Kinetics Homework Booklet Name MrB Period____

look for (s) for slow
look for (aq) for fast

1. Which of the following reactions is the slowest at room temperature?
   A. $NH_{3\,(g)} + HCl_{(g)} \Rightarrow NH_4Cl_{(s)}$
   B. $MgCl_{2\,(aq)} + Ca_{(s)} \Rightarrow Mg_{(s)} + CaCl_{2\,(aq)}$
   C. $HCl_{(aq)} + NaOH_{(aq)} \Rightarrow NaCl_{(aq)} + H_2O_{(l)}$
   D. $Ba(NO_3)_{2\,(aq)} + 2H_2O_{(l)} \Rightarrow Ba(OH)_{2\,(s)} + 2HNO_{3\,(aq)}$

2. Which of the following reactions is the fastest at room temperature?
   A. $NH_{3\,(g)} + HCl_{(g)} \Rightarrow NH_4Cl_{(s)}$
   B. $MgCl_{2\,(aq)} + Ca_{(s)} \Rightarrow Mg_{(s)} + CaCl_{2\,(aq)}$
   C. $HCl_{(aq)} + NaOH_{(aq)} \Rightarrow NaCl_{(aq)} + H_2O_{(l)}$
   D. $Ba(NO_3)_{2\,(aq)} + 2H_2O_{(l)} \Rightarrow Ba(OH)_{2\,(s)} + 2HNO_{3\,(aq)}$

3. Which of the following has the greatest reaction rate?
   A. $3H_{2\,(g)} + N_{2\,(g)} \Rightarrow 2NH_{3\,(g)}$
   B. $2\,H_2O_{2\,(l)} \Rightarrow 2H_2O_{(l)} + O_{2\,(g)}$
   C. $2Al_{(s)} + 3CaCl_{2\,(aq)} \Rightarrow 2AlCl_{3\,(aq)} + 3Ca_{(s)}$
   D. $AgNO_{3\,(aq)} + NaBr_{(aq)} \Rightarrow AgBr_{(s)} + NaNO_{3\,(aq)}$

4. Which of the following reactions would have the greatest reaction rate at room temperature?
   A. $C_3H_{8\,(g)} + 5O_{2\,(g)} \Rightarrow 3\,CO_{2\,(g)} + 4\,H_2O_{(g)}$
   B. $Ca_{(s)} + 2H_2O_{(g)} \Rightarrow Ca(OH)_{2\,(aq)} + H_{2\,(g)}$
   C. $AgNO_{3\,(aq)} + NaCl_{(aq)} \Rightarrow AgCl_{(s)} + NaNO_{3\,(aq)}$
   D. $Na_2CO_{3\,(s)} + 2HCl_{(aq)} \Rightarrow 2NaCl_{(aq)} + CO_{2\,(g)} + H_2O_{(g)}$

Sept 7

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 3.50/25
   B. 0.18 grams per second
   C. 0.32 grams per second 8/25
   D. 4.50 grams per second forgot sec. stacks

$$\frac{(8.00 - 3.50)\text{ g of Mg}}{25\text{ sec}} = .18$$

6. Consider the following reaction:

$$Fe_2O_{3(s)} + 2Al_{(s)} \Rightarrow Al_2O_{3(s)} + 2\,Fe_{(s)}$$

If 0.50 mol of Fe is produced in 10.0 sec, what is the rate of consumption of Fe_2O_3 in mol/sec?

A. 5.0×10^{-2} mol/sec B. 2.5×10^{-2} mol/sec C. 1.0×10^{-1} mol/sec D. 5.0 mol/sec

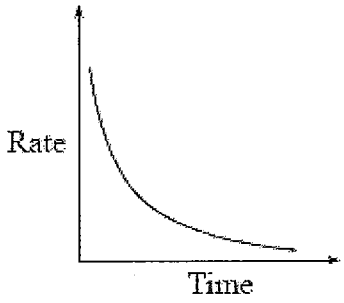
$$\frac{.50\text{ mol Fe}}{10.0\text{ sec}} \times \frac{1\,Fe_2O_3}{2\,Fe} = \frac{.025\text{ mol } Fe_2O_3}{\text{sec}}$$

7. Consider the following reaction:

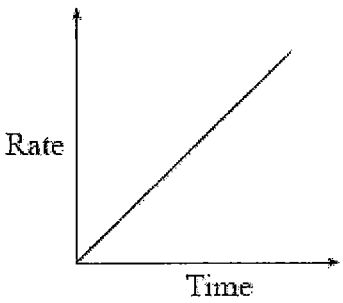
$$2H_2O_{2\,(l)} \rightarrow 2H_2O_{(l)} + O_{2\,(g)}$$

Which graph shows the relationship between the rate of consumption of H_2O_2 and time?

A.

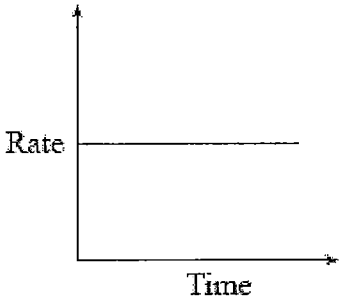


B.

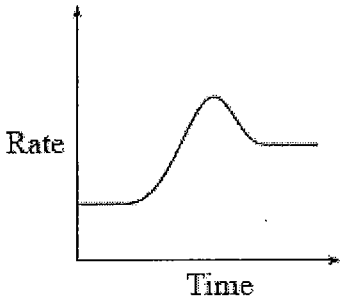


after collision theory

C.



D.



8. Consider the following:

When a candle ($C_{20}H_{42}$) burns, the following reaction occurs:

$$2C_{20}H_{42\,(s)} + 61O_{2\,(g)} \rightarrow 40\,CO_{2\,(g)} + 42H_2O_{(g)} + \text{heat}$$

If the rate of production of 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

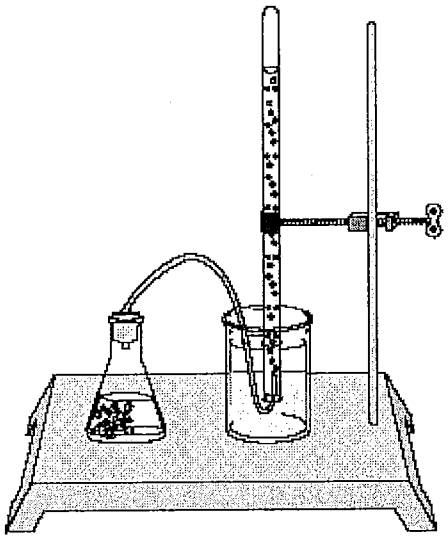
$$\frac{0.98\ g\ of\ CO_2}{min} \times \frac{1\ mole\ CO_2}{44.0\ g\ of\ CO_2} \times \frac{61\ O_2}{40\ CO_2} \times \frac{32.0\ g}{1\ mole\ O_2}$$

$$= 1.0869\ g/min$$

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

$$2Al_{(s)} + 6HCl_{(aq)} \rightarrow 2AlCl_{3\,(aq)} + 3H_{2\,(g)}$$

The data from the experiment is below:



The following data is collected:

Time (s)	Volume of H_2 (mL)	
0.0	0.0	
10.0	21.1	21.1
20.0	40.9	19.8
30.0	60.0	19.1
40.0	77.6	17.6

a. Calculate the rate of formation of $H_{2\,(g)}$ in mL per second for the time interval between 10.0 seconds and 30.0 seconds.

$\frac{(60.0 - 21.1)\ mL\ H_2}{(30.0 - 10.0)\ sec} = \frac{38.9\ mL\ H_2}{20.0\ sec} = 1.945 = 1.94\ \frac{mL\ H_2}{sec}$

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

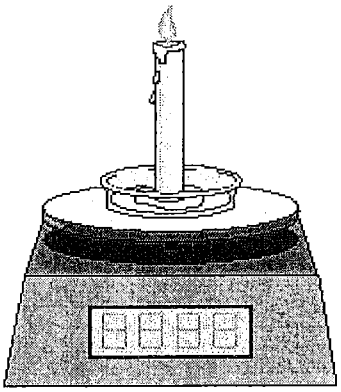
As reactants get used up, there are fewer reactants to collide ∴ fewer collisions ∴ fewer successful collisions

c. Provide one suggestion of how the rate of hydrogen gas could be increased.

