Chemistry 12 - Rxn Kinetics Answer Key

1. B
2. C
3. D
4. C
5. D
6. C
7. C
8. D
9. A
10. B
11. B
12. D
13. a) 1.95mL/s
b) H_2 formation decreases, b/c less [reactants] and less collisions
c) Inc. Temp.
Inc. SA
14. 6.6×10^{-3} mol/min
15. 18 g Carbon
16. a) 6.0g/min
b) Dec. in [Cu] as it is consumed in the rxn
c) Inc. Temp. = Inc. # of collisions and KE
Inc. SA of Cu = Inc # collision sites
17. 54.9 g $CaCO_3$
18. B
19. D
20. C
21. B
22. B
23. A
24. a) Mass, loss of CO_2
b) pH, Dec. in [HCl] = Inc. in pH
25. a) Mass of solid (Inc. as rxn proceeds)
b) pH, Inc. in $Cr(OH)_3$ (base) = Inc. in pH
26. C
27. C
28. C
29. B
30. D
31. B
32. Dec. Temp = Dec. in # of successful collisions
Dec. SA = Dec in # of sites for collisions
33. Engine has high temp = Inc in # of collisions
Inc. in SA of gas = Inc. in rate.
34. D
35. B
36. C
37. C
38. B
39. D
40. D
41. B
42. B
43. a) B
b) Molecules in A are numerous and complex, therefore unlikely to occur all at once.
c) Homogeneous
44. a) Inc. $[O_2]$ accessible for rxn, Inc. speed of molecules.
b) cover with container (Dec. $[O_2]$), Dec. temp = slower rate.
45. D
46. D
47. D
48. C
49. A
50. A
51. A
52. B
53. A
54. C
55. C
56. B
57. C
58. B
59. C
60. See diagram
61. See diagram
62. B
63. D
64. C
65. A
66. A
67. D
68. A

69. a) see diagram
b) No, the molecules might not have the correct geometry
c) see diagram
70. a) the E_a
b) see diagram
71. a) & b) see diagram
c) more
72. a) Lower
b) upper, lower Ea = catalyzed
c) exothermic, reactants have higher energy than products (loses heat)
d) 1, only one Ea bump indicates only one step (activated complex)
e) 2
73. a) $N_2O_2 + 0_2 \rightarrow 2NO_2$
b) Dec. in Ea and no change in H
74. C
75. C
76. D
77. D
78. D
79. A
80. C
81. B
82. A
83. D
84. A
85. D
86. D
87. A
88. B
89. D
90. B
91. D
92. D
93. C
94. D
95. A
96. C
97. A
98. a) $O_3 + OCl \rightarrow 2O_2 + Cl$
b) OCl
c) Cl
d) B, there is a catalyst present.
99. a) Mass, Dec. due to loss of gas
b) pH, Inc. in pH due to Inc. in $[Mg(OH)_2]$
100. see answer
101. a) $CO + NO_2 \rightarrow CO_2 + NO$
b) $CO + N_2O_4 \rightarrow CO_2 + NO + NO_2$
c) #1, b/c Inc. [CO] in # 2 would Inc. rate b/c CO is used in the RDS
102. a) $Cl_2 \rightarrow 2Cl$
b) a species that is produced in one step and used in a subsequent step
c) Cl, H
103. D
104. B
105. D
106. B
107. a) see diagram
b) diagram would not change.
108. a) watch Dec. in mass as H_2 (g) is released; watch change in Temp (exo)
b) Low Ea, b/c violent rxn (fast rate)
109. a) 0.09gAl/min
b)Inc. SA of metal = Inc. in rxn sites
Inc. Temp = Inc. # collisions
110. a) #1 = 25mL/min
#2 = 11 mL/min
b) Dec. Temp or [Reactant]
111. a) Slow, b/c 5 molecules with perfect KE and correct geometry = unlikely
b) $HI + PtHOI \rightarrow H_2O + I_2 + Pt$
c) Pt_2HOOI , PtHOI
d) Pt
e) rxn # 1 = too may molecules
catalyst in rxn # 2 = Inc. Rate
More steps = lower Ea in Rxn # 2

Prescribed Learning Outcomes - Chemistry 12

Kinetics Section

A: Reaction Kinetics (Introduction)

