THE OFFICIAL STUDY GUIDE FOR:
"CHEMICAL KINETICS"

Multiple Choice Section: This study guide is a compilation of questions from provincial exams since April 1994. I urge you to become intimately familiar with question types. You will notice that questions from one year to another are very similar in their composition. Identification of question types will allow you to be more efficient in answering these questions on the provincial examination. My recommendations for using this study guide are as follows :

1. **DO ALL THE QUESTIONS** in this booklet. These are actual Provincial Exam questions! Your own provincial exam and unit test will include questions similar to the ones in this booklet!
2. **RESIST THE URGE TO LOOK AT THE ANSWER KEY** until you have given all the questions in the section your best effort. Don't do one question, then look at the key, then do another and look at the key, and so on. Each time you look at one answer in the study guide, your eye will notice other answers around them, and this will reduce the effectiveness of those questions in helping you to learn.
3. **LEARN FROM YOUR MISTAKES**! If you get a question wrong, **figure out why**! If you are having difficulty, **talk to your study partner**, or maybe **phone someone in your Peer Tutoring group**. Get together with group members or other students from class and work on these questions together. Explain how you got your answers to tough questions to others. In explaining yourself to someone else, you will learn the material better yourself (try it!) Ask your teacher to explain the questions to you during tutorial or after school. **Your goal should be to get 100% on any Chemistry 12 multiple choice test**- learning from your mistakes in this booklet will really help you in your efforts to meet this goal!
4. **This is REALLY CRUCIAL**: **DO NOT mark the answer anywhere on the questions themselves**. For example, do not circle any of options A B C or D-instead use a different sheet of paper to place your answers on. By avoiding this urge, you can re-use this study guide effectively again, when preparing for your final exam. In the box to the left, put an asterisk or small note to yourself to indicate that you got the question wrong and need to come back to it. If you got the question correct initially, a check mark might be assurance that you understand this type of question and therefore can concentrate on other questions that present a challenge to you.
5. **Check Off the STATUS box on the PRESCRIBED LEARNING OUTCOMES sheet**. I have tried to organize the questions in the identical sequence to which they appear on your Acid Base Prescribed Learning Outcome sheet. By doing this, you can be confident that you know everything you need to know for both the UNIT EXAM and PROVINCIAL EXAM !

TABLE OF CONTENTS:

INTRODUCTION

1. A2 **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.

2. A2 Consider the following reaction:
   Under certain conditions, the rate of decomposition of NO_2 is 3.2×10^{-3} mol/s. The rate of formation of O_2 is:
   A. 1.6×10^{-3} mol/s
   B. 3.2×10^{-3} mol/s
   C. 4.8×10^{-3} mol/s
   D. 6.4×10^{-3} mol/s

3. A2 Consider the following reaction:

   $$2N_2O_{5(g)} \rightarrow 4NO_{2(g)} + O_{2(g)}$$

   At a certain temperature the rate of decomposition of N_2O_5 is 2.5×10^{-6} mol/s. **The rate of formation of NO_2 is:**
   A. 1.0×10^{-5} mol/s B. 1.3×10^{-6} mol/s C. 2.5×10^{-6} mol/s D. 5.0×10^{-6} mol/s

4. A2 Consider the following reaction:

   $$N_2 + 3H_2 \rightarrow 2NH_3$$

   The rate of formation of NH_3 is 3.0 mL/min . The rate of consumption of H_2 is
   A. 1.5mL/min B. 2.0mL/min C. 4.5mL/min D. 9.0mL/min

5. A2 **Which of the following units can be used to express the rate of a chemical reaction?**
   A. mL/g B. mol/L C. g/mol D. mol/min

6. A2 Consider the following reaction:

$$HgO_{(s)} \rightarrow Hg_{(\ell)} + \frac{1}{2}O_{2(g)}$$

The rate of this reaction can be expressed as...