↑ temp — grind up Al (s)
↑ [HCl] — add catalyst

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:

$$2C_{28}H_{58(s)} + 85O_{2(g)} \rightarrow 56CO_{2(g)} + 58H_2O_{(g)}$$



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 CO_2 in mol/min over the 30.0 min

$$\frac{(25.6 - 22.8)\ g\ C_{28}H_{58}}{30.0\ min} \times \frac{1\ mole\ C_{28}H_{58}}{394.0\ g\ C_{28}H_{58}} \times \frac{56\ mole\ CO_2}{2\ moles\ C_{28}H_{58}} = \frac{6.6528 \times 10^{-3}\ mol\ CO_2}{min} = \frac{6.6 \times 10^{-3}\ mol\ CO_2}{min}$$

11. Consider the following reaction:

$$C_{12}H_{22}O_{11\,(s)} \Rightarrow 11\,H_2O_{\,(g)} + 12\,C_{\,(s)}$$

The rate of decomposition of is 0.75 mol/min.
What mass of C is produced in 10.0 seconds?

$$10.0\ sec \times \frac{1\ min}{60\ sec} \times \frac{.75\ mole\ C_{12}H_{22}O_{11}}{min} \times \frac{12\ mole\ C}{1\ mole\ C_{12}H_{22}O_{11}}$$

$$\times \frac{12.0\ g}{1\ mole\ C} = 18.0\ g\ C$$

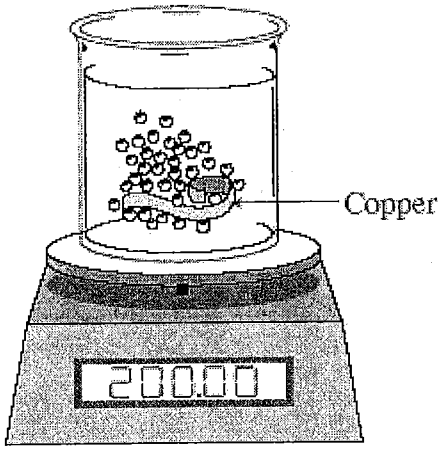
12.

Consider the following reaction:

$$3Cu_{(s)} + 8HNO_{3(aq)} \rightarrow 3Cu(NO_3)_{2(aq)} + 2NO_{(g)} + 4H_2O_{(\ell)}$$

A piece of copper is added to a nitric acid solution in an open beaker, allowing the $NO_{(g)}$ 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



a. Calculate the average rate of consumption of copper in grams per minute over the 8.0 minutes.

$$\frac{(200.00 - 184.80)\text{ g NO}}{8.0\text{ min}} \times \frac{1\text{ mole NO}}{30.0\text{ g NO}} \times \frac{3\text{ mole Cu}}{2\text{ mole NO}} \times \frac{63.5\text{ g Cu}}{1\text{ mole Cu}}$$

$$= 6.0325\ \frac{\text{g Cu}}{\text{min}} = 6.0\ \frac{\text{g Cu}}{\text{min}}$$

b. Explain why the reaction rate slows down as the time goes from 0.0 to 8.0 minutes.

As Cu and HNO_3 get used up, there will be fewer reactants to collide. ∴ fewer collisions ∴ fewer successful collisions

c. List two ways in which the reaction rate could be increased and explain your choices.

↑ temp — more collisions and more energy in each collision

↑ $[HNO_3]$ — more collisions

grind up Cu — more collisions

add catalyst — lowers energy needed for successful collision

13. Consider the following reaction in an open container:

$$CaCO_{3(s)} + 2HCl_{(aq)} \Rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

A 155.0 g sample of $CaCO_{3\,(s)}$ is placed in the flask and $HCl_{\,(aq)}$ is added.
The reaction consumes HCl at an average rate of 7.30 grams of $HCl_{\,(aq)}$ per minute.
The reaction is allowed to go for 10.0 minutes. How many grams of $CaCO_{3\,(s)}$ will be left over at the end of the 10.0 minutes?

$10.0\ \text{min} \times \frac{7.30\ \text{g HCl}}{\text{min}} \times \frac{1\ \text{mole HCl}}{36.5\ \text{g HCl}} \times \frac{1\ \text{mole } CaCO_3}{2\ \text{moles HCl}} \times \frac{100.1\ \text{g CaCO}_3}{1\ \text{mole CaCO}_3}$

$= 100.1\ \text{g of } CaCO_3 = 100.\ 1\ \text{g } CaCO_3$ got used up

$\therefore (155.0 - 100.) = 55\ \text{g of } CaCO_3$ got used up.

14. Consider the following reaction:

$$COCl_{2\,(g)} \Rightarrow CO_{\,(g)} + Cl_{2\,(g)}$$

Which of the following could be used to determine reation 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. in increase in the mass of the system

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

$$CaCO_{3(s)} + 2HCl_{(aq)} \Rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)} + \text{heat}$$

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

A. a change in $[Cl^-]$ ✗
B. an increase in the acidity decrease
C. a change in the gas pressure not an open
(D) a decrease in the mass of the system

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

$CaCO_{3(s)} + 2HCl_{(aq)} \Rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)} + \text{heat}$

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

A. a change in $[Cl^-]$
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:

$C_3H_{8\,(g)} + 5O_{2\,(g)} \Rightarrow 3\,CO_{2\,(g)} + 4\,H_2O_{(g)}$ $\Delta H = -114$ kJ

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 $CO_{2\,(g)}$
D. increase the temperature

changing rates. so move to after

18. Consider the following reactions in an open system:

I. $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$
II. $CaCO_{3\,(s)} \rightarrow CaO_{(s)} + CO_{2\,(g)}$
III. $CaO_{(s)} + SiO_{2\,(s)} \rightarrow CaSiO_{3\,(s)}$ no gases
IV. $AgNO_{3\,(aq)} + NaCl_{(aq)} \rightarrow NaNO_{3\,(aq)} + AgCl_{(s)}$ no gases

In which of the above could the reaction rate be determined by $\triangle$ mass of system?
$\triangle$ time

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

19. Consider the following:

When a candle $(C_{20}H_{42})$ burns, the following reaction occurs:

$2C_{20}H_{42(s)} + 61O_{2(g)} \rightarrow 40CO_{2(g)} + 42H_2O_{(g)} + \text{heat}$

Sept 7

Which of the following properties could be monitored in order to determine the reaction rate of the burning candle?

A. mass of $C_{20}H_{42\,(s)}$
B. pressure of $H_2O_{\,(g)}$
C. surface area of $C_{20}H_{42\,(s)}$
D. concentration of $C_{20}H_{42\,(s)}$

$Fe_2O_3 + 2H_3PO_4 \rightarrow P_2O_5 + 2Fe(OH)_3$

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

$CaCO_{3\,(s)} + 2HCl_{\,(aq)} \rightarrow CaCl_{2\,(aq)} + H_2O_{\,(l)} + CO_{2\,(g)}$ Change 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 $\frac{\Delta \text{mass}}{\Delta \text{time}}$ if open system

What would change and why?

mass ↓ as $CO_{2\,(g)}$ leaves

Property #2 $\frac{\Delta \text{pressure}}{\Delta \text{time}}$ if closed system

What would change and why?

pressure ↑ as more gases are produced

$\frac{\Delta \text{pH}}{\Delta \text{time}}$ pH ↑ as HCl gets used up.

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

$2HNO_{3(aq)} + 2HCl_{(aq)} + Cu_{(s)} \rightarrow Cu(NO_3)_2 + N_2O_{4\,(g)} + H_2O_{(\ell)}$

$C_{(s)} + 2H_2O_{\,(g)} \rightarrow CO_{2\,(g)} + 2H_{2\,(g)}$ Change 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 $\frac{\Delta \text{mass of C}}{\Delta \text{time}}$

What would change and why?

mass ↓ as $C_{(s)}$ gets used up.

Property #2 $\frac{\Delta \text{pressure}}{\Delta \text{time}}$ if closed

What would change and why?

pressure ↑ because more gases are produced.

22. Consider the following reaction:

$$3Fe_2O_{3\,(s)} + CO_{(g)} \Rightarrow 2\,Fe_3O_{4\,(s)} + CO_{2\,(g)} + 46\ kJ$$

changing rates.

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

A. remove some of the $Fe_3O_{4\,(s)}$
B. decrease the temperature
C. increase the surface area of the $Fe_2O_{3\,(s)}$
D. increase the volume of the reaction vessel no gases

23. Given the following:

$$CaCO_{3(s)} + 2HCl_{(aq)} \Rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)} + \text{heat}$$

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

A. increasing pressure } no gases
B. decreasing pressure }
C. increasing temperature
D. decreasing temperature

24. Consider the following reaction:

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2\,(aq)} + H_{2\,(g)}$$

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 $ZnCl_2$

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:

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2\,(aq)} + H_{2\,(g)}$$

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. A catalyst was added
B. The Mg was powdered
C. The $[H_2]$ was decreased
D. The temperature was decreased

so second experiment took longer so is slower!

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:

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2\,(aq)} + H_{2\,(g)}$$

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.

put it in fridge so ↓ temp ↓ collisions and ↓ energy in each collision

wrap it up prevent butter and other reactants from colliding

add an inhibitor ↑ energy needed for successful collision

lump butter.