A1: Give examples of reactions proceeding at different rates
A2: Describe rate in terms of some quantity (produced or consumed) per unit of time
A3: Experimentally determine rate of a reaction
A4: Identify properties that could be monitored in order to determine a reaction rate
A5: Recognize some of the factors that control reaction rates
A6: Compare and contrast factors affecting the rates of both homogeneous and heterogeneous reactions
A7: Discuss situations in which the rate of reaction must be controlled

B: Reaction Kinetics (Collision Theory)

B1: Demonstrate an awareness of the following:
- reactions are the result of collisions between reactant particles
- not all collisions are successful
- sufficient kinetic energy (KE) and favourable geometry are required
- to increase the rate of a reaction one must increase the frequency of successful collisions
- energy changes are involved in reactions as bonds are broken and formed

B2: Describe the activated complex in terms of its potential energy (PE), stability, and structure
B3: Define *activation energy*
B4: Describe the relationship between activation energy and rate of reaction
B5: Describe the changes in KE and PE as reactant molecules aproach each other
B6: Draw and label PE diagrams for both exothermic and endothermic reactions, including ΔH, activation energy, and the energy of the activated complex
B7: Relate the sign of ΔH to whether the reaction is exothermic or endothermic
B8: Write a chemical equation including the energy term (given a ΔH value) and vice versa
B9: Describe the role of the following factors in reaction rate:
- nature of reactants
- concentration
- temperature
- surface area

C: Reaction Kinetics (Reaction mechanisms and Catalysts)

C1: Use examples to demonstrate that most reactions involve more than one step
C2: Describe a reaction mechanism as the series of steps (collisions) that result in the overall reaction
C3: Define *catalyst*
C4: Compare and contrast the PE diagrams for a catalyzed and uncatalyzed reaction in terms of:
- reaction mechanism
- ΔH
- activation energy

C5: Identify reactant, product, reaction intermediate, and catalyst from a given reaction mechanism
C6: Describe the uses of specific catalysts in a variety of situations

A1. Give examples of reactions proceeding at different rates

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. $2H_2O_{2\,(l)} \Rightarrow 2H_2O_{(l)} + O_{2\,(g)}$
   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. $C_3H_{8\,(g)} + 5O_{2\,(g)} \Rightarrow 3CO_{2\,(g)} + 4H_2O_{(g)}$
   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. $Na_2CO_{3\,(s)} + 2HCl_{(aq)} \Rightarrow 2NaCl_{(aq)} + CO_{2\,(g)} + H_2O_{(g)}$

5. Which of the following reactions is most likely to proceed at the greatest rate under standard conditions?
   A. $Zn_{(s)} + S_{(s)} \rightarrow ZnS_{(s)}$
   B. $H_{2\,(g)} + I_{2\,(g)} \rightarrow 2HI_{(g)}$
   C. $Cu_{(s)} + Cl_{2\,(g)} \rightarrow CuCl_{2(s)}$
   D. $2KOH_{(aq)} + H_2SO_{4(aq)} \rightarrow 2H_2O_{(l)} + K_2SO_{4\,(aq)}$

A2. Describe rate in terms of some quantity per unit of time

6. Which of the following quantities, when graphed, can be used to determine a reaction rate?
   A. Colour vs density
   B. Pressure vs temperature
   C. Gas volume vs time
   D. Mass vs activation energy

7. The rate of a chemical reaction can be expressed in
   A. grams per mole
   B. energy consumed per mole
   C. volume of gas per unit time
   D. moles formed per litre of solution

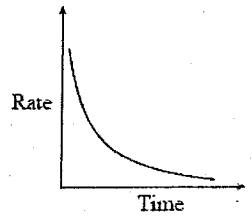
8. Which of the following can be used to represent the rate of a reaction?
   A. g/L B. g/mol C. (g x min)/mol D. mol/(L x min)

9. Consider the following reaction:

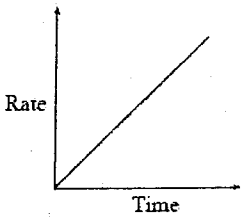
$$2H_2O_{2\,(l)} \rightarrow 2H_2O_{(l)} + O_{2\,(g)}$$

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

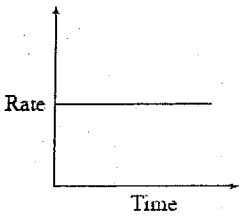
A.



