

1. Which of the following reactions is the slowest at room temperature?

- A.  $\text{NH}_3(\text{g}) + \text{HCl}(\text{g}) \rightleftharpoons \text{NH}_4\text{Cl}(\text{s})$   
 B.  $\text{MgCl}_2(\text{aq}) + \text{Ca}(\text{s}) \rightleftharpoons \text{Mg}(\text{s}) + \text{CaCl}_2(\text{aq})$   
 C.  $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightleftharpoons \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$   
 D.  $\text{Ba}(\text{NO}_3)_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{Ba}(\text{OH})_2(\text{s}) + 2\text{HNO}_3(\text{aq})$

2. Which of the following reactions is the fastest at room temperature?

- A.  $\text{NH}_3(\text{g}) + \text{HCl}(\text{g}) \rightleftharpoons \text{NH}_4\text{Cl}(\text{s})$   
 B.  $\text{MgCl}_2(\text{aq}) + \text{Ca}(\text{s}) \rightleftharpoons \text{Mg}(\text{s}) + \text{CaCl}_2(\text{aq})$   
 C.  $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightleftharpoons \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$   
 D.  $\text{Ba}(\text{NO}_3)_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{Ba}(\text{OH})_2(\text{s}) + 2\text{HNO}_3(\text{aq})$

3. Which of the following has the greatest reaction rate?

- A.  $3\text{H}_2(\text{g}) + \text{N}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$   
 B.  $2\text{H}_2\text{O}_2(\text{l}) \rightleftharpoons 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$   
 C.  $2\text{Al}(\text{s}) + 3\text{CaCl}_2(\text{aq}) \rightleftharpoons 2\text{AlCl}_3(\text{aq}) + 3\text{Ca}(\text{s})$   
 D.  $\text{AgNO}_3(\text{aq}) + \text{NaBr}(\text{aq}) \rightleftharpoons \text{AgBr}(\text{s}) + \text{NaNO}_3(\text{aq})$

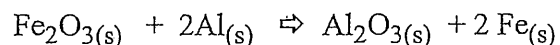
4. Which of the following reactions would have the greatest reaction rate at room temperature?

- A.  $\text{C}_3\text{H}_8(\text{g}) + 5\text{O}_2(\text{g}) \rightleftharpoons 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{g})$   
 B.  $\text{Ca}(\text{s}) + 2\text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{Ca}(\text{OH})_2(\text{aq}) + \text{H}_2(\text{g})$   
 C.  $\text{AgNO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \rightleftharpoons \text{AgCl}(\text{s}) + \text{NaNO}_3(\text{aq})$   
 D.  $\text{Na}_2\text{CO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightleftharpoons 2\text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$

5. An 8.00 grams piece of magnesium was placed into 6.0 M HCl. After 25 seconds, 3.50 grams of unreacted magnesium remained. The average rate at which magnesium was consumed is

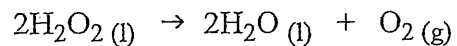
- A. 0.14 grams per second  
 B. 0.18 grams per second  
 C. 0.32 grams per second  
 D. 4.50 grams per second

6. Consider the following reaction:



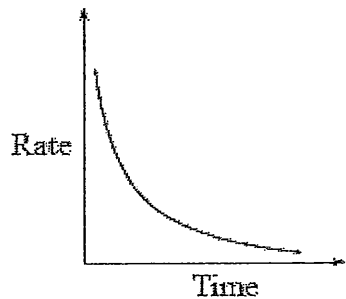
If 0.50 mol of Fe is produced in 10.0 sec, what is the rate of consumption of Fe<sub>2</sub>O<sub>3</sub> in mol/sec?

7. Consider the following reaction:

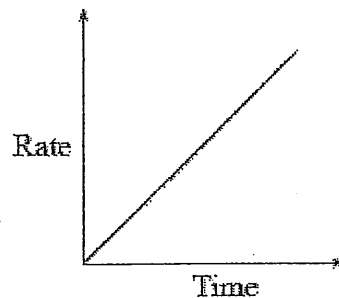


Which graph shows the relationship between the rate of consumption of  $\text{H}_2\text{O}_2$  and time?

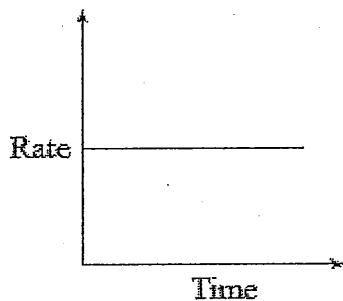
A.



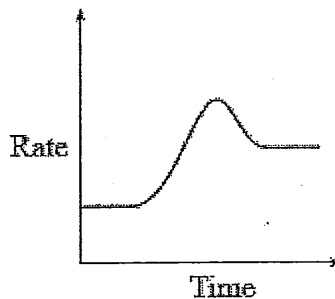
B.



C.

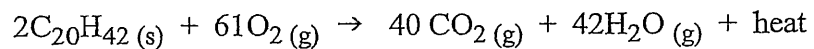


D.



8. Consider the following:

When a candle ( $\text{C}_{20}\text{H}_{42}$ ) burns, the following reaction occurs:



If the rate of production of  $\text{CO}_2$  is 0.98 g/min, what is the rate of oxygen consumption?

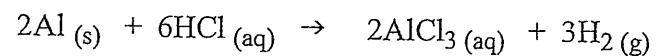
A. 0.47 g/min

B. 0.54 g/min

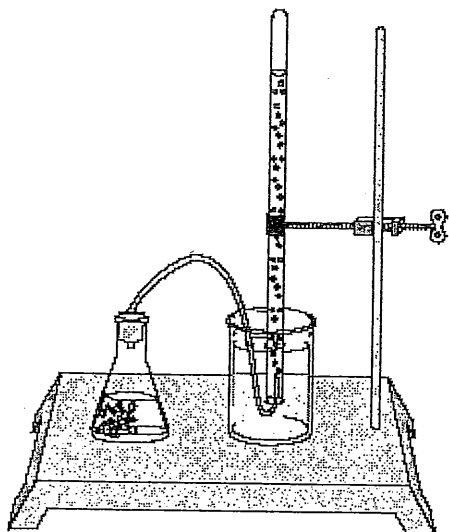
C. 0.71 g/min

D. 1.1 g/min

9. Aluminum metal is reacted with hydrochloric acid to form aluminum chloride and hydrogen gas in the following reaction:



The data from the experiment is below:



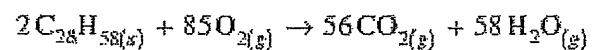
The following data is collected:

Time (s)	Volume of H <sub>2</sub> (mL)
0.0	0.0
10.0	21.1
20.0	40.9
30.0	60.0
40.0	77.6

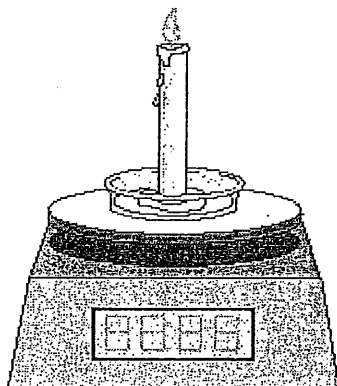
- a. Calculate the rate of formation of H<sub>2</sub> (g) in mL per second for the time interval between 10.0 seconds and 30.0 seconds.

- b. How does the rate of formation change as the reaction proceeds?  
Explain using Collision Theory.

The mass of a burning candle is monitored to determine the rate of combustion of paraffin.  
An accepted reaction for the combustion of paraffin is:



The following data is observed:

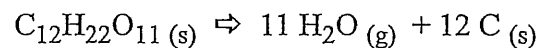


Time (min)	Mass of Candle (g)
0.0	25.6
6.0	25.1
12.0	24.5
18.0	23.9
24.0	23.4
30.0	22.8

10.

a. Calculate the average rate of production of  $\text{CO}_2$  in mol/min over the 30.0 min

11. Consider the following reaction:

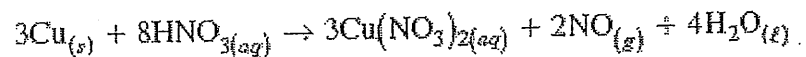


The rate of decomposition of is 0.75 mol/min.

What mass of C is produced in 10.0 seconds?

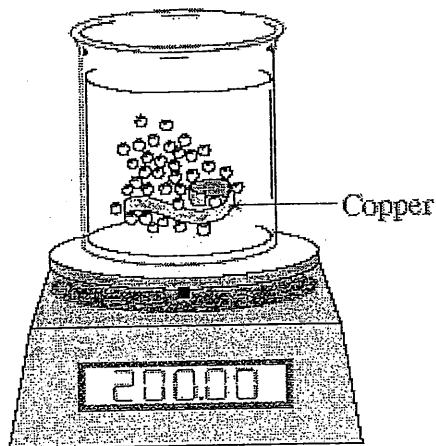
12.

Consider the following reaction:



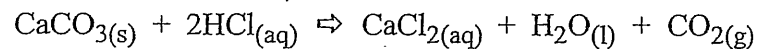
A piece of copper is added to a nitric acid solution in an open beaker, allowing the  $\text{NO}_{(g)}$  to escape. The following data was obtained:

TIME (min)	MASS OF BEAKER AND CONTENTS (g)
0.0	200.00
1.0	197.50
2.0	195.45
3.0	193.55
4.0	191.70
5.0	189.90
6.0	188.15
7.0	186.45
8.0	184.80



- Calculate the average rate of consumption of copper in grams per minute over the 8.0 minutes.
- Explain why the reaction rate slows down as the time goes from 0.0 to 8.0 minutes.
- List two ways in which the reaction rate could be increased and explain your choices.