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.

exo

$$2C_8H_{18\,(l)} + 25O_{2\,(g)} \rightarrow 16CO_{2\,(g)} + 18H_2O_{\,(g)}$$

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

pressure ↑ in car engine so [gases] ↑ and so ↑ collisions so ↑ successful collisions

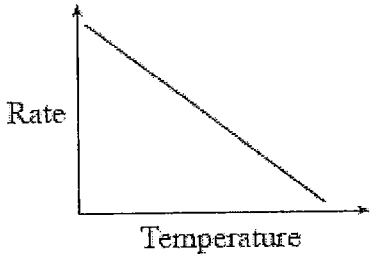
temp ↑

29. Consider the following reaction:

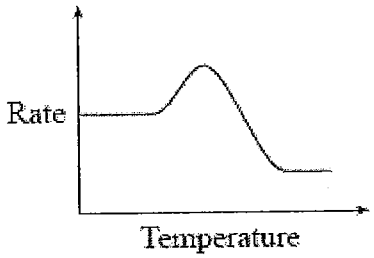
$$CH_{4\,(g)} + O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2H_2O_{\,(g)} + \text{heat}$$

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

A.

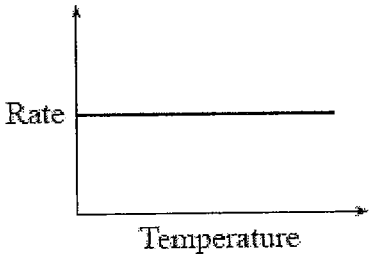


B.

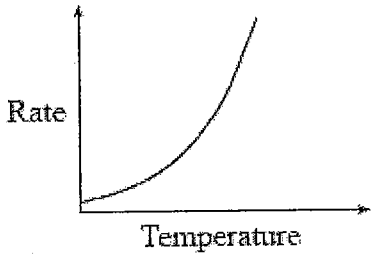


Tues Sept 11

C.



(D.)



30. In order for a collision between reactant particles to be successful
    A. ΔH must be positive
    B. the system must be open
    (C.) there must be sufficient KE
    D. KE > 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
    A. a particle that has maximum KE and minimum PE
    B. a particle that is used up in one step of a reaction mechanism and produced in a later one
    C. a particle that is produced in one step of a reaction mechanism and used up in a later one
    (D.) an unstable particle that is neither a reactant nor a product

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. $2C_8H_{18\,(l)} + 25\,O_{2\,(g)} \rightarrow 16CO_{2\,(g)} + 18H_2O_{\,(g)}$

B. $Pb^{+2}{}_{(aq)} + SO_4{}^{-2}{}_{(aq)} \rightarrow PbSO_{4\,(s)}$

a. Which reaction is most likely to have a faster reaction rate? B

b. Using the collision theory, provide two reasons as an explanation.

① (aq) is faster than (g) ∴ more collisions ∴ more successful

② Fewer particles need to collide in B ∴ easier to have a successful collision

③ B has charged particles that attract each other ∴ easier to have successful collisions

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

blowing ↑ $[O_2]$ near the splint ∴ more collisions between splint & O_2 ∴ more successful collisions

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

① Smother the fire. ∴ $[O_2]$ ↓ and fewer collisions
② Put water on it to remove the heat + lower temp. ∴ fewer collisions and less energy/collision
③ Use CO_2 extinguisher. CO_2 will displace O_2 (①) and remove heat.
④ Separate logs from fire to ↓ the collisions.

37. Consider the following reaction:

$$H_{2\,(g)} + I_{2\,(g)} \rightarrow 2HI_{(g)}$$

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

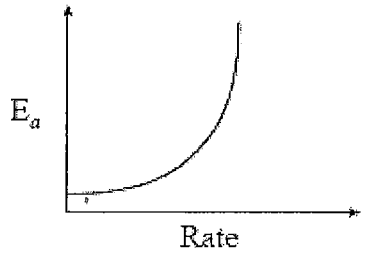
	KE	PE	Stability
A.	~~high~~	high	~~stable~~
B.	low	~~low~~	~~stable~~
C.	~~high~~	~~low~~	unstable
(D.)	low	high	unstable

38. Activation energy is defined as the
A. ΔH
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

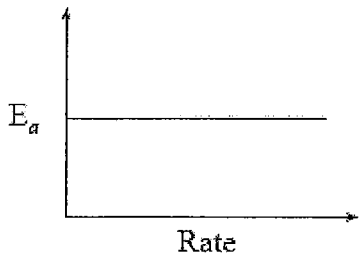
39. Which of the following best describes *activation energy*?
A. PE of activated complex
B. (PE of products) - (PE of reactants)
C. (PE of reactants) - (PE of activated complex)
(D.) (PE of activated complex) - (PE of reactants)

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?

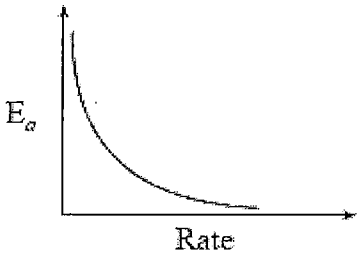
A.



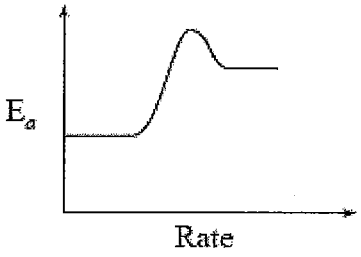
B.



C.

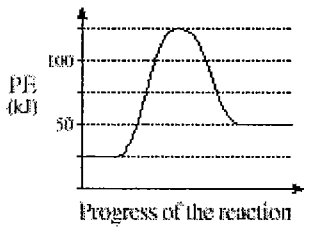


D.

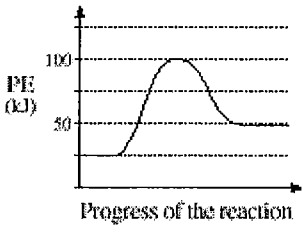


41. Which of the following graphs most likely represents the slowest forward reaction?

A.

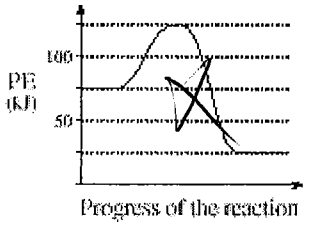


B.

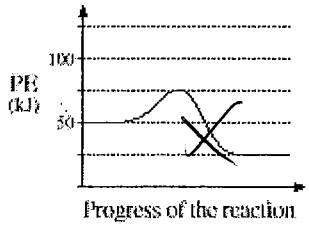


highest Ea endothermic.

C.

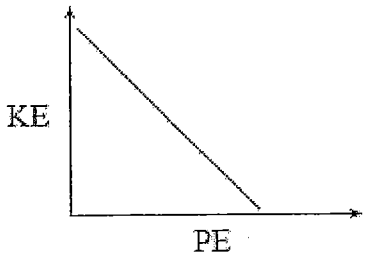


D.

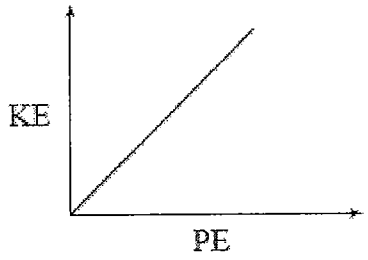


42. Which of the following graphs best describes the changes in KE and PE as reactant molecules approach each other?

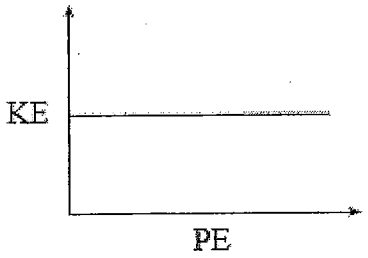
A.



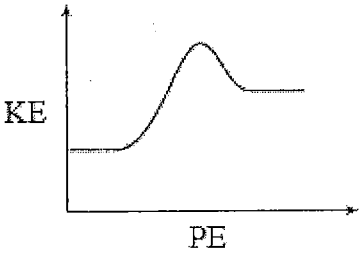
B.



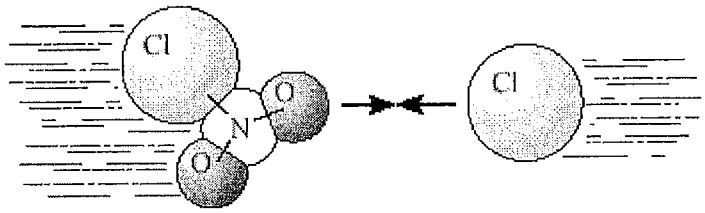
C.



D.



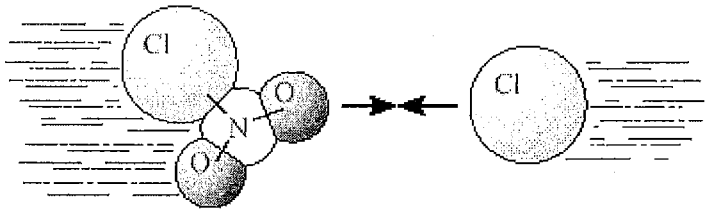
43. The following diagram shows reactant molecules approaching one another:



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 ΔH of the reaction.
B. It increases the ΔH of the reaction
C. It reduces the required activation energy.
D. It causes the reaction to become exothermic.