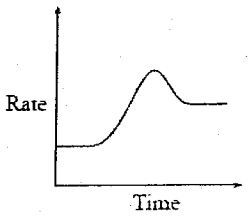
B.



C.



D.



A3. Experimentally determine rate of a reaction

10. 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

11. Consider the following reaction:

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

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

12. Consider the following:

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

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

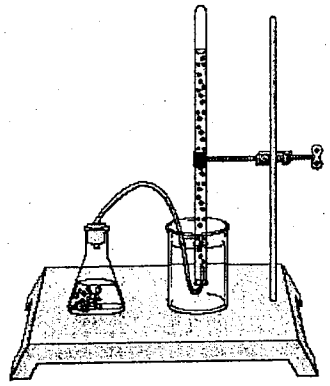
If the rate of production of CO_2 is 0.98 g/min, what is the rate of oxygen consumption?

A. 0.47 g/min B. 0.54 g/min C. 0.71 g/min D. 1.1 g/min

13. 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
20.0	40.9
30.0	60.0
40.0	77.6

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.

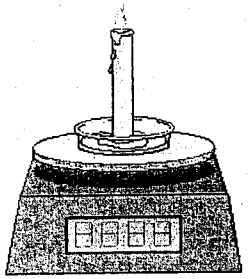
b. How does the rate of formation change as the reaction proceeds? Explain using Collision Theory.

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

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

14.

a. Calculate the average rate of production of CO_2 in mol/min over the 30.0 min

15. 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?

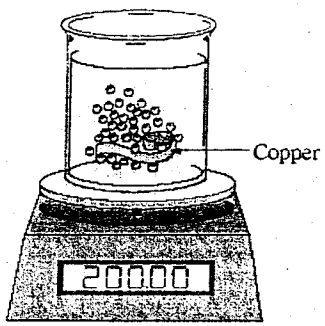
16.

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.

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

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

17. 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?

A4. Identify properties that could be monitored in order to determine a reaction rate

18. 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

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

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

The reaction rate could be calculated by using which of the following?
A. a change in $[Cl^-]$
B. an increase in the acidity
C. a change in the gas pressure
D. a decrease in the mass of the system

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

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

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

21. Consider the following reaction:

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

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

22. 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. $CaO_{\,(s)} + SiO_{2\,(s)} \rightarrow CaSiO_{3\,(s)}$
IV. $AgNO_{3\,(aq)} + NaCl_{\,(aq)} \rightarrow NaNO_{3\,(aq)} + AgCl_{\,(s)}$

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

23. Consider the following:

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

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

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 $C_{20}H_{42\,(s)}$

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

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

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?

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

$$H_2O\,(l) + 2H_2Cr_2O_{7\,(aq)} + 2NH_{3\,(g)} \rightarrow 4Cr(OH)_{3\,(s)} + N_2O_{3\,(g)}$$

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 _____
What would change and why?

Property #2 _____
What would change and why?

A5. Recognize some of the factors that control reaction rates

26. Consider the following reaction:

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

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

27. Consider the following reaction:

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

Adding some $MnO_{2\,(s)}$ speeds up the chemical reaction above. Which of the following best explains this?
A. Adding $MnO_{2\,(s)}$ increases the KE of all the particles in the reaction.
B. Adding $MnO_{2\,(s)}$ increases concentration of reactants.
C. Adding $MnO_{2\,(s)}$ finds a new reaction mechanism for the reaction that has a lower Ea.
D. Adding $MnO_{2\,(s)}$ changes the nature of reactants.

28. 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
B. decreasing pressure
C. increasing temperature
D. decreasing temperature

29. 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 $ZnCl_2$

30. 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

31. 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

32. 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.

33. 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.

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

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

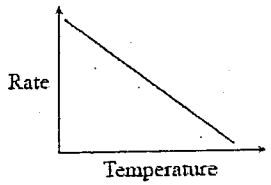
A6. Compare and contrast factors affecting the rates of both homogenous and heterogeneous reactions

34. Consider the following reaction:

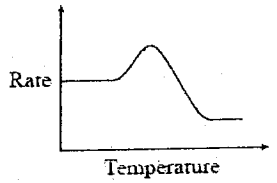
$$CH_{4\,(g)} + O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2H_2O_{\,(g)} + \text{heat}$$

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

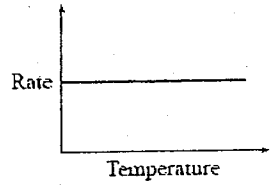
A.