13. Consider the following reaction in an open container:

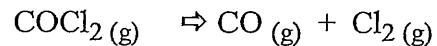


A 155.0 g sample of  $\text{CaCO}_3(\text{s})$  is placed in the flask and  $\text{HCl}(\text{aq})$  is added.

The reaction consumes  $\text{HCl}$  at an average rate of 7.30 grams of  $\text{HCl}(\text{aq})$  per minute.

The reaction is allowed to go for 10.0 minutes. How many grams of  $\text{CaCO}_3(\text{s})$  will be left over at the end of the 10.0 minutes?

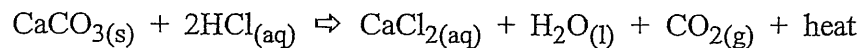
14. Consider the following reaction:



Which of the following could be used to determine reaction rate in a closed system?

- A. a decrease in gas pressure
- B. an increase in gas pressure
- C. a decrease in the mass of the system
- D. an increase in the mass of the system

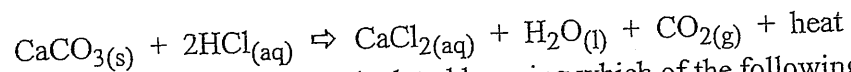
15. Consider the following reaction occurring in an open container:



The reaction rate could be calculated by using which of the following?

- A. a change in  $[\text{Cl}^-]$
- B. an increase in the acidity

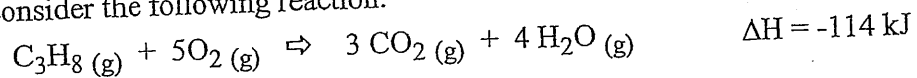
16. Consider the following reaction occurring in an closed container:



The reaction rate could be calculated by using which of the following?

- A. a change in  $[\text{Cl}^-]$
- B. an increase in the mass of the system
- C. an increase in the gas pressure of the container
- D. a decrease in the mass of the system

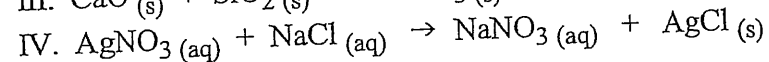
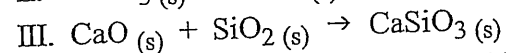
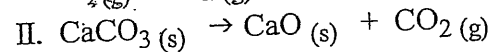
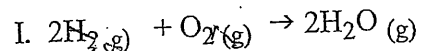
17. Consider the following reaction:



How could the rate of this reaction be decreased?

- A. increase the pressure
- B. increase the volume of the container the gases are in
- C. remove some  $\text{CO}_2(\text{g})$
- D. increase the temperature

18. Consider the following reactions in an open system:

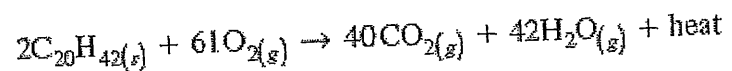


In which of the above could the reaction rate be determined by  $\frac{\Delta \text{ mass of system?}}{\Delta \text{ time}}$

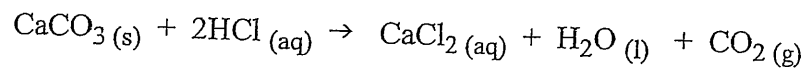
- A. I
- B. II
- C. III
- D. IV

19. Consider the following:

When a candle ( $\text{C}_{20}\text{H}_{42}$ ) burns, the following reaction occurs:



20. A student wishes to monitor the rate of the following reaction:



Identify two different properties that could be used to monitor the rate of the reaction. Describe the property and how it would change as the reaction proceeds.

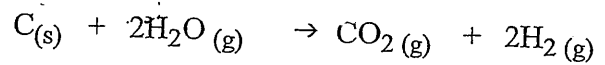
Property #1 \_\_\_\_\_

What would change and why?

Property #2 \_\_\_\_\_

What would change and why?

21. A student wishes to monitor the rate of the following reaction:



Identify two different properties that could be used to monitor the rate of the reaction. Describe the property and how it would change as the reaction proceeds.

Property #1 \_\_\_\_\_

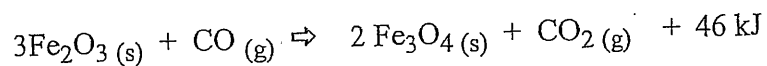
What would change and why?

Property #2 \_\_\_\_\_

What would change and why?



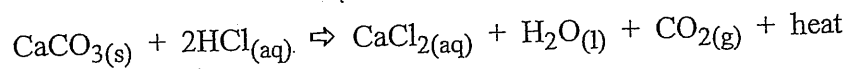
22. Consider the following reaction:



Which of the following would cause the rate of the reaction to increase?

- A. remove some of the  $\text{Fe}_3\text{O}_4(\text{s})$
- B. decrease the temperature
- C. increase the surface area of the  $\text{Fe}_2\text{O}_3(\text{s})$
- D. increase the volume of the reaction vessel

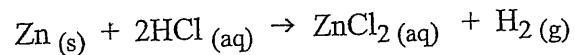
23. Given the following:



Which of the following will cause the reaction rate to increase?

- A. increasing pressure
- B. decreasing pressure
- C. increasing temperature
- D. decreasing temperature

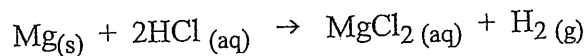
24. Consider the following reaction:



Which of the following would increase the reaction rate?

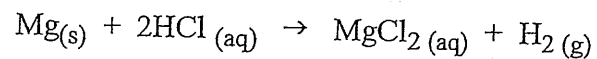
- A. an increase in the pressure
- B. an increase in temperature
- C. an increase in the concentration of Zn
- D. an increase in the concentration of  $\text{ZnCl}_2$

25. A student placed 3.0 g of Mg into some HCl in two different experiments. In each case, it reacted according to the following equation:



In the first experiment, it took 3.2 minutes for all of the Mg to react. In the second experiment, it took 5.4 minutes for all the Mg to react. Which of the following could account for the change

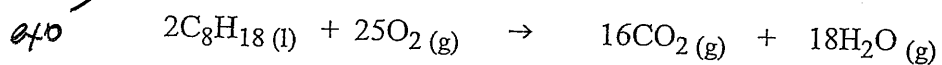
26. A student placed 3.0 g of Mg into some HCl in two different experiments. In each case, it reacted according to the following equation:



In the first experiment, it took 3.2 minutes for all of the Mg to react. In the second experiment, it took 5.4 minutes for all the Mg to react. Which of the following could account for the change in rate of the second experiment?

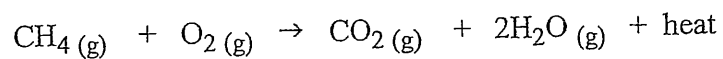
- A. The temperature was increased
  - B. The Mg was melted into a lump before adding
  - C. The pressure within the system was decreased
  - D. The pressure within the system was increased
27. Companies that produce butter find it necessary to slow down the reaction rate that causes the butter to spoil. The spoiling of the butter is an exothermic chemical reaction. List two things that could be done to slow down the reaction rate and describe how those two things would accomplish the task.

28. Gasoline engines produce many gases that are harmful to the air. (Because these reactions are endothermic, the following chemical reaction does not occur very quickly in nature.)



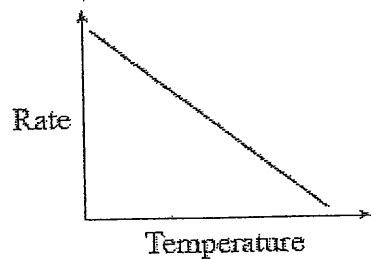
Describe two reasons why the reaction rate would be higher in a gasoline engine than in nature, using the Collision Theory.

29. Consider the following reaction:

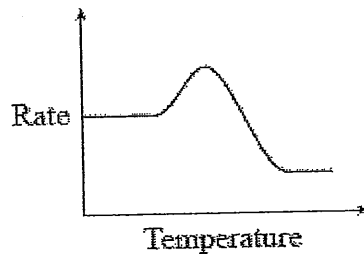


The diagram which represents the relationship between rate and temperature is:

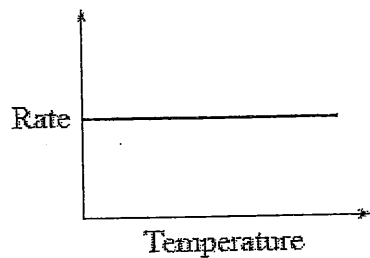
A.



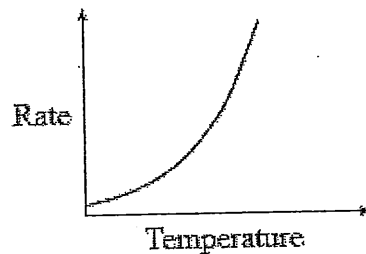
B.



C.



D.



30. In order for a collision between reactant particles to be successful

- A.  $\Delta H$  must be positive
- B. the system must be open
- C. there must be sufficient KE
- D.  $\text{KE} > \text{PE}$

31. Which of the following would result in a successful collision between reactant particles?

- A. particles have sufficient KE
- B. particles convert all their PE into KE
- C. particles are in an excited state and are catalyzed
- D. particles have sufficient KE and proper molecular orientation

32. An activated complex can be described as

33. Which of the following is true of the kinetic and potential energies as reactant molecules approach each other to form an activated complex?