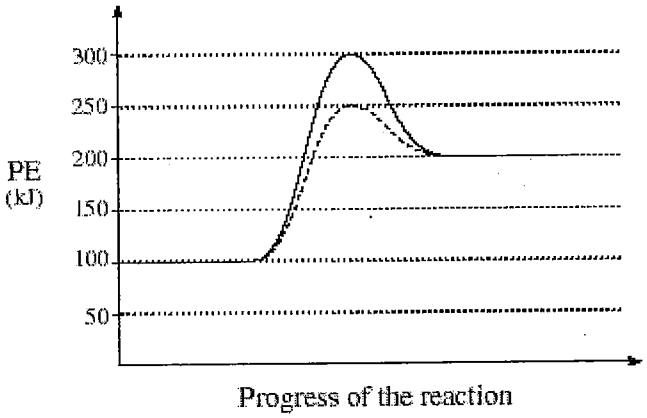
48. How does the addition of an inhibitor decrease the reaction rate of an exothermic reaction?

A. It reduces the ΔH of the reaction.
B. It increases the ΔH of the reaction
C. It increases the required activation energy.
D. It causes the reaction to become endothermic.

49. What happens to the activation energy and ΔH of a chemical reaction when an inhibitor is added?

	Activation energy	ΔH
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:

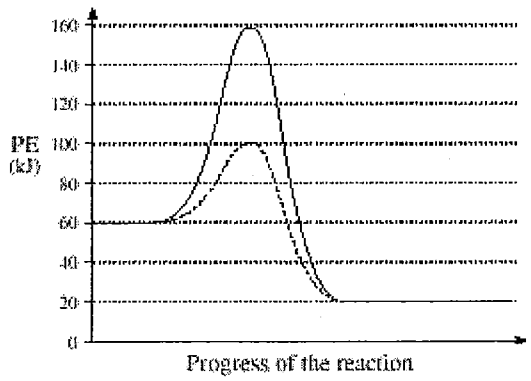


50.

Which of the following best describes the **forward** reaction?

	Reaction	Activation Energy	ΔH
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.	100 kJ	40 kJ
C.	100 kJ	160 kJ
D.	60 kJ	100 kJ

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

A. $PE_{reactants} > PE_{activated\ complex} > PE_{products}$

B. $PE_{products} > PE_{activated\ complex} > PE_{reactants}$

C. $PE_{activated\ complex} > PE_{reactants} > PE_{products}$

D. $PE_{activated\ complex} > PE_{products} > PE_{reactants}$

53. Consider the following reaction:

$$O_{(g)} + O_{3\,(g)} \rightarrow 2O_{2\,(g)}$$

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

	E_a	ΔH
A.	E_a(catalyzed) $< E_a$,	ΔH (catalyzed) $< \Delta H$
B.	E_a(catalyzed) $< E_a$	unchanged
C.	E_a(catalyzed) $> E_a$	unchanged
D.	unchanged	ΔH (catalyzed) $> \Delta H$

54. Which of the following would change the value of the activation energy for a double replacement reaction?

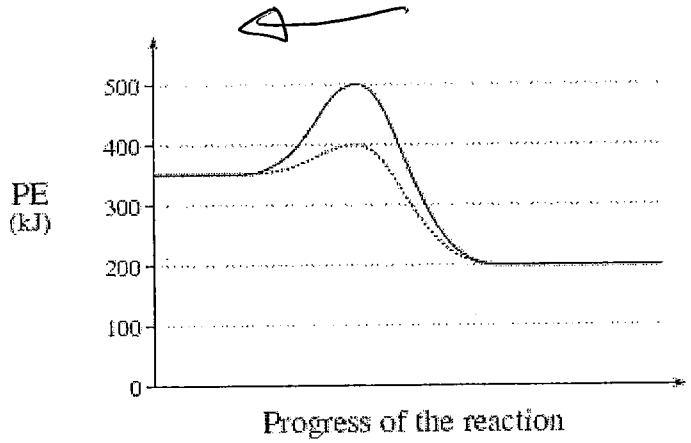
A. adding a catalyst

B. changing the surface area

C. changing the temperature

D. changing the concentrations of reactants

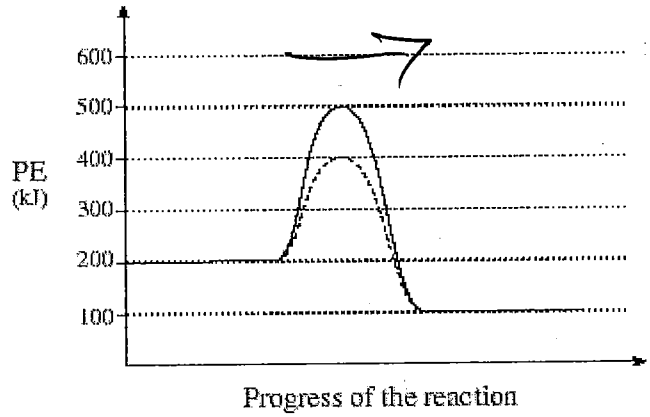
55. Consider the following PE diagram:



Which of the following is true of the **reverse** reaction?

	Activated complex (kJ)	ΔH (kJ)
A. catalyzed	200	-150
B. catalyzed	300	+150
C. uncatalyzed	400	-150
D. uncatalyzed	500	+150

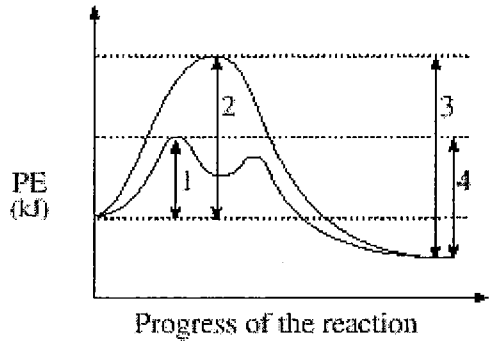
56. Consider the following PE diagrams of a catalyzed and uncatalyzed reaction:



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

A. 200 kJ B. 300 kJ C. 500kJ D. 400 kJ

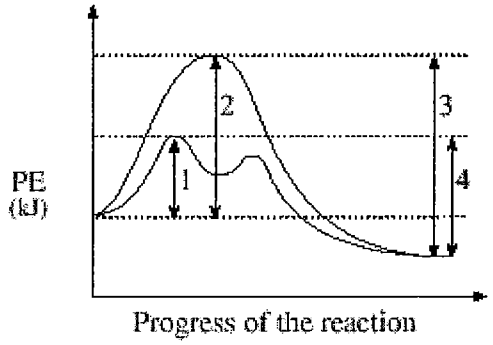
57. Consider the following PE diagram:



Identify the activation energy for the forward uncatalyzed reaction.

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

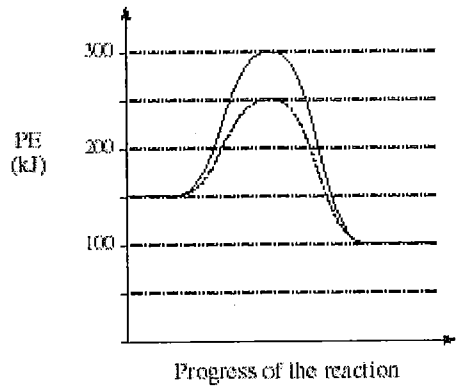
58. Consider the following PE diagram:



Identify the activation energy for the **reverse** catalyzed reaction.

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

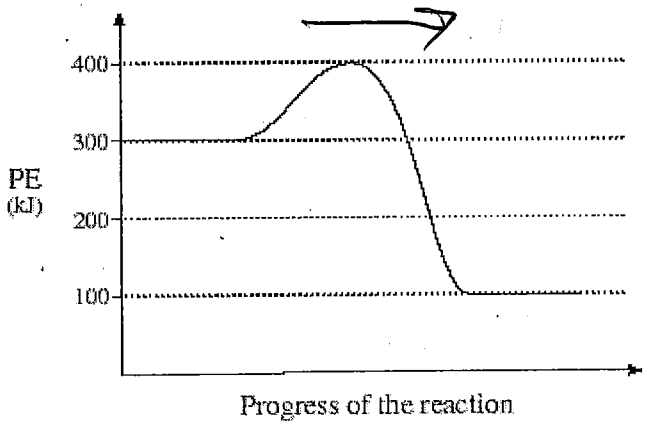
59. Consider the following PE diagram:



Which of the following is true for the forward reaction?