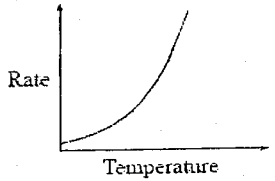
B.



C.



D.



35. Which of the following affects the rate of heterogeneous reactions, but not affect the rate of homogeneous reactions?

A. catalyst B. surface area C. concentration D. temperature

36. Which of the following does not affect both homogenous and heterogeneous reaction rates:
    A. addition of a catalyst
    B. change in temperature
    C. change in surface area
    D. change in concentration

A7. Discuss situations in which the rate of reaction must be controlled

B1. Demonstrate an awareness of the following:

- reactions are the result of collisions between reactant particles
- not all collisions are successful
- sufficient kinetic energy (KE) and favourable geometry are required
- to increase the rate of a reaction one must increase the frequency of successful collisions
- energy changes are involved in reactions as bonds are broken and formed

37. 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

38. 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

39. 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

40. 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

41. Which of the following is true of the kinetic and poptential 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

42. 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

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

    c. Is Reaction B an example of a homogeneous or heterogeneous reaction? _____

44. 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.

B2. Describe the activated complex in terms of its potential energy (PE), stability, and structure

45. 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

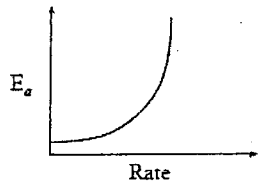
46. Activation energy is defined as the
A. ΔH
B. average amount of kinetic energy
C. unstable particle that can either form products or return to reactants
D. the amount of energy needed for a successful collision

47. 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)

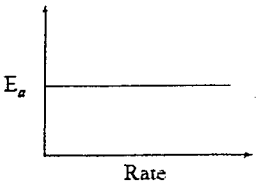
B4. Describe the relationship between activation energy and rate of reaction

48. 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.

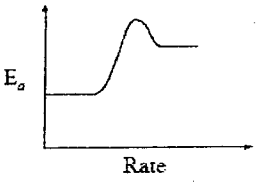


B.



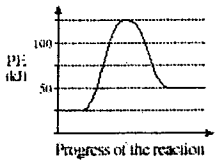
C.

D.

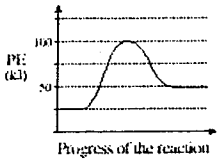


49. Which of the following graphs most likely represents the slowest forward reaction?

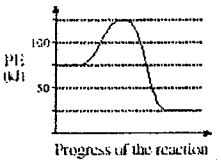
A.



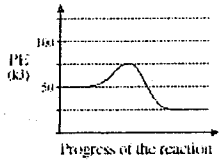
B.



C.



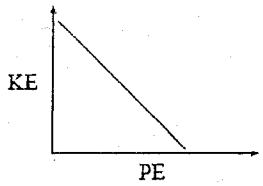
D.



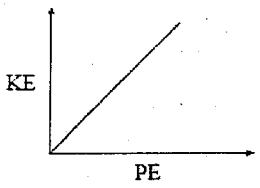
B5. Describe the changes in KE and PE as reactant molecules approach each other

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

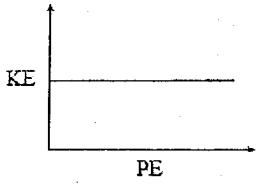
A.



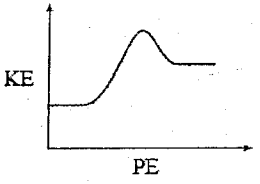
B.



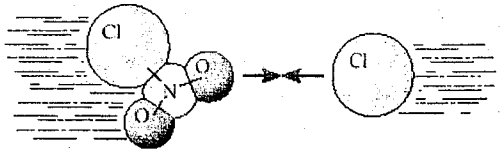
C.



D.



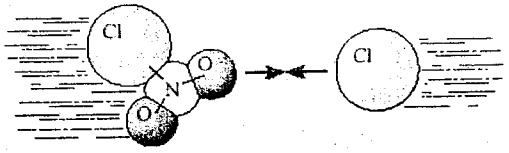
51. The following diagram shows reactant molecules approaching one another:



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.