KE

PE

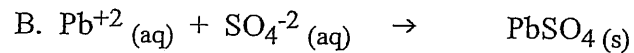
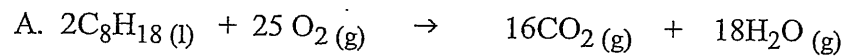
- |                     |                  |
|---------------------|------------------|
| A. increases        | decreases        |
| B. decreases        | increases        |
| C. decreases        | remains constant |
| D. remains constant | remains constant |

34. Which of the following are necessary for successful collisions between reactant molecules?

- I. high concentration
- II. sufficient energy
- III. correct geometry
- IV. presence of a catalyst

- A. I and II only
- B. II and III only
- C. III and IV only
- D. I, II and III only

35. Two uncatalyzed reactions are carried out at the same temperature:

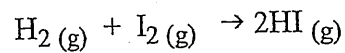


- a. Which reaction is most likely to have a faster reaction rate? \_\_\_\_\_
- b. Using the collision theory, provide two reasons as an explanation.

36. a. Using Collision Theory, explain why blowing gently on a glowing splint may make it burn faster.

b. List two ways in which you could extinguish a fire and explain, using Collision Theory, how each of those methods would work.

37. Consider the following reaction:



Which of the following is true of the activated complex relative to the reactants?

- |    | KE              | PE             | Stability         |
|----|-----------------|----------------|-------------------|
| A. | <del>high</del> | high           | <del>stable</del> |
| B. | low             | <del>low</del> | <del>stable</del> |
| C. | <del>high</del> | <del>low</del> | unstable          |
| D. | low             | high           | unstable          |

38. Activation energy is defined as the

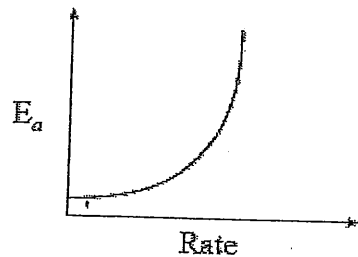
- A.  $\Delta H$
- B. average amount of kinetic energy
- C. unstable particle that can either form products or return to reactants
- D. the amount of energy needed for a successful collision

39. Which of the following best describes *activation energy*?

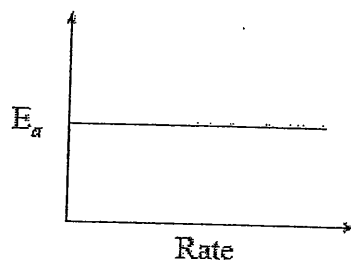
- A. PE of activated complex

40. A certain reaction is able to proceed by various mechanisms. Each mechanism has a different  $E_a$  and results in a different overall rate. Which of the following best describes the relationship between the  $E_a$  values and the rates?

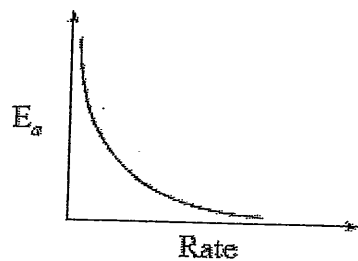
A.



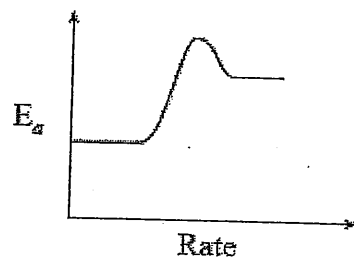
B.



C.

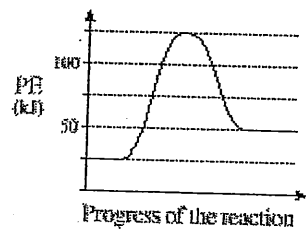


D.

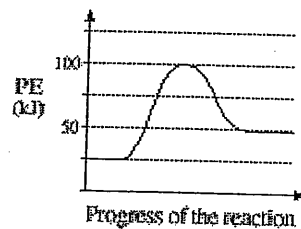


41. Which of the following graphs most likely represents the slowest forward reaction?

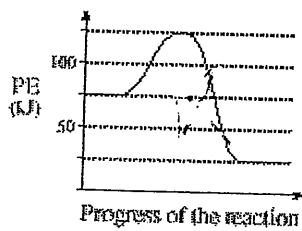
A.



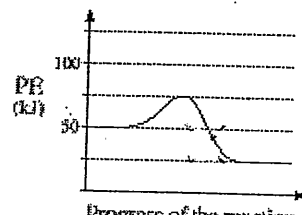
B.



C.

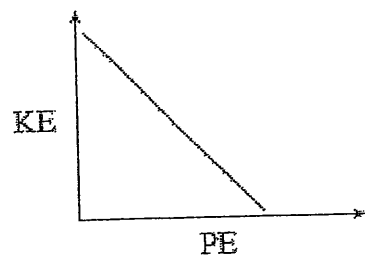


D.

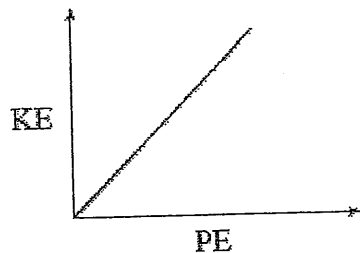


42. Which of the following graphs best describes the changes in KE and PE as reactant molecules approach each other?

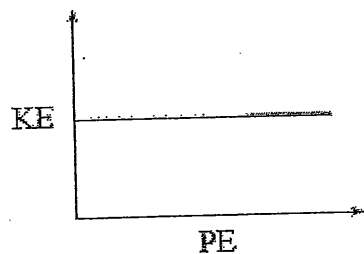
A.



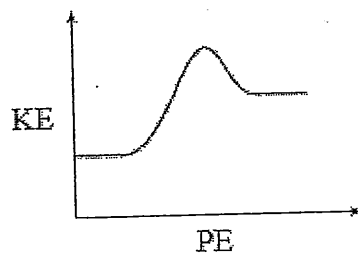
B.



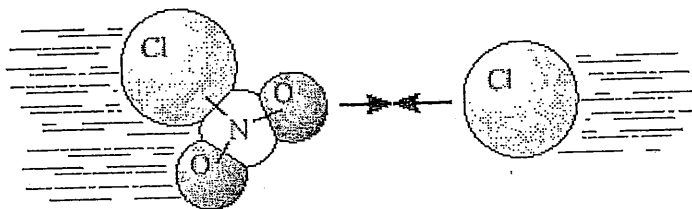
C.



D.



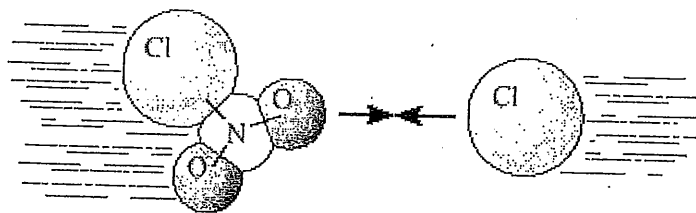
43. The following diagram shows reactant molecules approaching one another:



In order for this reaction to take place, what must occur?

- A. There must be sufficient KE and correct geometry to have a successful collision.
- B. The KE must be larger than the PE.
- C. The reaction must be exothermic.
- D. The products formed must be more stable than the reactants.

44. The following diagram shows reactant molecules approaching one another:



What is happening to the KE and PE?

KE

PE

- |               |            |
|---------------|------------|
| A. increasing | increasing |
| B. decreasing | increasing |
| C. decreasing | decreasing |
| D. increasing | decreasing |

45. What happens to the PE and KE of the reactant particles as the activated complex is formed?

PE

KE

- |              |           |
|--------------|-----------|
| A. increases | decreases |
| B. increases | increases |
| C. decreases | decreases |
| D. decreases | increases |

46. How do KE and PE change as reactant particles collide with each other?

KE

PE

- |              |           |
|--------------|-----------|
| A. increases | increases |
| B. increases | decreases |
| C. decreases | increases |
| D. decreases | decreases |

47. How does the addition of a catalyst increase the reaction rate of an endothermic reaction?

- A. It reduces the  $\Delta H$  of the reaction.
- B. It increases the  $\Delta H$  of the reaction.
- C. It reduces the required activation energy.
- D. It causes the reaction to become exothermic.

48. How does the addition of an inhibitor decrease the reaction rate of an exothermic reaction?

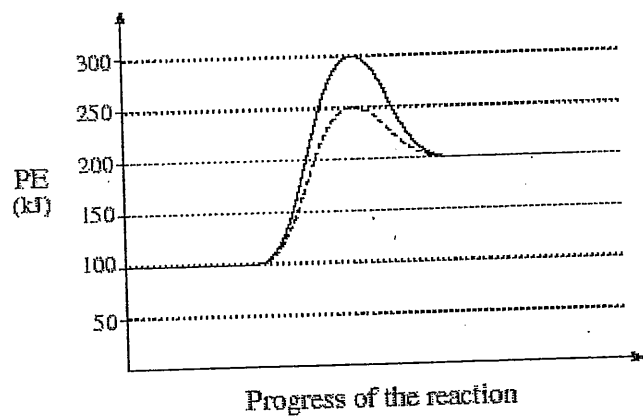
- A. It reduces the  $\Delta H$  of the reaction.
- B. It increases the  $\Delta H$  of the reaction.