A. $\text{rate} = [O_2]^{\frac{1}{2}}$

B. $\text{rate} = \frac{\Delta[O_2]}{\Delta t}$

C. $\text{rate} = \frac{\Delta[Hg]}{\Delta t}$

D. $\text{rate} = \frac{\Delta[HgO]}{\Delta t}$

7. A2 **The rate of a chemical reaction is equal to the slope of a graph with the axes labeled:**

	x-axis	*y*-axis
A.	time	rate
B.	mass	time
C.	volume of gas	time
D.	time	concentration

8. A2 Which of the following can be used to represent the rate of a reaction?

A. $\frac{g}{L}$

B. $\frac{g}{mol}$

C. $\frac{g \cdot min}{mol}$

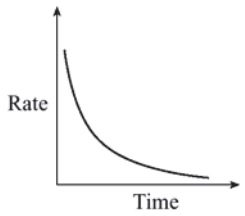
D. $\frac{mol}{L \cdot min}$

9. A2 Consider the following reaction:

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

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

A.



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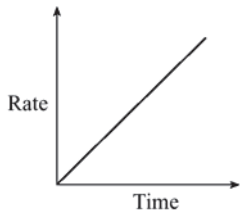

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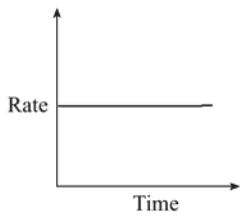

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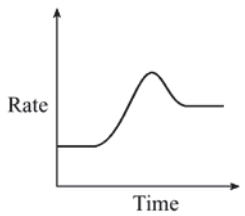


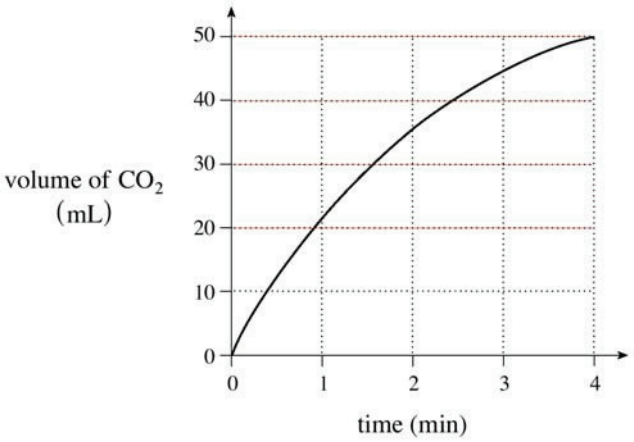
10. A2 Consider the following reaction:

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

At a certain temperature, 1.0 mol CH_4 is consumed in 4.0 minutes.
The rate of production of H_2O is
A. 0.25 mol/min B. 0.50 mol/min C. 2.0 mol/min D. 8.0 mol/min

11. A3 Consider the graph for the following reaction:

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



The average rate of reaction is greatest in the time interval

A. 0-1minute
B. 0-2minutes
C. 0-3minutes
D. 0-4minutes

12. A3 **Consider the following reaction:**
Data collected for the above reaction are summarized in the table below:

Time (min)	Mass of Zn (g)	Volume H_2 (mL)	Temperature (°C)
0	4.65	0	20
2	4.50	50	21
4	4.35	100	22

The rate of this reaction can be measured in units of
A. g/ min
B. g/mL
C. min/ mL
D. g/ (mL)(°C)

13. A3 An 8.00 g piece of magnesium was placed into 6.0 M HCl. After 25 s, 3.50 g of unreacted magnesium remained. **The average rate at which magnesium was consumed is**
A. 0.14 g/s B. 0.18 g/s C. 0.32 g/s D. 4.50 g/s

14. A3 Consider the following reaction:
Solid zinc was added to 1.0 M HC1. In 20.0 s, the temperature of the container increased by 0.5°C and 25.00 mL of H_2 was produced. The rate of this reaction was
A. 0.5°C/s
B. 1.0 M HC1/s
C. 1.25 mL H_2/s
D. 0.050 mol HC1/s

15. A3 Consider the following reaction:

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

If the rate of formation of NH_3 is 9.0×10^{-4} mol/s, then the rate of consumption of N_2 is
A. 4.5×10^{-4} mol/s. B. 6.0×10^{-4} mol/s. C. 9.0×10^{-4} mol/s. D. 1.4×10^{-3} mol/s.