52. 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

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

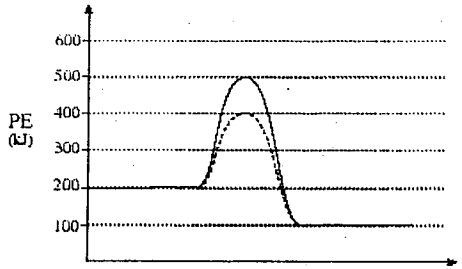
	PE	KE
A.	increases	decreases
B.	increases	increases
C.	decreases	decreases
D.	decreases	increases

54. 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

B6. Draw and label PE diagrams for both exothermic and endothermic reactions, including ΔH, E_a and energy of activated complex

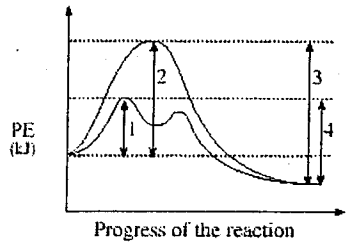
55. Consider the following PE diagrams of a catalyzed and uncatalyzed reaction:



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

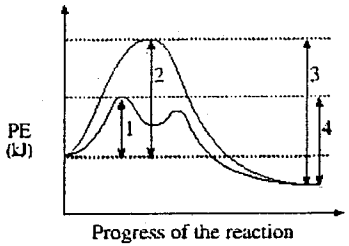
56. Consider the following PE diagram:



Identify the activation energy for the forward uncatalyzed reaction.

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

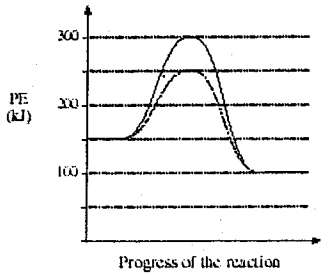
57. Consider the following PE diagram:



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

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

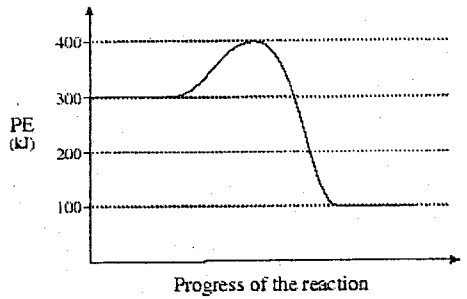
58. Consider the following PE diagram:



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

59. Consider the following PE diagram:

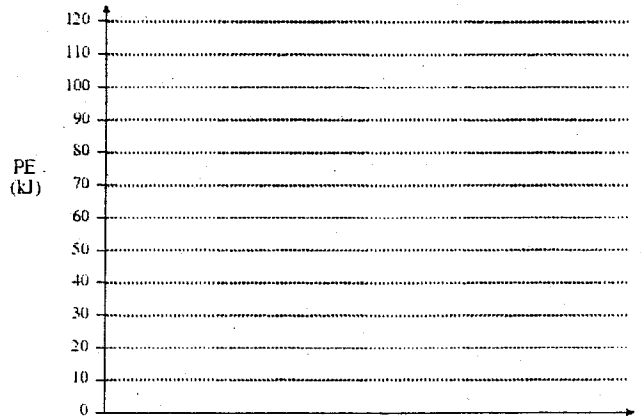


Which of the following is true for the forward reaction:

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

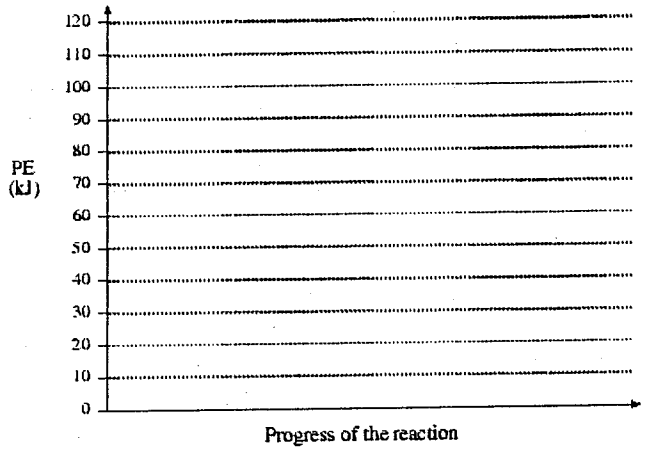
60. In the graph below draw a slow exothermic reaction, labeling
- activation energy
- activated complex
- ΔH