49. What happens to the activation energy and  $\Delta H$  of a chemical reaction when an inhibitor is added?

- | Activation energy | $\Delta H$     |
|-------------------|----------------|
| A. increases      | increases      |
| B. decreases      | stays the same |
| C. decreases      | decreases      |
| D. increases      | stays the same |

Consider the following PE diagram for a catalyzed and uncatalyzed reaction:

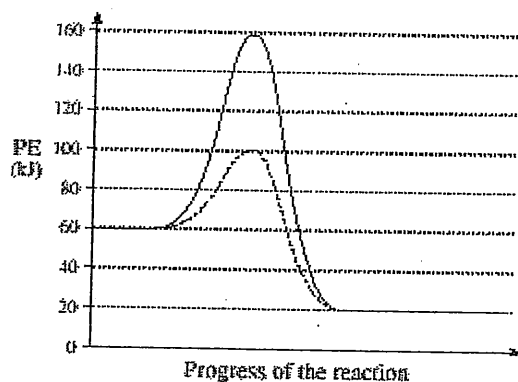


50.

Which of the following best describes the forward reaction?

- | Reaction       | Activation Energy | $\Delta H$ |
|----------------|-------------------|------------|
| A. catalyzed   | 150 kJ            | -100 kJ    |
| B. uncatalyzed | 150 kJ            | -100 kJ    |
| C. catalyzed   | 200 kJ            | +100 kJ    |
| D. uncatalyzed | 200 kJ            | +100 kJ    |

51. Consider the following potential energy diagram for a reaction:



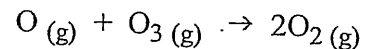
Which of the following represents the correct potential energy level of the activated complexes?

	Forward uncatalyzed activated complex	Forward catalyzed activated complex
A.	160 kJ	100 kJ
B.	<del>100</del> kJ	40 kJ
C.	<del>100</del> kJ	160 kJ
D.	<del>160</del> kJ	100 kJ

52. For an exothermic reaction, which of the following is true?

- A.  $PE_{\text{reactants}} > PE_{\text{activated complex}} > PE_{\text{products}}$
- B.  $PE_{\text{products}} > PE_{\text{activated complex}} > PE_{\text{reactants}}$
- C.  $PE_{\text{activated complex}} > PE_{\text{reactants}} > PE_{\text{products}}$
- D.  $PE_{\text{activated complex}} > PE_{\text{products}} > PE_{\text{reactants}}$

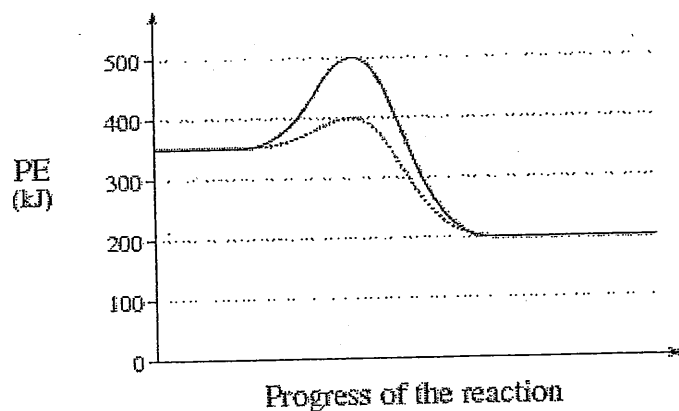
53. Consider the following reaction:



Which of the following describes how the reaction's catalyzed PE diagram compares to the reaction's uncatalyzed PE diagram?

- | $E_a$                            | $\Delta H$                              |
|----------------------------------|---|
| A. $E_a(\text{catalyzed}) < E_a$ | $\Delta H(\text{catalyzed}) < \Delta H$ |
| B. $E_a(\text{catalyzed}) < E_a$ | unchanged                               |
| C. $E_a(\text{catalyzed}) > E_a$ | unchanged                               |
| D. unchanged                     | $\Delta H(\text{catalyzed}) > \Delta H$ |

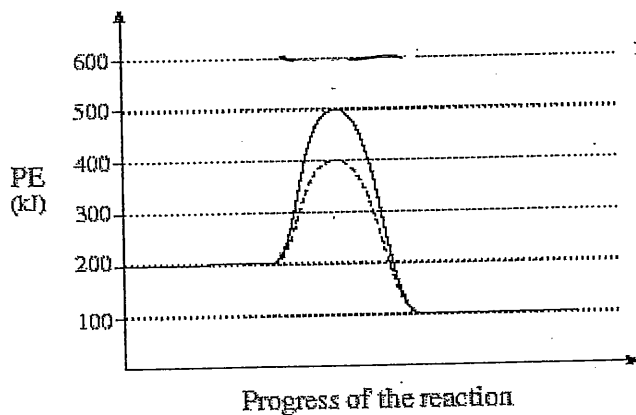
55. Consider the following PE diagram:



Which of the following is true of the reverse reaction?

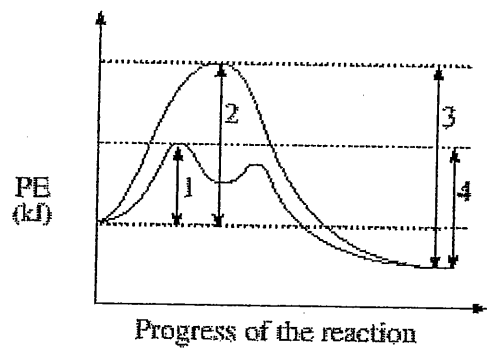
	Activated complex (kJ)	$\Delta H$ (kJ)
A. catalyzed	<del>200</del>	<del>-150</del>
B. catalyzed	<del>300</del>	+150
C. uncatalyzed	<del>300</del>	<del>-150</del>
D. uncatalyzed	500	+150

56. Consider the following PE diagrams of a catalyzed and uncatalyzed reaction:



In the uncatalyzed forward reaction, what is the minimum potential energy required to change reactants into the activated complex?

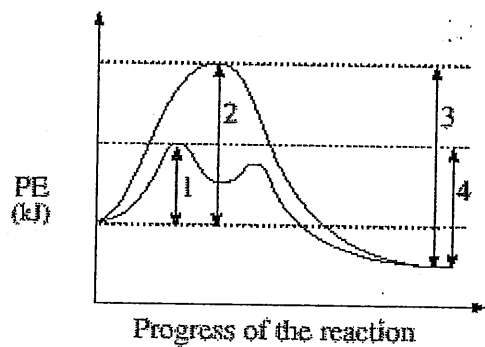
57. Consider the following PE diagram:



Identify the activation energy for the forward uncatalyzed reaction.

- A. 1
- B. 2
- C. 3
- D. 4

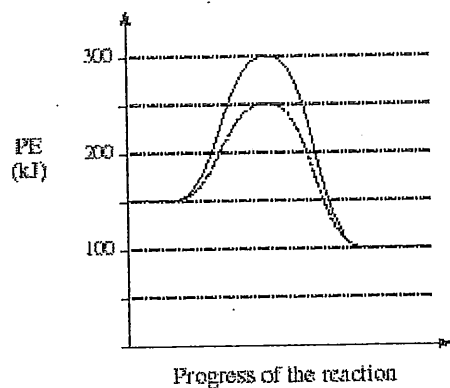
58. Consider the following PE diagram:



Identify the activation energy for the reverse catalyzed reaction.

- A. 1
- B. 2
- C. 3
- D. 4

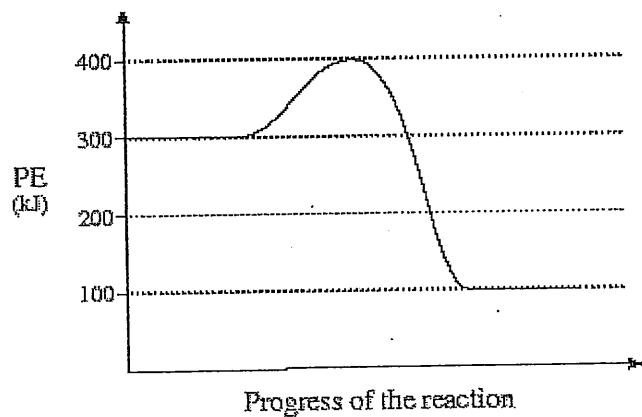
59. Consider the following PE diagram:



Which of the following is true for the forward reaction?