16. A3 Consider the reaction:

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

A 0.040 mol piece of aluminum reacted completely in 20s. The rate of formation of hydrogen gas is

A. 0. 0013 mol/s B. 0. 0020 mol/s C. 0. 0030 mol/s D. 0. 0060 mol/s

17. A3 A 25.0 mL sample of hydrogen peroxide decomposes producing 50.0mL of oxygen gas in 137 s.
The rate of formation of O_2 in mL/min is:
A. 0.182 mL/min B. 0.365 mL/min C. 10.9 mL/min D. 21.9 mL/min

18. A3 At 30°C, a 25.0mL sample of bleach decomposes producing 50.0mL of oxygen gas in 80 seconds. **The rate of oxygen formation can be determined by the expression:**
A. 50.0 mL/80 s B. 50.0 mL/30° C C. 25.0 mL/80 s D. 25.0 mL/30°C

19. A3 Consider the reaction:

$$Ca_{(s)} + 2H_2O_{(\ell)} \rightarrow Ca(OH)_{2(aq)} + H_{2(g)}$$

At a certain temperature, 2.50 g Ca reacts completely in 30.0 seconds.
The rate of consumption of Ca is
A. 0.00208 mol/min B. 0.0833 mol/min C. 0.125 mol/min D. 5.00 mol/min

20. A4 Consider the following reaction:

$$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow H_2O_{(l)} + NaCl_{(aq)}$$

The rate of this reaction could be determined by monitoring the change in concentration of:
A. H^+ B. Cl^- C. Na^+ D. H_2O

21. A4 Consider the following reaction at constant temperature in an **open** system:

$$MgCO_{3(s)} + 2HCl_{(aq)} \rightarrow CO_{2(g)} + H_2O_{(l)} + MgCl_{2(aq)}$$

Which of the following properties could be used to determine reaction rate?
A. mass of the system B. pressure of the gas
C. concentration of H_2O D. concentration of $MgCO_3$

22. A4 Magnesium metal reacts rapidly with hydrochloric acid in an open beaker to produce aqueous magnesium chloride and hydrogen gas. **Which of the following could be used to measure the rate of this reaction?**
A. the volume of the solution B. the colour of gas produced
C. the concentration of the chloride ion D. the mass of the beaker and its contents

23. A4 **Which of the following properties could be used to measure the rate of the following reaction taking place in an open container?**

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

A. mass of Zn B. solubility of HCl C. concentration of Cl^- D. colour of the solution

24. A5 Consider the following reaction:

$$2S_{(s)} + 3O_{2(g)} \rightarrow 2SO_{3(g)} + \text{heat}$$

The rate of this reaction could be increased by
A. decreasing temperature. B. adding a catalyst.
C. increasing the concentration of $S_{(s)}$ D. increasing the concentration of $SO_{3(g)}$.

25. A5 $Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$ **Which combination of factors will affect the rate of the following reaction?**

A. temperature and surface area only B. temperature and concentration only
C. concentration and surface area only D. temperature, concentration and surface area

26. A5 **In general, reaction rates double when the temperature is increased by 10° C. The temperature of a reaction is increased by 40° C. The rate of the reaction will increase by a factor of:**

A. 2 B. 4 C. 8 D. 16

27. A5 Consider the following reaction:

$2MnO_{4(aq)}^{-} + 5C_2O_4^{2-}{}_{(aq)} + 16H_{(aq)}^{+} \rightarrow 2Mn^{2+}{}_{(aq)} + 10CO_{2(g)} + 8H_2O_{(l)}$