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



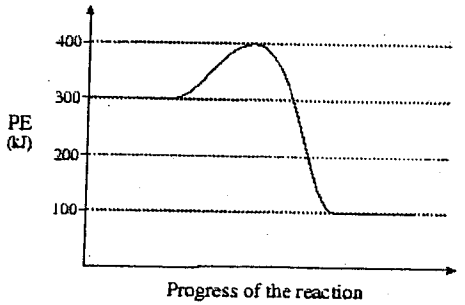
Describe how this diagram would change if the concentration of the HCl were increased

61. 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



B7. Relate the sign of H to whether the reaction is exothermic or endothermic

62. 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

B8. Describe the role of the following factors in reaction rates:

- nature of reactants
- concentration
- temperature
- surface area
- pressure

63. 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. $CaO_{(s)} + H_2O_{(l)} \Rightarrow Ca(OH)_{2\,(aq)}$ $\Delta H = -65.2$ kJ
D. $CaO_{(s)} + 3C_{(s)} \Rightarrow CaC_{2\,(s)} + CO_{(g)}$ $\Delta H = +464.8$ kJ

64. Which of the following reactions is endothermic?
A. $H_{2\,(g)} + S \rightarrow H_2S_{(g)} + 20$kJ
B. $4Fe_{(s)} + 3O_{2\,(g)} - 821$ kJ $\rightarrow 2Fe_2O_{3\,(s)}$
C. $CO_{2\,(g)} \rightarrow C(s) + O_{2\,(g)}$ $\Delta H = +393$ kJ
D. $N_{2(g)} + 2H_{2(g)} \rightarrow 2NH_{3\,(g)}$ $\Delta H = -92$kJ

B9. Use examples to demonstrate that most reactions involve more than one step

65. Given this reaction:

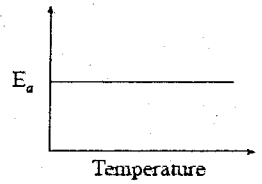
$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)} + 112\ kJ$$

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

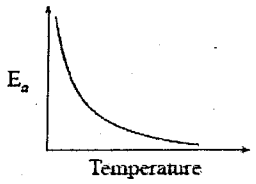
A. Increase the temperature by 10°C and increase the [reactants] by a factor of two.
B. Increase the temperature by 10°C and decrease the [reactants] by a factor of two.
C. Decrease the temperature by 10°C and increase the [reactants] by a factor of two.
D. Decrease the temperature by 10°C and decrease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

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

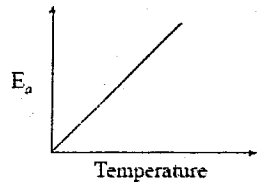
A.



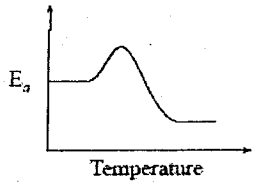
B.



C.



D.



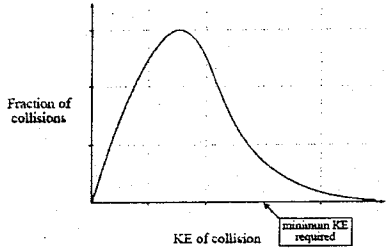
67. Which factor explains why potassium generally reacts faster than sodium?

A. surface area
B. temperature
C. concentration
D. nature of reactants

68. Under which of the following conditions will the reaction rate decrease for a reaction?

A. a catalyst is removed
B. products are removed
C. temperature is increased
D. solid reactants are ground into powder

69. Consider the following Kinetic Energy Diagram:

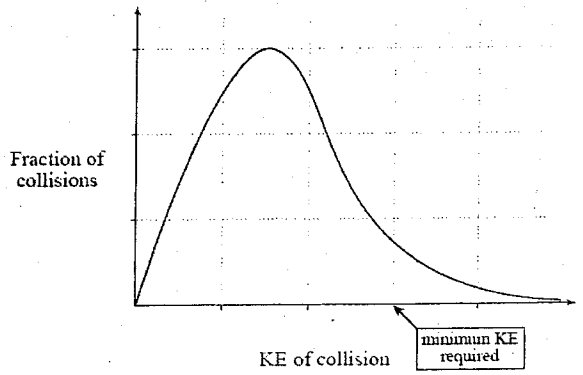


a. Shade in the area that represents the reactant particles that have enough energy to form product particles.

b. Will all the particles in the shaded area form products? _____
Explain your answer using Collision Theory.