Reaction	PE of Activated Complex (kJ)	$\Delta H$ (kJ)
A. catalyzed	100	-50
B. uncatalyzed	300	-50
C. catalyzed	250	+50
D. uncatalyzed	150	-50

60. Consider the following PE diagram:



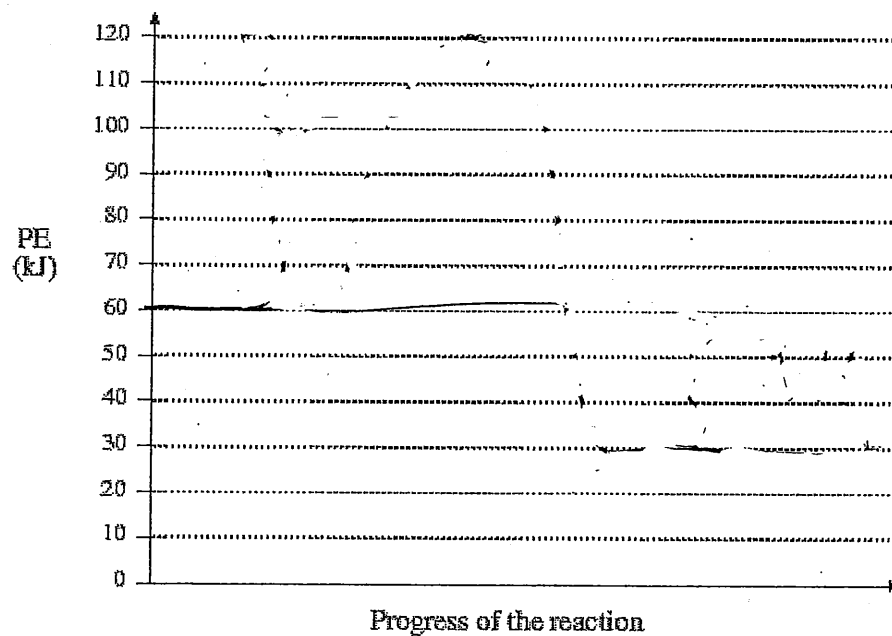
Which of the following is true for the forward reaction:

$\Delta H$ (kJ)	PE of activated complex (kJ)
-----------------	------------------------------

61. In the graph below draw a slow exothermic reaction, labeling

- activation energy
- activated complex
- $\Delta H$

The reaction for the graph is:  $\text{Cu}_{(s)} + 2\text{HCl}_{(aq)} \rightarrow \text{CuCl}_{2(aq)} + \text{H}_{2(g)}$



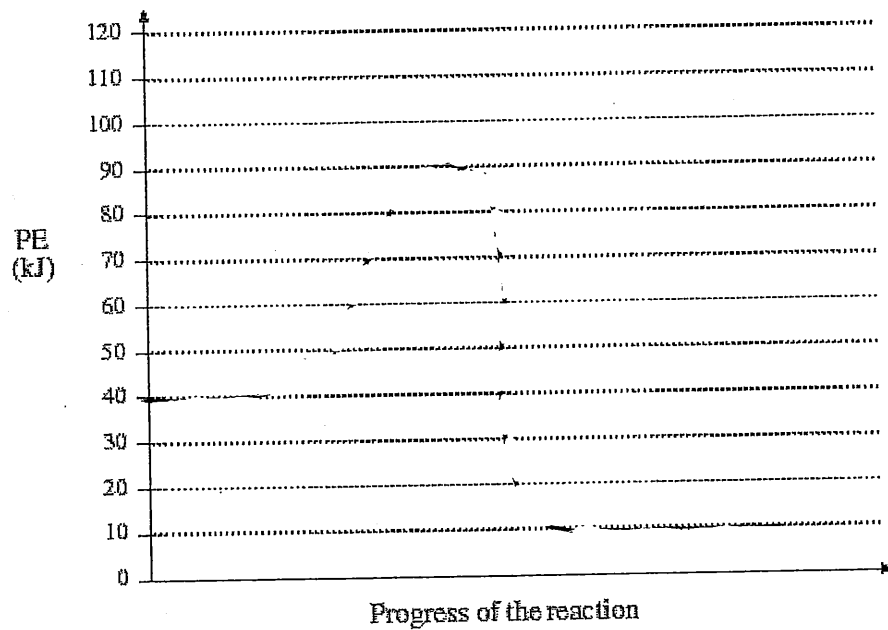
Describe how this diagram would change if the concentration of the HCl were increased

62. Using the axes below, sketch a PE diagram for a chemical reaction in which:

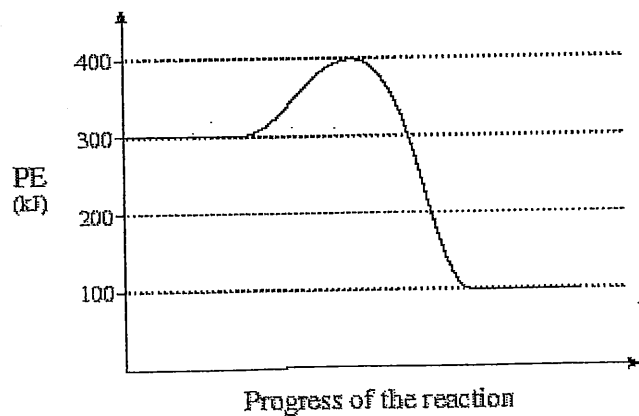
$$E_a = 50 \text{ kJ}$$

$$\Delta H = -30 \text{ kJ}$$

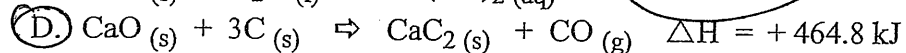
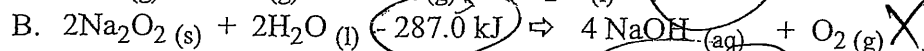
activated complex is at 90 kJ



63. Consider the following PE diagram:

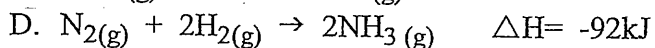
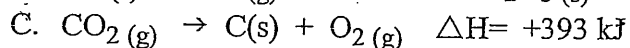
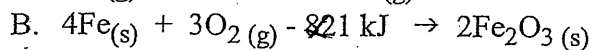
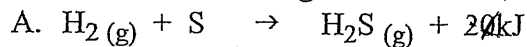


64. Which of the following reactions is endothermic?

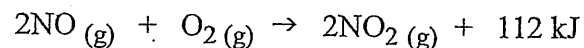


*Remove*

65. Which of the following reactions is endothermic?



66. Given this reaction:



Which of the following will cause the greatest increase in the reaction rate?

A. Increase the temperature by  $10^\circ\text{C}$  and increase the [reactants] by a factor of two.

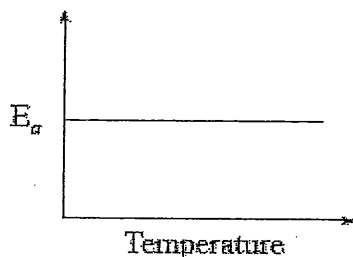
B. Increase the temperature by  $10^\circ\text{C}$  and decrease the [reactants] by a factor of two.

C. Decrease the temperature by  $10^\circ\text{C}$  and increase the [reactants] by a factor of two.

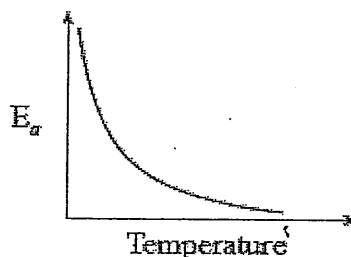
D. Decrease the temperature by  $10^\circ\text{C}$  and decrease the [reactants] by a factor of two.

67. Which graph shows the relationship between the activation energy and temperature?

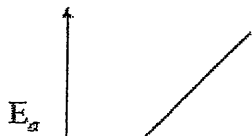
A.



B.



C.

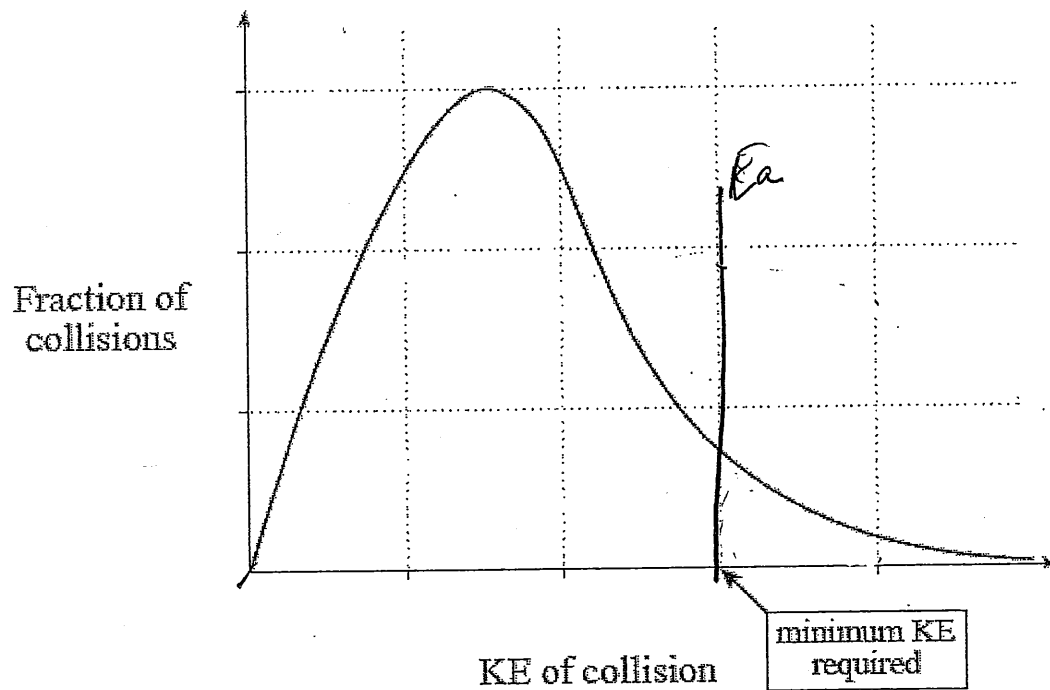


D.



