Chapter 7 – Kinetics: Rates and Mechanisms

Super Problem

$$X(g) + 2\,Y(g) \rightarrow Z(g)$$
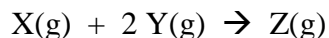
The reaction represented above was studied at 25°C. The data collected are shown in the table below.

Experiment	[X]	[Y]	Initial rate of formation of Z ($mol\ L^{-1}\ sec^{-1}$)
1	0.200	0.200	1.20×10^{-5}
2	0.200	0.400	2.40×10^{-5}
3	0.100	0.200	6.00×10^{-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 B.

(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	
$Y + Y \rightleftharpoons D$	(fast)	$X \rightarrow D$	(slow)	$X + Y \rightarrow D$	(slow)
$X + D \rightarrow Z$	(slow)	$D + Y \rightarrow G$	(fast)	$Y + D \rightarrow Z$	(fast)
		$G + Y \rightarrow Z$	(fast)		

(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.

    (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.

Reaction Pathway
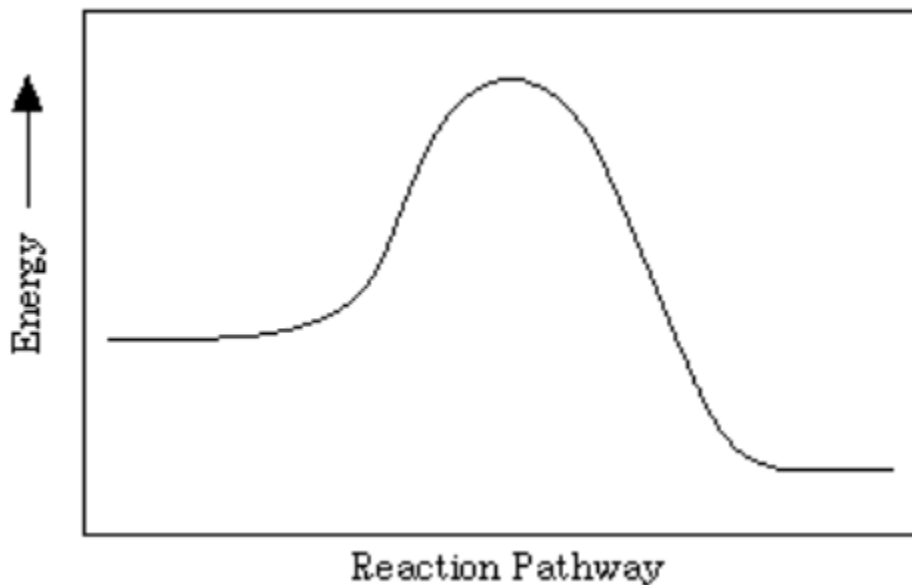
(h) The collision between X and Y occur with enough energy to overcome the activation energy barrier, E_a, however no products are formed. Identify and explain one other factor that affects whether the collision will result in a reaction.