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

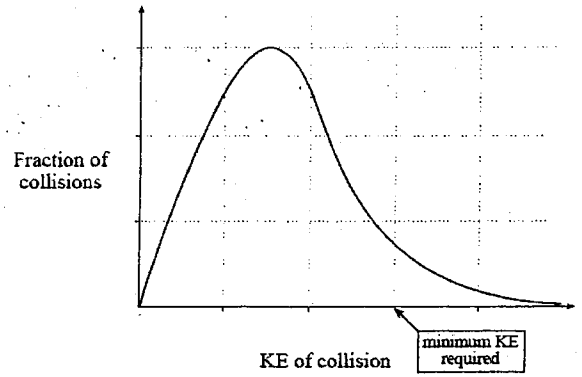
70. Consider the following Kinetic Energy Diagram:



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

b. Use a dotted line to show how would the Kinetic Energy Curve change if the an inhibitor was added.

71. Consider the following Kinetic Energy Diagram:



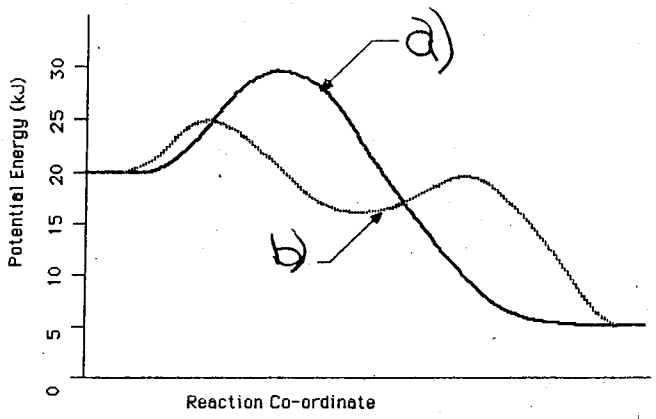
a. Shade in the area of the curve that represents the number of reactant particles with sufficient energy to form product particles.

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? _____ .

C1. Use examples to demonstrate that most reactions involve more than one step

72. 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? _____
Which of the two diagrams represents the uncatalyzed reaction? _____

b. Explain your answer to the previous question.

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

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

e. How many steps in the catalyzed reaction ? _____

C2. Describe a reaction mechanism as the series of steps that result in the overall reaction

73. 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 _____

b. Describe how adding a catalyst would affect the activation energy and ΔH for the overall reaction?

C3. Define catalyst

74. 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.

75. 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.

76. 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.

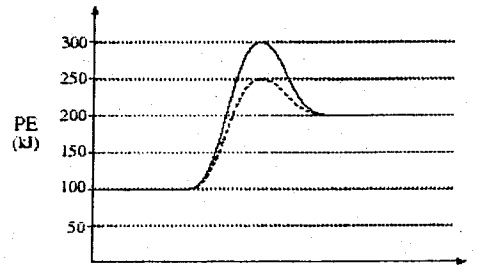
C4. Compare and contrast the PE diagrams for a catalyzed and uncatalyzed reaction in terms of:

- reaction mechanism
- ΔH
- activation energy

77. 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

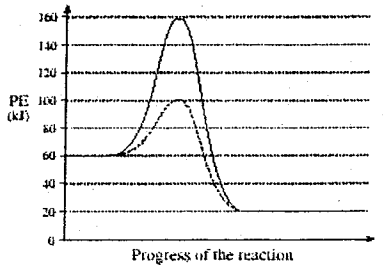
Consider the following PE diagram for a catalyzed and uncatalyzed reaction:



78.
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

79. 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.	40 kJ	100 kJ

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

81. Consider the following reaction:

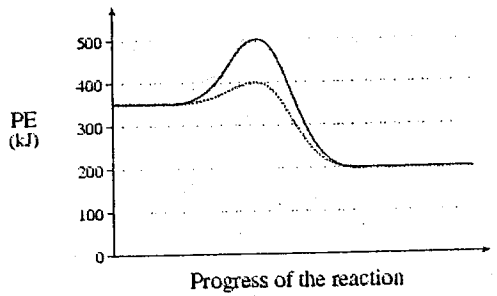
$$O_{(g)} + O_{3\,(g)} \rightarrow 2O_{2\,(g)}$$