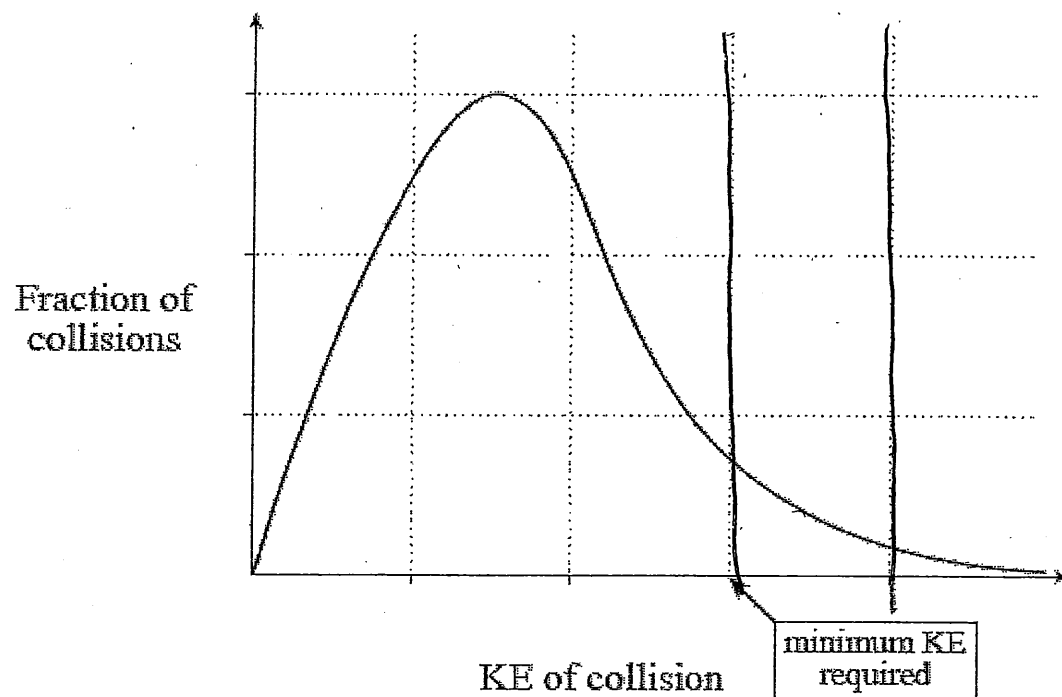


68. Consider the following Kinetic Energy Diagram:



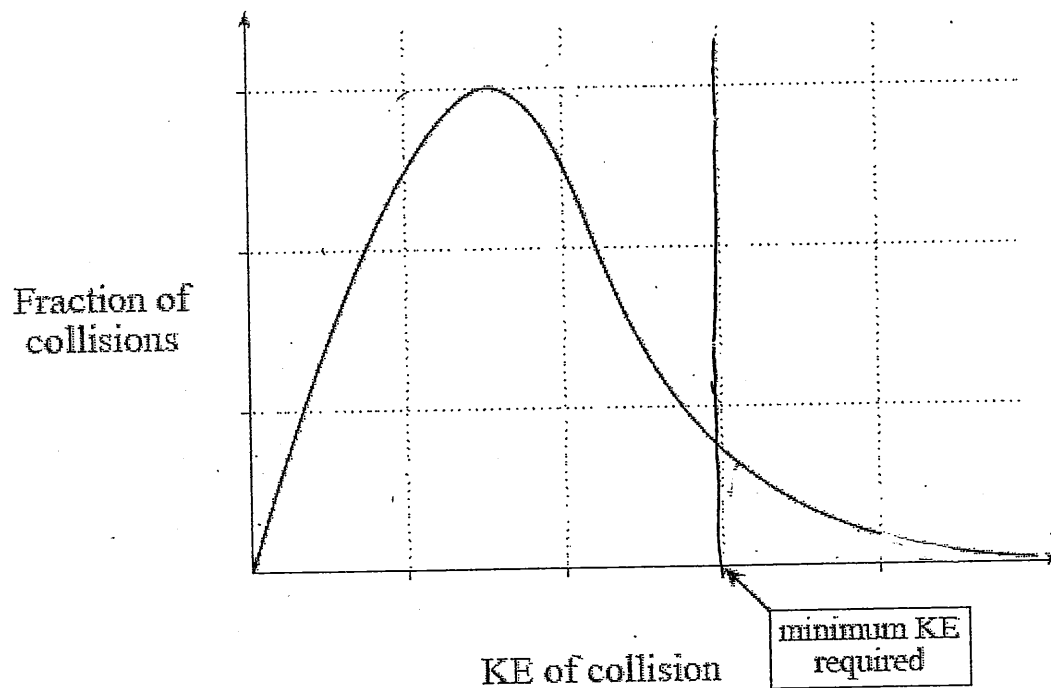
- Shade in the area that represents the reactant particles that have enough energy to form product particles.
- Will all the particles in the shaded area form products? \_\_\_\_\_  
Explain your answer using Collision Theory.
- Use a dotted line to show how would the Kinetic Energy Curve change if the temperature was raised.

69. Consider the following Kinetic Energy Diagram:



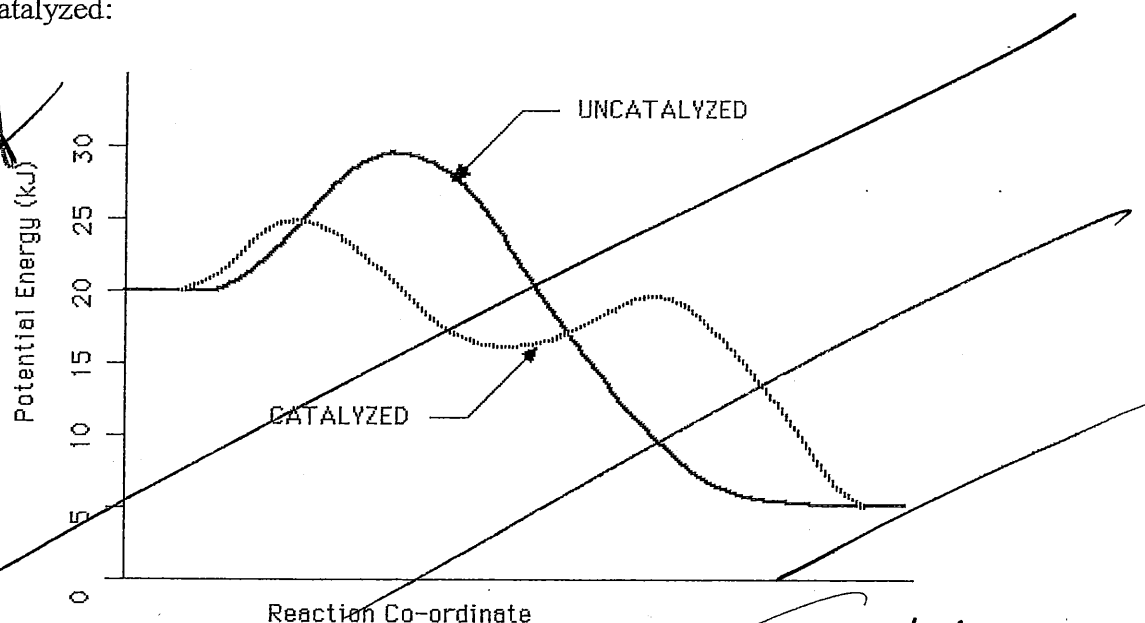
- Which part of a Potential Energy Diagram does the minimum KE required line correspond to?
- Use a dotted line to show how would the Kinetic Energy Curve change if the an inhibitor was added.

70. Consider the following Kinetic Energy Diagram:



- Shade in the area of the curve that represents the number of reactant particles with sufficient energy to form product particles.
- Using a dotted line, show how the curve would change if the concentration of the reactants was increased.
- Would there be more or fewer particles with sufficient KE to have a successful collision if the reactant concentration was increased? \_\_\_\_\_

71. Consider the following PE diagram of a chemical reaction and the same reaction being catalyzed:



a. Which of the two diagrams represents the catalyzed reaction? dotted  
Which of the two diagrams represents the uncatalyzed reaction?

b. Explain your answer to the previous question.

*It says so*

c. Is the uncatalyzed reaction endothermic or exothermic? exo  
Explain your answer.

*PE of Prod < PE reactants*

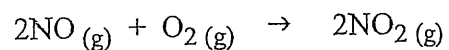
d. How many steps in the uncatalyzed reaction? 2 Explain your answer.

*2 humps*

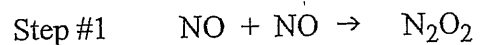
e. How many steps in the catalyzed reaction?

2

72. Consider the following overall reaction which is exothermic:



a. Complete the proposed two-step mechanism.



b. Describe how adding a catalyst would affect the activation energy and,  $\Delta H$  for the overall reaction?

73. Which of the following could describe a catalyst?

- A. A substance that increases the reaction time.
- B. A substance that provides an alternate mechanism with a higher activation energy.
- C. A substance that is formed in one step and used up in a subsequent step in a reaction mechanism.
- D. A substance that is used up in one step and reformed in a subsequent step in a reaction mechanism.