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

60. Consider the following PE diagram:



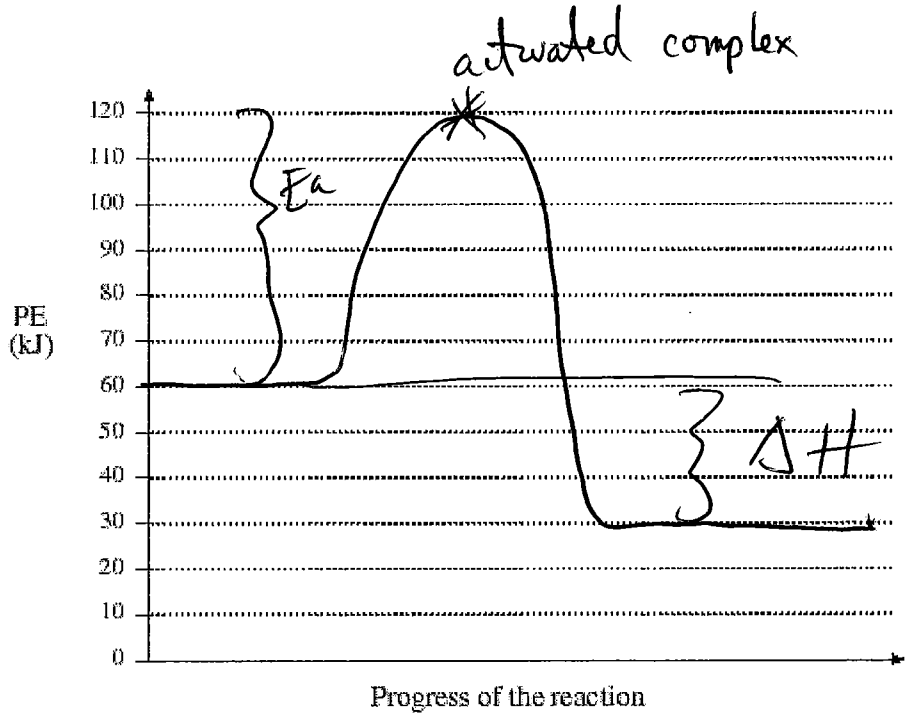
Which of the following is true for the forward reaction:

	△H (kJ)	PE of activated complex (kJ)
A.	~~+200~~	400
B.	~~+200~~	~~100~~
C.	-200	400
D.	-200	~~100~~

high Ea

61. In the graph below draw a slow exothermic reaction, labeling
    - activation energy
    - activated complex
    - ΔH

The reaction for the graph is: $Cu_{(s)} + 2HCl_{(aq)} \rightarrow CuCl_{2\,(aq)} + H_{2\,(g)}$



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

nothing changes

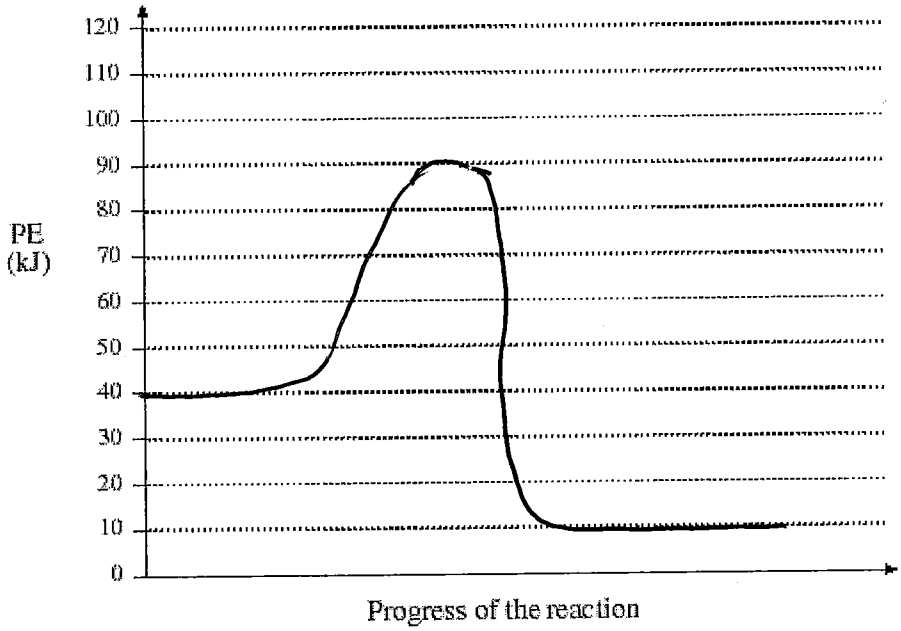
62. Using the axes below, sketch a PE diagram for a chemical reaction in which:

Ea = 50 kJ

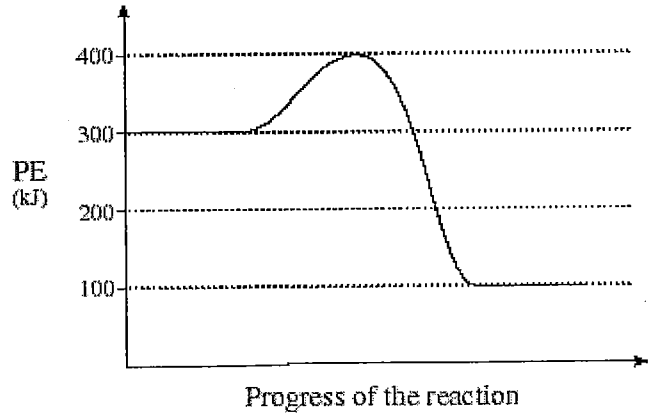
$\Delta H = -30$ kJ

activated complex is at 90 kJ

add labelling



63. Consider the following PE diagram:



Which of the following describes the type of reaction and ΔH for the **reverse** reaction?

	Type of reaction	ΔH
A.	exothermic	postitive
B.	endothermic	positive
C.	exothermic	negative
D.	endothermic	negative

64. Which of the following reactions is endothermic?

A. $CH_{4\,(g)} + 2O_{2\,(g)} \Rightarrow CO_{2\,(g)} + 2H_2O_{(l)} + 890.3\ kJ$

B. $2Na_2O_{2\,(s)} + 2H_2O_{(l)} - 287.0\ kJ \Rightarrow 4\,NaOH_{(aq)} + O_{2\,(g)}$

C. $CaO_{(s)} + H_2O_{(l)} \Rightarrow Ca(OH)_{2\,(aq)} \quad \Delta H = -65.2\ kJ$

D. $CaO_{(s)} + 3C_{(s)} \Rightarrow CaC_{2\,(s)} + CO_{(g)} \quad \Delta H = +464.8\ kJ$

65. Which of the following reactions is endothermic?

A. $H_{2\,(g)} + S \rightarrow H_2S_{(g)} + 20kJ$

B. $4Fe_{(s)} + 3O_{2\,(g)} - 821\ kJ \rightarrow 2Fe_2O_{3\,(s)}$

C. $CO_{2\,(g)} \rightarrow C(s) + O_{2\,(g)} \quad \Delta H = +393\ kJ$

D. $N_{2(g)} + 2H_{2(g)} \rightarrow 2NH_{3\,(g)} \quad \Delta H = -92kJ$

66. Given this reaction:

$$2NO_{(g)} + O_{2\,(g)} \rightarrow 2NO_{2\,(g)} + 112\ kJ$$

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

A. Increase the temperature by 10°C and increase the [reactants] by a factor of two.

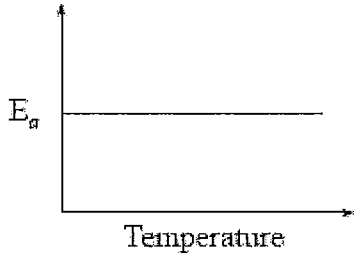
B. Increase the temperature by 10°C and decrease the [reactants] by a factor of two.

C. Decrease the temperature by 10°C and increase the [reactants] by a factor of two.

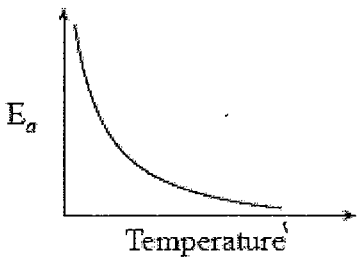
D. Decrease the temperature by 10°C and decrease the [reactants] by a factor of two.

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

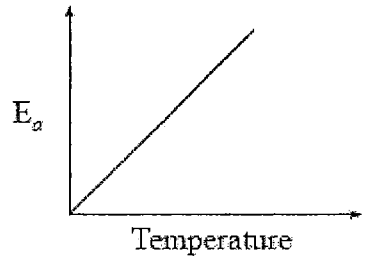
A.



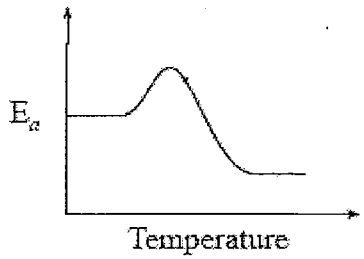
B.



