mathbf{Y}\left(g\right) \to \, \mathbf{Z}(g)$ 

The reaction represented above was studied at 25°C. The data collected are shown in the table below.

Experiment	[X]	[Y]	Initial rate of formation of Z (mol L <sup>-1</sup> sec <sup>-1</sup> )
1	0.200	0.200	$1.20 \times 10^{-5}$
2	0.200	0.400	$2.40 \times 10^{-5}$
3	0.100	0.200	$6.00 \times 10^{-6}$

- a. Calculate the initial rate of disappearance of substance Y in Experiment 1.
- b. Determine the order of the reaction with respect to each reactant. Show your work. i. X

- ii. Y
- c. Write the rate law for the reaction consistent with part A.
- d. Calculate the value of the rate constant, *k*. Be sure to include proper units.

- e. In a closed 2.50 L reaction vessel at 22°C, 0.0254 mole of substance X was reacted with 0.0495 mol Y
  - i. Determine the limiting reactant. Justify your answer mathematically.
  - ii. Calculate the number of moles of Z formed.
  - iii. Calculate the total pressure in the flask at the completion of the reaction.
- f. Three possible mechanisms for this reaction are shown below.

Mechanism 1	Mechanism 2	Mechanism 3
$\begin{array}{ll} Y+Y \rightarrow D & (fast) \\ X+D \rightarrow Z & (slow) \end{array}$	$\begin{array}{ll} X \rightarrow D & (slow) \\ D+Y \rightarrow G & (fast) \\ G+Y \rightarrow Z & (fast) \end{array}$	$\begin{array}{ll} X+Y \rightarrow D & (slow) \\ Y+D \rightarrow Z & (fast) \end{array}$

- i. Select the one most consistent with the experimental data. Justify your choice by writing a rate law for each of the three mechanisms.
- ii. Identify substance D in the mechanisms shown above as an intermediate or a catalyst. Justify your answer.



g. The following diagram shows the energy of the reaction as the reaction progresses.



Reaction Pathway

- i. Clearly label the activation energy for the forward reaction.
- ii. Clearly label the enthalpy change for the reaction.
- iii. On the diagram draw a second energy curve showing the effect of a catalyst on the reaction.
- h. The collision between X and Y occur with enough energy to over the activation energy barrier, Ea, however no products are formed. Identify and explain one other factor that affects whether the collision will result in a reaction.