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) $> \Delta H$

82. Which of the following would change the value of the activation energy for a heterogenous reaction?
A. adding a catalyst
B. changing the surface area
C. changing the temperature
D. changing the concentrations of reactants

83. 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	200	+150
C. uncatalyzed	300	-150
D. uncatalyzed	500	+150

C5. Identify reactant, product, reaction intermediate, and catalyst from a given reaction mechanism

84. 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

85. 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

86. 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. $2H_3O^+ + 3I^- + H_2O_2 + HI + HOI + I_2 \Leftrightarrow HI + 4H_2O + HOI + I_2 + I_3^-$

B. $I^- + I_2 \Leftrightarrow I_3^-$

C. $H_3O^+ + I^- + H_2O_2 \Leftrightarrow H_2O + I_3^-$

D. $2H_3O^+ + 3I^- + H_2O_2 \Leftrightarrow 4H_2O + I_3^-$

87. 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

88. 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

89. 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

90. 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

91. 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

92. 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

93. 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

94. 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

95. 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

96. 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

97. 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. $N_2O + 2H_2 \rightarrow 2H_2O + N_2$

98. 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:

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

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.

99. 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 _____
What would change and why?

Property #2 _____
What would change and why?

100. 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.

101. 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: _____ fast step

Proposed Mechansim #2

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

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

102.

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

Step 1: _____

b. What is the definition for a reaction intermediate?

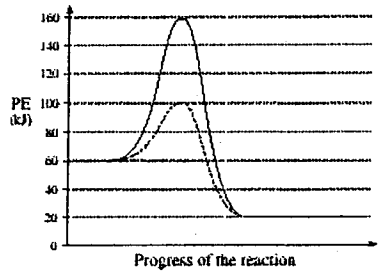
c. List at least one reaction intermediate from the steps above. _____

C6: Review

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

104. 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

105. 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

106. Consider the following reaction:

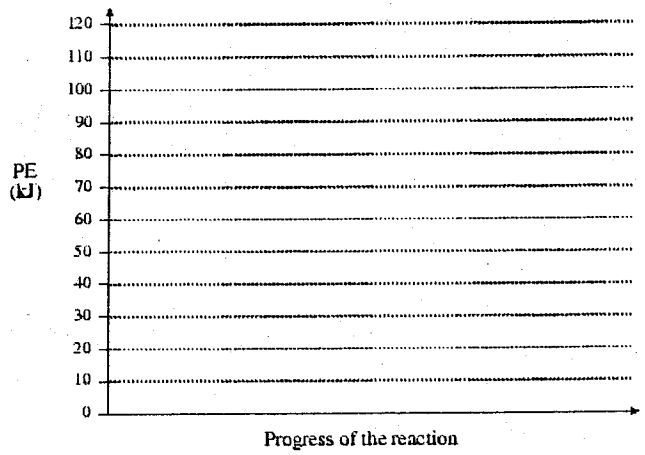
$$H_{2\,(g)} + I_{2\,(g)} \rightarrow 2HI_{(g)}$$

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

107. 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.

108. 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.

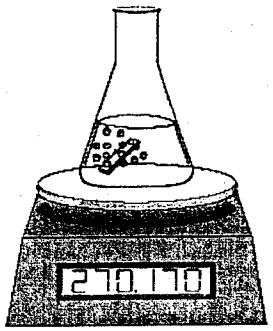
Method 1: _____

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:

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



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

109.

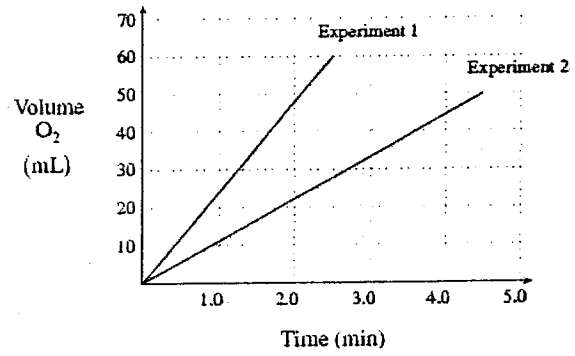
a. Calculate the rate of consumption of the aluminum metal over the 60 seconds.

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

110. 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.

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.

111. 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? _____
Explain your answer.

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:

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; _____

d. Identify any catalysts: _____

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