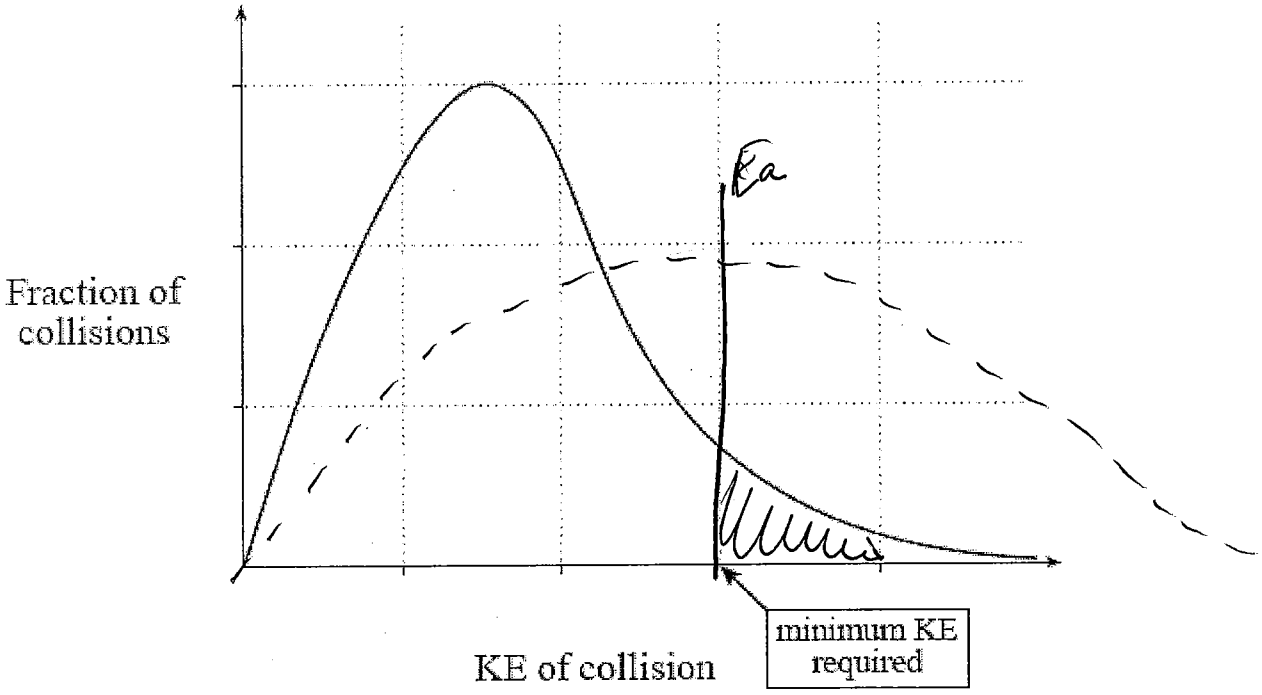
C.



D.



68. Consider the following Kinetic Energy Diagram:

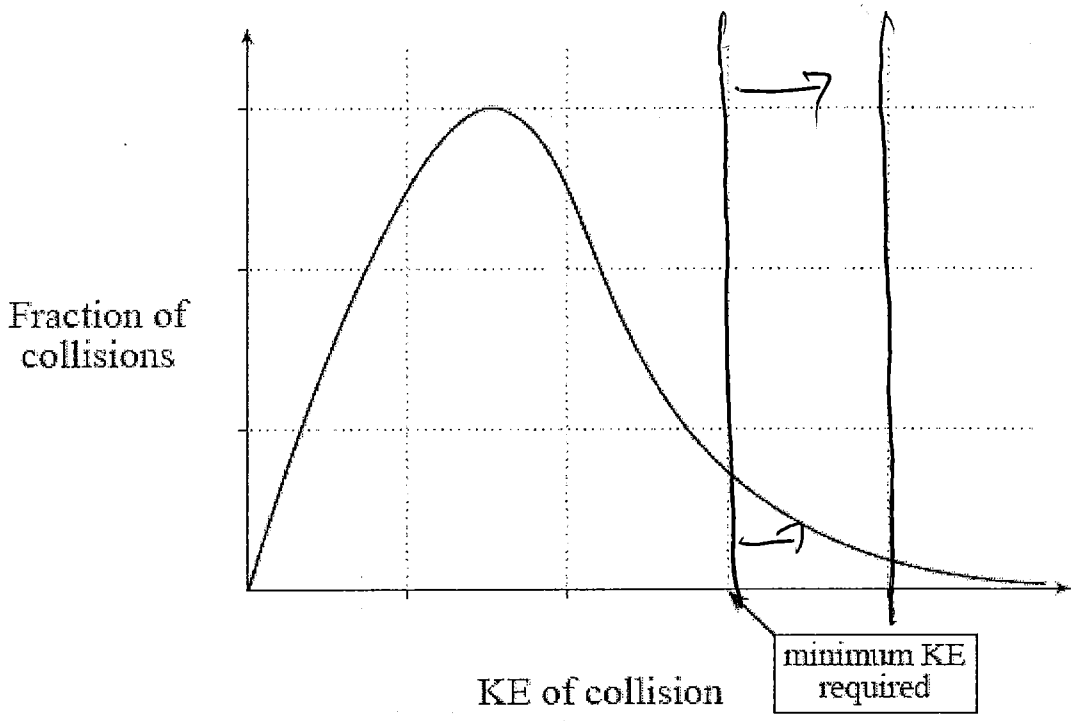


a. Shade in the area that represents the reactant particles that have enough energy to form product particles.

b. Will all the particles in the shaded area form products? No
Explain your answer using Collision Theory.
Must still have proper geometry

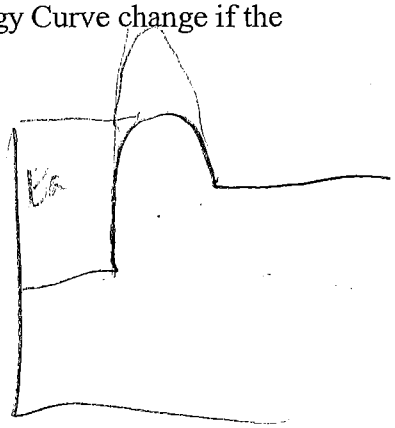
c. Use a dotted line to show how would the Kinetic Energy Curve change if the temperature was raised.

69. Consider the following Kinetic Energy Diagram:

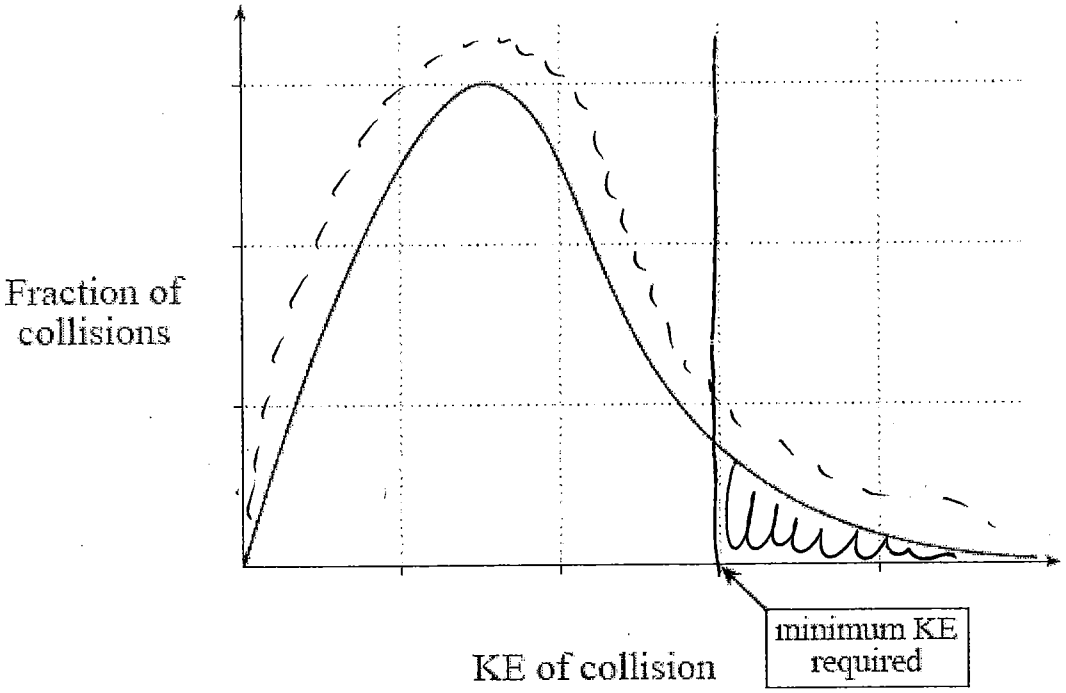


a. Which part of a Potential Energy Diagram does the minimum KE required line correspond to? Ea

b. 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:



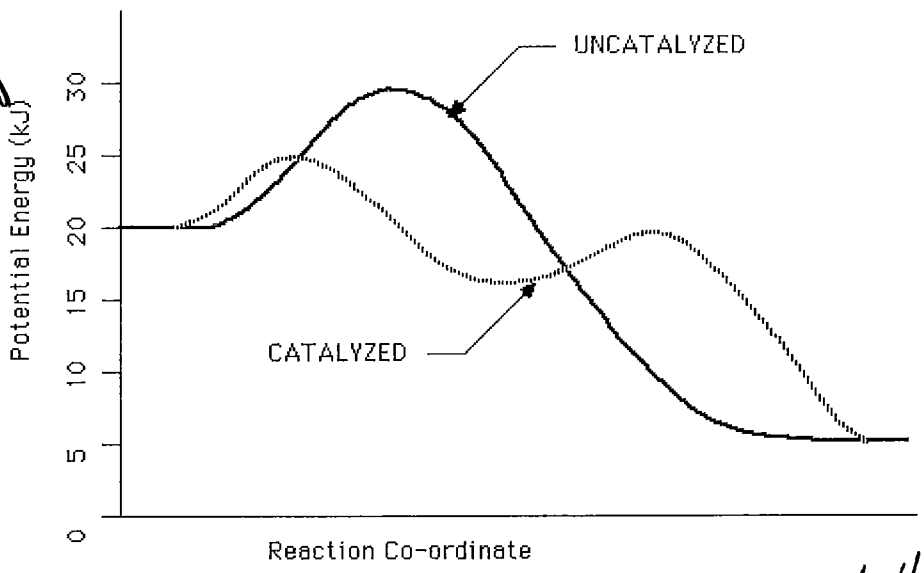
a. Shade in the area of the curve that represents the number of reactant particles with sufficient energy to form product particles.

b. Using a dotted line, show how the curve would change if the concentration of the reactants was increased.

c. Would there be more or fewer particles with sufficient KE to have a successful collision if the reactant concentration was increased? More.