74. A proposed reaction mechanism for a reaction is:

Step 1	$\text{H}_3\text{O}^+ + \text{I}^- \rightarrow \text{HI} + \text{H}_2\text{O}$
Step 2	$\text{H}_2\text{O}_2 + \text{HI} \rightarrow \text{H}_2\text{O} + \text{HOI}$
Step 3	$\text{HOI} + \text{H}_3\text{O}^+ + \text{I}^- \rightarrow 2\text{H}_2\text{O} + \text{I}_2$
Step 4	$\text{I}_2 + \text{I}^- \rightarrow \text{I}_3^-$

75. A proposed reaction mechanism for a reaction is:

Step 1	$\text{H}_3\text{O}^+ + \text{I}^- \rightarrow \text{HI} + \text{H}_2\text{O}$
Step 2	$\text{H}_2\text{O}_2 + \text{HI} \rightarrow \text{H}_2\text{O} + \text{HOI}$
Step 3	$\text{HOI} + \text{H}_3\text{O}^+ + \text{I}^- \rightarrow 2\text{H}_2\text{O} + \text{I}_2$
Step 4	$\text{I}_2 + \text{I}^- \rightarrow \text{I}_3^-$

In the above mechanism, which would be the best description for  $\text{I}^-$ ?

- A. a product
- B. a reaction intermediate
- C. a catalyst
- D. a reactant

76. A proposed reaction mechanism for a reaction is:

Step 1	$\text{H}_3\text{O}^+ + \text{I}^- \rightarrow \text{HI} + \text{H}_2\text{O}$
Step 2	$\text{H}_2\text{O}_2 + \text{HI} \rightarrow \text{H}_2\text{O} + \text{HOI}$
Step 3	$\text{HOI} + \text{H}_3\text{O}^+ + \text{I}^- \rightarrow 2\text{H}_2\text{O} + \text{I}_2$
Step 4	$\text{I}_2 + \text{I}^- \rightarrow \text{I}_3^-$

What would be the overall reaction?

- A.  $2\text{H}_3\text{O}^+ + 3\text{I}^- + \text{H}_2\text{O}_2 \rightarrow \text{HI} + \text{HOI} + \text{I}_2 + 4\text{H}_2\text{O} + \text{I}_3^-$
- B.  $\text{I}^- + \text{I}_2 \rightarrow \text{I}_3^-$
- C.  $\text{H}_3\text{O}^+ + \text{I}^- + \text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{I}_3^-$
- D.  $2\text{H}_3\text{O}^+ + 3\text{I}^- + \text{H}_2\text{O}_2 \rightarrow 4\text{H}_2\text{O} + \text{I}_3^-$

77. Consider the following reaction mechanism:

Step 1	$\text{Cl}_2 \rightarrow 2\text{Cl}$
Step 2	$\text{CHCl}_3 + \text{Cl} \rightarrow \text{HCl} + \text{CCl}_3$
Step 3	$\text{CCl}_3 + \text{Cl} \rightarrow \text{CCl}_4$

Which of the following is a reactant in the overall reaction?

A.  $\text{Cl}_2$

B.  $\text{Cl}$

C.  $\text{HCl}$

D.  $\text{CCl}_3$

78. Consider the following reaction mechanism:

Step 1	$\text{Cl}_2 \rightarrow 2\text{Cl}$
Step 2	$\text{CHCl}_3 + \text{Cl} \rightarrow \text{HCl} + \text{CCl}_3$
Step 3	$\text{CCl}_3 + \text{Cl} \rightarrow \text{CCl}_4$

Which of the following is a reaction intermediary in the overall reaction?

A.  $\text{Cl}_2$

B.  $\text{Cl}$

C.  $\text{HCl}$

D.  $\text{CCl}_4$

79. Consider the following reaction mechanism:

Step 1	$\text{NO}_2 + \text{SO}_2 \rightarrow \text{SO}_3 + \text{NO}$
Step 2	$\text{NO} + \frac{1}{2}\text{O}_2 \rightarrow \text{NO}_2$

Which of the following best describes  $\text{NO}_2$  ?

A. reactant

B. reaction

C. product

D. catalyst

80. Consider the following reaction mechanism:

Step 1	$\text{NO}_2 + \text{SO}_2 \rightarrow \text{SO}_3 + \text{NO}$
Step 2	$\text{NO} + \frac{1}{2}\text{O}_2 \rightarrow \text{NO}_2$

Which of the following best describes NO ?

- A. reactant      B. reaction intermediary      C. product      D. catalyst

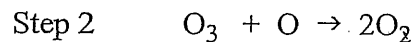
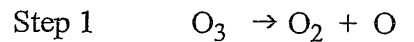
81. Consider the following reaction mechanism?

Step 1	$2\text{NO}_2 \rightarrow \text{NO}_3 + \text{NO}$
Step 2	$\text{NO}_3 + \text{CO} \rightarrow \text{NO}_2 + \text{CO}_2$

Which of the following best describes  $\text{NO}_3$  ?

- A. product      B. reactant      C. catalyst      D. reaction intermediary

82. Consider the following reaction mechanism:



Which of the following could represent the activated complex for Step 2?

- A. O      B.  $\text{O}_2$       C.  $\text{O}_3$       D.  $\text{O}_4$

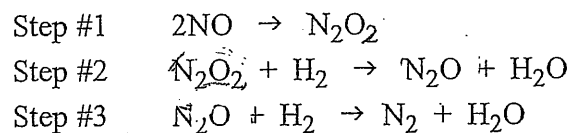
83. Consider the following reaction mechanism:

Step 1.	$\text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2$
Step 2.	$\text{O} + \text{NO}_2 \rightarrow \text{NO} + \text{O}_2$

Which of the following represents the activated complex for Step 1?



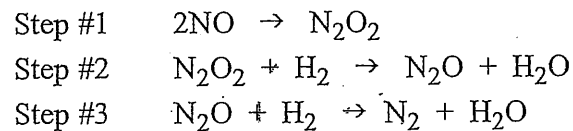
84. A reaction has the following mechanism:



Which of the following substances is a reaction intermediate?

- A.  $\text{H}_2$                       B.  $\text{NO}$                       C.  $\text{H}_2\text{O}$                       D.  $\text{N}_2\text{O}$

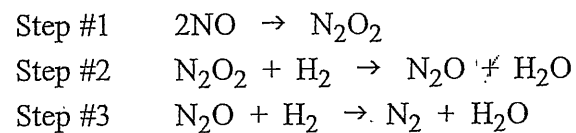
85. A reaction has the following mechanism:



Which of the following substances is a reactant?

- A.  $\text{H}_2$                       B.  $\text{N}_2\text{O}_2$                       C.  $\text{H}_2\text{O}$                       D.  $\text{N}_2\text{O}$

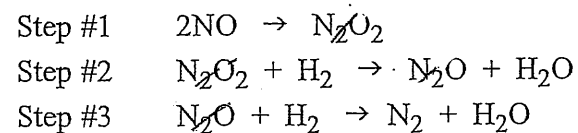
86. A reaction has the following mechanism:



Which of the following substances is a product?

- A.  $\text{H}_2$                       B.  $\text{N}_2\text{O}_2$                       C.  $\text{H}_2\text{O}$                       D.  $\text{N}_2\text{O}$

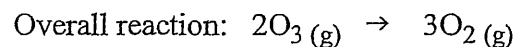
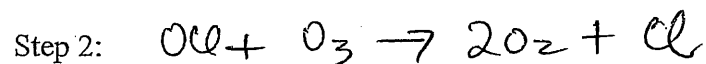
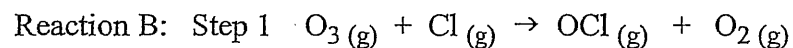
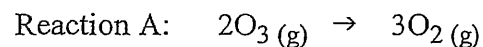
87. A reaction has the following mechanism:



Which of the following substances is the overall reaction?

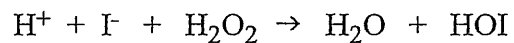
- A.  $2\text{NO} + 2\text{H}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O}$

88. The destruction of the ozone layer high in the Earth's atmosphere can take place as either a one step reaction or as a series of two steps in another reaction mechanism.

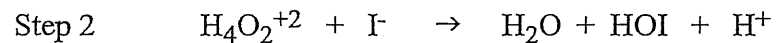
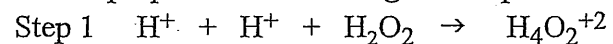


- a. Fill in the missing Step 2: \_\_\_\_\_
- b. Identify any reaction intermediates; \_\_\_\_\_
- c. Identify any catalysts: \_\_\_\_\_
- d. Which will go faster - the overall reaction (Reaction A) or the two step reaction mechanism (Reaction B) that is made up of two steps? \_\_\_\_\_  
Explain your answer.

89. Consider the following reaction:

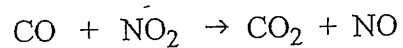


A student proposes the following two-step mechanism for the above fast reaction:



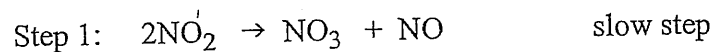
Would you agree or disagree with the proposed mechanism? Explain your answer.

90. Consider the following reaction:



- a. The first step in each of two proposed reaction mechanisms for the above reaction is listed below. If each proposed reaction mechanism consists of only two steps, determine the second step for each mechanism.

Proposed Mechanism #1



Step 2: \_\_\_\_\_ fast step

Proposed Mechanism #2



Step 2: \_\_\_\_\_ slow step

- b. Experimental data show that the rate of the reaction is not affected by a change in the CO concentration. Which of the two proposed mechanisms would be consistent with this data? Explain your answer.

Correct Mechanism \_\_\_\_\_

Explanation

Consider the following reaction mechanism:

Step 1	?
Step 2	$\text{H}_2 + \text{Cl} \rightarrow \text{HCl} + \text{H}$
Step 3	$\text{H} + \text{Cl}_2 \rightarrow \text{HCl} + \text{Cl}$
Step 4	$\text{Cl} + \text{Cl} \rightarrow \text{Cl}_2$
Overall	$\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$

91.

a. What is the missing equation that makes up Step 1?

Step 1: \_\_\_\_\_

b. What is the definition for a reaction intermediate?

c. List at least one reaction intermediate from the steps above. \_\_\_\_\_

### C6: Review

92. In order for a collision between reactant particles to be successful

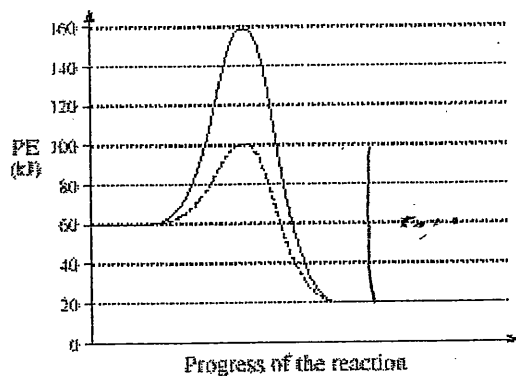
- I. There must be sufficient KE
- II. Collision geometry must be correct
- III. The reaction must take place in a closed system.
- IV. The reaction must be exothermic

Which of the above is needed?

- A. I only
- B. I and II only
- C. I, II, and III only
- D. I, II, III and IV

93. For an endothermic reaction, which of the following is true?

94. Consider the following potential energy diagram for a reaction:



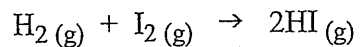
Which of the following represents the correct activation energies?

	Forward uncatalyzed $E_a$	Reverse catalyzed $E_a$
A.	160 kJ	100 kJ
B.	100 kJ	80 kJ
C.	100 kJ	160 kJ
D.	80 kJ	100 kJ

95. Which of the following factors only affects the rate of heterogeneous reactions?

- A. nature of reactants
- B. presence of a catalyst
- C. temperature of reactants
- D. surface area of reactants

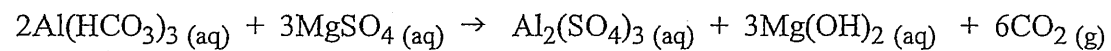
96. Consider the following reaction:



As a molecule of  $\text{H}_2$  approaches a molecule of  $\text{I}_2$  on a collision course, how do the KE and PE change?

- | KE           | PE        |
|--------------|-----------|
| A. increases | decreases |
| B. decreases | increases |
| C. decreases | decreases |
| D. increases | increases |

97. A student wishes to monitor the rate of the following reaction:



Identify two different properties that could be used to monitor the rate of the reaction. Describe the property and how it would change as the reaction proceeds.

Property #1 \_\_\_\_\_

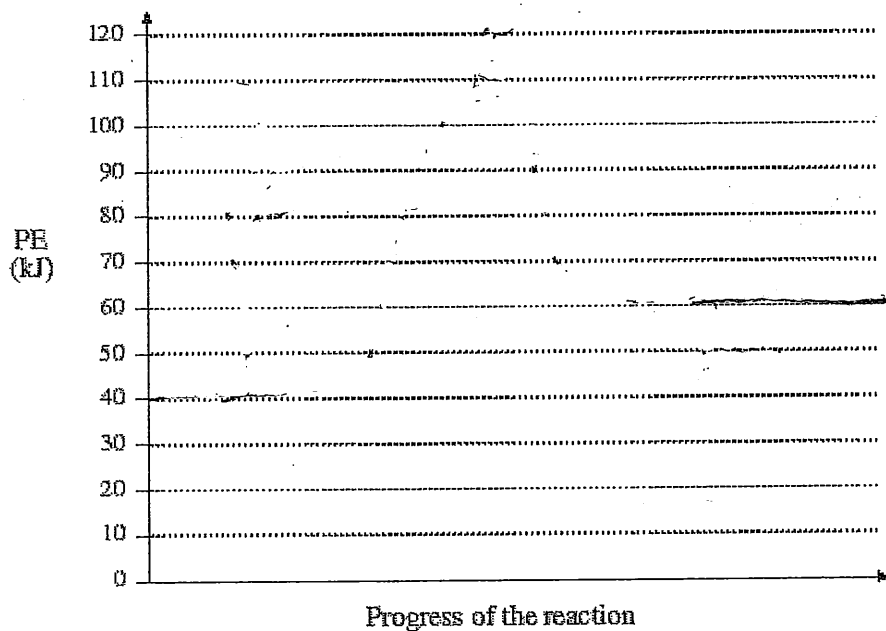
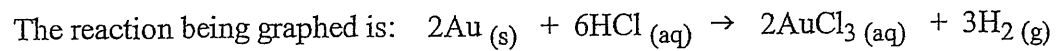
What would change and why?

Property #2 \_\_\_\_\_

What would change and why?

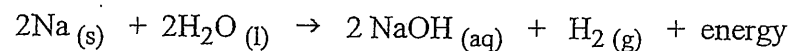
98. In the graph below draw a slow endothermic reaction, labeling

- activation energy which is 70 kJ
- activated complex
- $\Delta H$  which is 20 kJ



Describe how this diagram would change if the temperature were increased.

99. When solid sodium is placed in water at room temperature, an immediate, violent reaction occurs:



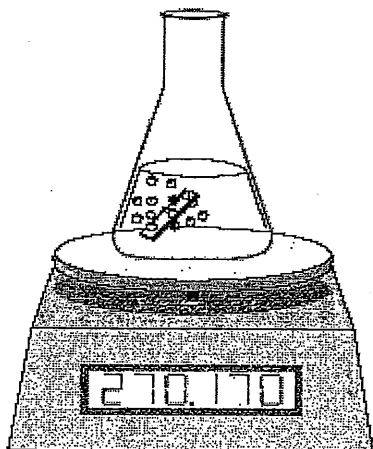
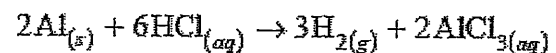
a. Describe two methods that could be used to experimentally determine the rate of reaction.

Method 1: \_\_\_\_\_

Method 2: \_\_\_\_\_

b. Would you expect the activation energy of this reaction to be high or low? Explain using Collision Theory.

An experiment is done to determine the rate of the following reaction:



The following data are collected:

TIME (s)	MASS OF FLASK PLUS CONTENTS (g)
0.0	270.230
30.0	270.200
60.0	270.170

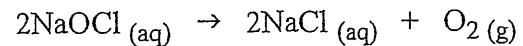
100.

a. Calculate the rate of consumption of the aluminum metal over the 60 seconds.

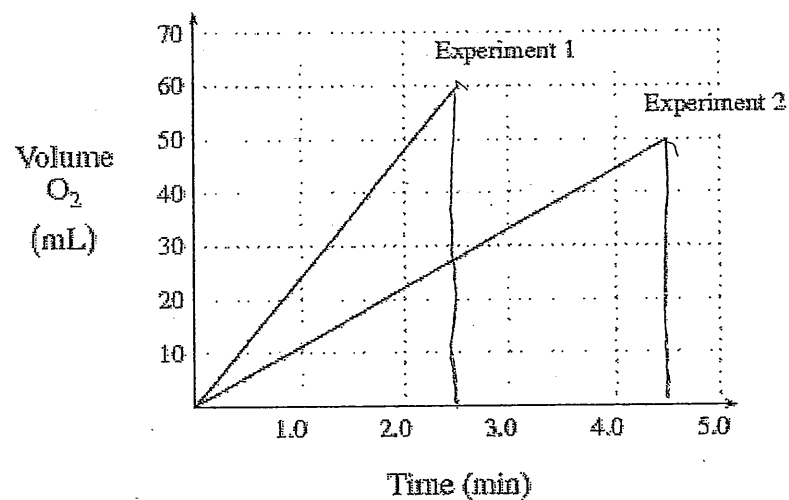
600



101. The release of  $O_2(g)$  resulting from the decomposition of bleach was measured in two different experiments according to the following equation:

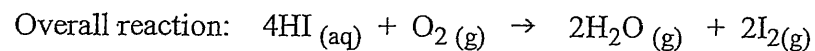


Data was collected and the following graph was drawn:



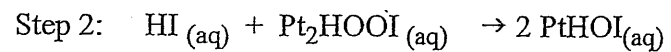
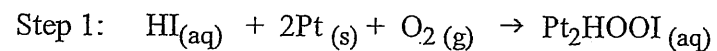
- a. Calculate the average rate of reaction for each experiment.
- b. Identify a variable from Experiment 1 and how it was changed to produce the different reaction rate for Experiment 2. Explain using collision theory.

102. Consider the following reaction:

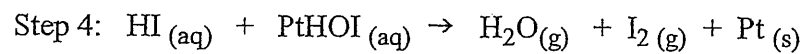


a. Would you expect this reaction to be slow or fast? \_\_\_\_\_  
Explain your answer.

b. A proposed mechanism for the above reaction could look like:



Step 3:



b. Fill in the missing Step 3: \_\_\_\_\_

c. Identify any reaction intermediates; \_\_\_\_\_

d. Identify any catalysts: \_\_\_\_\_

d. Provide two reasons why the proposed mechanism would probably go faster than the overall reaction.