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

Get rid of



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? 1 Explain your answer. 2 humps

e. How many steps in the catalyzed reaction ? 2

72. Consider the following overall reaction which is exothermic:

$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$$

a. Complete the proposed two-step mechanism.

Step #1 $NO + NO \rightarrow N_2O_2$

Step #2 $O_2 + N_2O_2 \rightarrow 2NO_2$

b. Describe how adding a catalyst would affect the activation energy and $\triangle H$ for the overall reaction? catalyst ↓ Ea no effect on ΔH

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	$H_3O^+ + I^- \rightarrow HI + H_2O$
Step 2	$H_2O_2 + HI \rightarrow H_2O + HOI$
Step 3	$HOI + H_3O^+ + I^- \rightarrow 2H_2O + I_2$
Step 4	$I_2 + I^- \rightarrow I_3^-$

In the above mechanism, which would be the best description for H_2O ?

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

75. A proposed reaction mechanism for a reaction is:

Step 1	$H_3O^+ + I^- \rightarrow HI + H_2O$
Step 2	$H_2O_2 + HI \rightarrow H_2O + HOI$
Step 3	$HOI + H_3O^+ + I^- \rightarrow 2H_2O + I_2$
Step 4	$I_2 + I^- \rightarrow I_3^-$

In the above mechanism, which would be the best description for 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	$H_3O^+ + I^- \rightarrow HI + H_2O$
Step 2	$H_2O_2 + HI \rightarrow H_2O + HOI$
Step 3	$HOI + H_3O^+ + I^- \rightarrow 2H_2O + I_2$
Step 4	$I_2 + I^- \rightarrow I_3^-$

What would be the overall reaction?

A. $2H_3O^+ + 3I^- + H_2O_2 + HI + HOI + I_2 \Rightarrow HI + 4H_2O + HOI + I_2 + I_3^-$
B. $I^- + I_2 \Rightarrow I_3^-$
C. $H_3O^+ + I^- + H_2O_2 \Rightarrow H_2O + I_3^-$
D. $2H_3O^+ + 3I^- + H_2O_2 \Rightarrow 4H_2O + I_3^-$

77. Consider the following reaction mechanism:

Step 1	$Cl_2 \rightarrow 2Cl$
Step 2	$CHCl_3 + Cl \rightarrow HCl + CCl_3$
Step 3	$CCl_3 + Cl \rightarrow CCl_4$

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

A. Cl_2 B. Cl C. HCl D. CCl_3

78. Consider the following reaction mechanism:

Step 1	$Cl_2 \rightarrow 2Cl$
Step 2	$CHCl_3 + Cl \rightarrow HCl + CCl_3$
Step 3	$CCl_3 + Cl \rightarrow CCl_4$

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

A. Cl_2 B. Cl C. HCl D. CCl_4

79. Consider the following reaction mechanism:

Step 1	$NO_2 + SO_2 \rightarrow SO_3 + NO$
Step 2	$NO + \frac{1}{2}O_2 \rightarrow NO_2$

Which of the following best describes NO_2 ?

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

80. Consider the following reaction mechanism:

Step 1	$NO_2 + SO_2 \rightarrow SO_3 + NO$
Step 2	$NO + \frac{1}{2}O_2 \rightarrow NO_2$

Which of the following best describes NO ?

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

81. Consider the following reaction mechanism?

Step 1	$2NO_2 \rightarrow NO_3 + NO$
Step 2	$NO_3 + CO \rightarrow NO_2 + CO_2$

Which of the following best describes NO_3 ?

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

82. Consider the following reaction mechanism:

Step 1 $O_3 \rightarrow O_2 + O$

Step 2 $O_3 + O \rightarrow 2O_2$

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

A. O B. O_2 C. O_3 D. O_4

83. Consider the following reaction mechanism:

Step 1.	$NO + O_3 \rightarrow NO_2 + O_2$
Step 2.	$O + NO_2 \rightarrow NO + O_2$

Which of the following substances is the catalyst?

A. O B. O_2 C. NO D. NO_2

84. A reaction has the following mechanism:

Step #1 $2NO \rightarrow N_2O_2$
Step #2 $N_2O_2 + H_2 \rightarrow N_2O + H_2O$
Step #3 $N_2O + H_2 \rightarrow N_2 + H_2O$

Which of the following substances is a reaction intermediate?
A. H_2 B. NO C. H_2O D. N_2O

85. A reaction has the following mechanism:

Step #1 $2NO \rightarrow N_2O_2$
Step #2 $N_2O_2 + H_2 \rightarrow N_2O + H_2O$
Step #3 $N_2O + H_2 \rightarrow N_2 + H_2O$

Which of the following substances is a reactant?
A. H_2 B. N_2O_2 C. H_2O D. N_2O

86. A reaction has the following mechanism:

Step #1 $2NO \rightarrow N_2O_2$
Step #2 $N_2O_2 + H_2 \rightarrow N_2O + H_2O$
Step #3 $N_2O + H_2 \rightarrow N_2 + H_2O$

Which of the following substances is a product?
A. H_2 B. N_2O_2 C. H_2O D. N_2O

87. A reaction has the following mechanism:

Step #1 $2NO \rightarrow N_2O_2$
Step #2 $N_2O_2 + H_2 \rightarrow N_2O + H_2O$
Step #3 $N_2O + H_2 \rightarrow N_2 + H_2O$

Which of the following substances is the overall reaction?
A. $2NO + 2H_2 \rightarrow N_2 + 2H_2O$
B. $2NO + 2H_2 + N_2O + N_2O_2 \rightarrow N_2O_2 + N_2O + N_2 + 2H_2O$
C. $N_2O_2 + N_2O \rightarrow 3H_2O$
D. $N_2O + 2H_2 \rightarrow 2H_2O + N_2$

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

Reaction A: $2O_{3\,(g)} \rightarrow 3O_{2\,(g)}$

Reaction B: Step 1 $O_{3\,(g)} + Cl_{(g)} \rightarrow OCl_{(g)} + O_{2\,(g)}$

Step 2: $OCl + O_3 \rightarrow 2O_2 + Cl$

Overall reaction: $2O_{3\,(g)} \rightarrow 3O_{2\,(g)}$

a. Fill in the missing Step 2: _____

b. Identify any reaction intermediates; OCl

c. Identify any catalysts: Cl

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? B
Explain your answer.

It has a catalyst

89. Consider the following reaction:

$$H^+ + I^- + H_2O_2 \rightarrow H_2O + HOI$$

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

Step 1 $H^+ + H^+ + H_2O_2 \rightarrow H_4O_2^{+2}$

Step 2 $H_4O_2^{+2} + I^- \rightarrow H_2O + HOI + H^+$

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

Disagree H^+ and H^+ would repel

90. Consider the following reaction:

$$CO + NO_2 \rightarrow CO_2 + NO$$

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 1: $2NO_2 \rightarrow NO_3 + NO$ slow step

Step 2: $CO + NO_3 \rightarrow CO_2 + NO_2$ fast step

Proposed Mechansim #2

Step 1: $2NO_2 \rightarrow N_2O_4$ fast step

Step 2: $N_2O_4 + CO \rightarrow CO_2 + NO_2 + NO$ 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 #1

Explanation

It is not affected by [CO] so it cannot be rate determining.

Consider the following reaction mechanism:

Step 1	?
Step 2	$H_2 + Cl \rightarrow HCl + H$
Step 3	$H + Cl_2 \rightarrow HCl + Cl$
Step 4	$Cl + Cl \rightarrow Cl_2$
Overall	$H_2 + Cl_2 \rightarrow 2HCl$

91.

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

Step 1: $Cl_2 \rightarrow 2Cl$

b. What is the definition for a reaction intermediate?

particle made first used up later

c. List at least one reaction intermediate from the steps above. Cl, H,

C6: Review

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

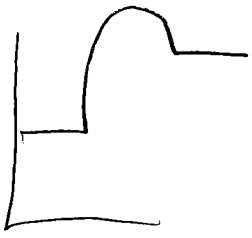
I. There must be sufficient KE
II. Collision geometry must be correct
III. The reaction must take place in a closed system.
IV. The reaction must be exothermic

Which of the above is needed?

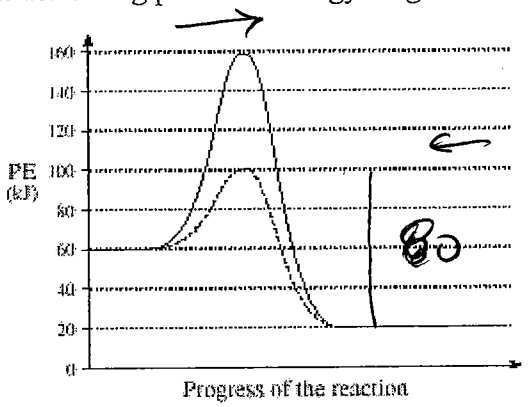
A. I only
B. I and II only
C. I, II, and III only
D. I, II, III and IV

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

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



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



Which of the following represents the correct activation energies?

	Forward uncatalyzed Ea	Reverse catalyzed Ea
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:

$$H_{2\,(g)} + I_{2\,(g)} \rightarrow 2HI_{(g)}$$

As a molecule of H_2 approaches a molecule of 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:

$$2Al(HCO_3)_{3\,(aq)} + 3MgSO_{4\,(aq)} \rightarrow Al_2(SO_4)_{3\,(aq)} + 3Mg(OH)_{2\,(aq)} + 6CO_{2\,(g)}$$

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 $\frac{\Delta \text{mass}}{\Delta \text{time}}$ if open system

What would change and why?

mass ↓ because gas leaves

Property #2 $\frac{\Delta \text{pressure}}{\Delta \text{time}}$ if closed system

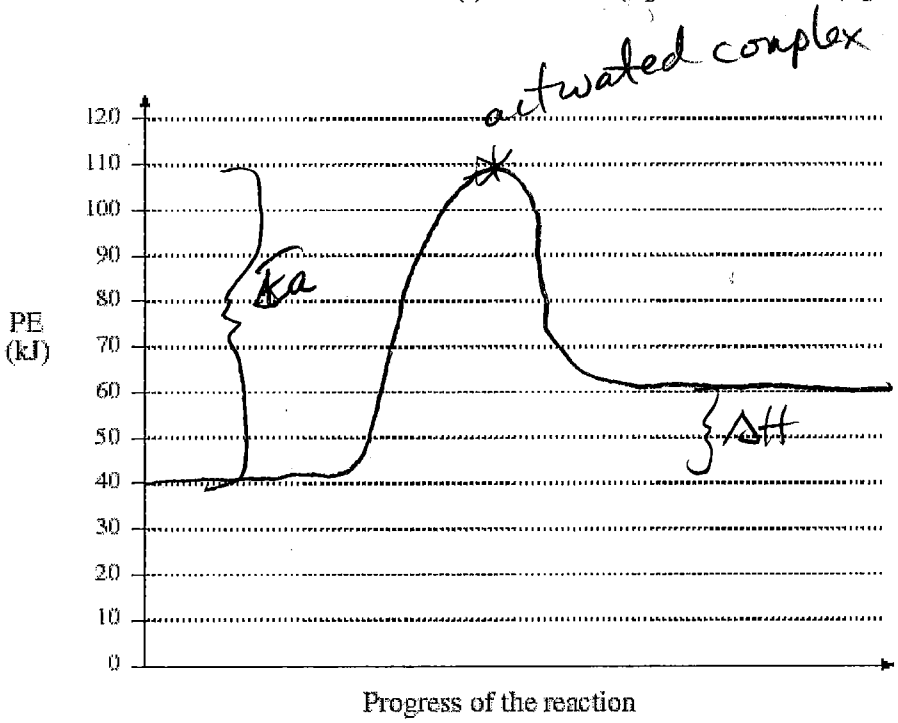
What would change and why?

pressure ↑

#3 $\frac{\Delta \text{pH}}{\Delta \text{time}}$ pH ↑ because $Mg(OH)_2$ produced

98. In the graph below draw a slow endothermic reaction, labeling
    - activation energy which is 70 kJ
    - activated complex
    - ΔH which is 20 kJ

The reaction being graphed is: $2Au_{(s)} + 6HCl_{(aq)} \rightarrow 2AuCl_{3\,(aq)} + 3H_{2\,(g)}$



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

no change

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

$$2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2\,NaOH_{(aq)} + H_{2(g)} + \text{energy}$$

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

Method 1: Same as 97

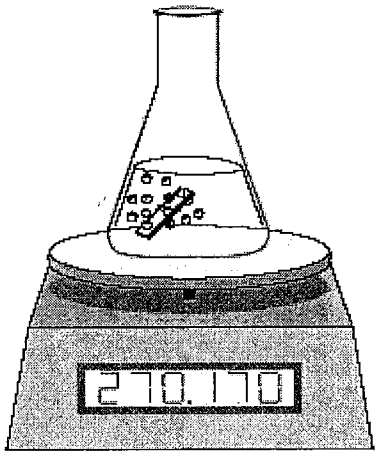
Method 2: _____

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

low Ea because there are a lot of successful collisions

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

$$2Al_{(s)} + 6HCl_{(aq)} \rightarrow 3H_{2(g)} + 2AlCl_{3(aq)}$$



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. (.060) 60.0

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

$$\frac{(270.230 - 270.170)\text{ g of } H_2}{60.0\text{ sec}} \times \frac{1\text{ mole } H_2}{2.0\text{ g of } H_2} \times \frac{2\text{ moles Al}}{3\text{ moles } H_2} = 9.0\times10^{-3}\ \frac{\text{g Al}}{\text{sec}}$$

$3.3\times10^{-1}\ \frac{\text{g Al}}{\text{min}}$

b. List one way in which the reaction rate could have been increased, and explain your answer using the Collision Theory.

↑ temp ↑ collisions ↑ energy per collision

[HCl] ↑ ↑ collisions

grind up Al(s) ↑ collisions

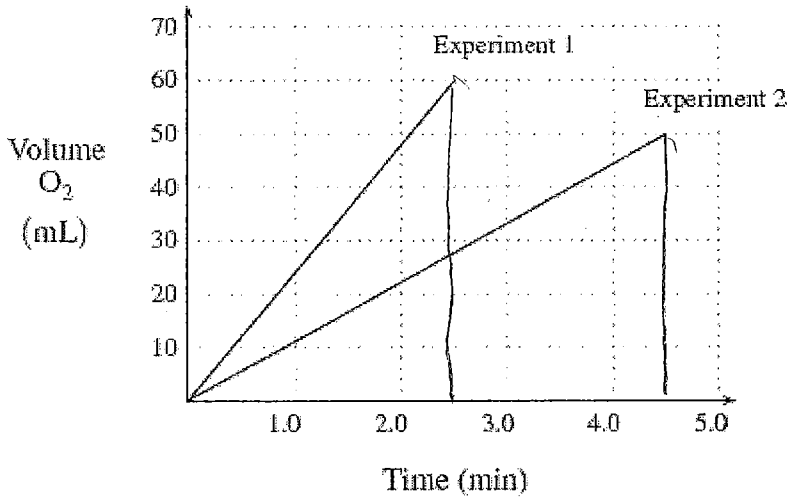
add catalyst ↓ energy needed for successful collision

∴ more successful collisions

101. The release of $O_{2\,(g)}$ resulting from the decomposition of bleach was measured in two different experiments according to the following equation:

$$2NaOCl_{\,(aq)} \rightarrow 2NaCl_{\,(aq)} + O_{2\,(g)}$$

Data was collected and the following graph was drawn:



a. Calculate the average rate of reaction for each experiment.

Experiment 1

$\frac{60.0\ mL\ O_2}{2.5\ min} = 24\ mL/min$

Experiment 2

$\frac{50.0\ mL\ O_2}{4.5\ min} = 11.1\ mL/min$

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.

rate ↓ ∴ temp ↓ → ↓ collisions → ↓ energy per collision

or [ ] ↓ → ↓ collisions

or inhibitor added → ↑ energy needed for a successful collision

∴ fewer successful collisions

102. Consider the following reaction:

Overall reaction: $4HI_{(aq)} + O_{2(g)} \rightarrow 2H_2O_{(g)} + 2I_{2(g)}$

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

5 particles

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

Step 1: $HI_{(aq)} + 2Pt_{(s)} + O_{2(g)} \rightarrow Pt_2HOOI_{(aq)}$

Step 2: $HI_{(aq)} + Pt_2HOOI_{(aq)} \rightarrow 2\ PtHOI_{(aq)}$

Step 3: $PtHOI + HI \rightarrow Pt + H_2O + I_2$

Step 4: $HI_{(aq)} + PtHOI_{(aq)} \rightarrow H_2O_{(g)} + I_{2(g)} + Pt_{(s)}$

b. Fill in the missing Step 3: _____

c. Identify any reaction intermediates; Pt_2HOOI $PtHOI$

d. Identify any catalysts: Pt

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

fewer collisions / step

catalyst