The rate of decomposition of the oxalate ion is increased by

A. adding NaOH. B. removing CO_2 C. adding a catalyst D. decreasing the pressure

28. A5 Consider the following reaction:

$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$

To increase the rate of decomposition of $CaCO_3$, one could

A. add CO_2 B. remove CO_2 C. increase the temperature. D. decrease the temperature.

29. A5 Consider the following reaction:

$2N_2O_{5(g)} + 110\ kJ \rightarrow 4NO_{2(g)} + O_{2(g)}$

The rate of reaction is increased by

A. adding a catalyst. B. removing some O_2
C. decreasing the temperature. D. increasing the volume of the container.

30. A6 An untreated sugar cube does not burn when held over a lighted match. A sugar cube coated with cigarette ash readily ignites and burns. All of the cigarette ash remains after the reaction. The **factor** that caused this change in rate is the

A. nature of reactants. B. presence of a catalyst.
C. increase in surface area. D. increase in concentration.

31. A6 Consider the following factors:
I. Concentration of reactants.
II. Temperature of reactants.
III. Surface area of reactants.
The factors that affect the rate of a chemical reaction between two gases are

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

32. A6 **Which of the following are necessary for successful collisions to occur?**
I. Favourable collision geometry.
II. Sufficient kinetic energy.
III. Large ΔH.

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

33. A6 Dust particles suspended in the air inside unheated grain elevators can sometimes react explosively because the dust particles have a

A. high kinetic energy. B. high activation energy.
C. catalytic effect on the reaction. D. large surface area for the reaction.

34. A6 **Which of the following factors affects the rate of heterogeneous reactions only?**

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

35. A6

I.	nature of reactants
II.	presence of a catalyst
III.	temperature of system
IV.	concentrations of reactants

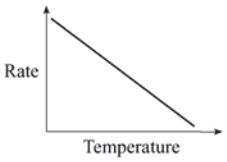
Which of the following factors **affect the rates** of both homogeneous and heterogeneous reactions?

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

36. A6 Consider the following reaction:

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

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

A.


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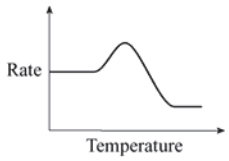

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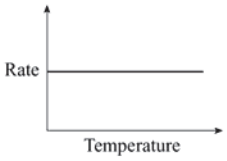

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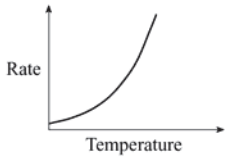


COLLISION THEORY

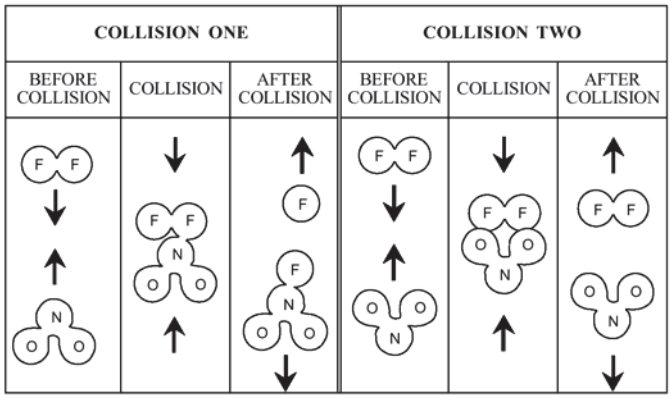
37. B1

I.	increasing frequency of collisions
II.	increasing the kinetic energy of collision
III.	decreasing the potential energy of collision

Increasing the temperature of a reaction increases the reaction rate by:

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

38. B1 Consider the following collisions, each occurring at the same temperature:
Which one of the following factors explains why collision one is successful while collision two is not successful?



A. Catalyst.
B. Geometry.
C. Concentration.
D. **Kinetic energy**.

39. B1 Consider the following reaction:

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

As the temperature of the above system is increased, the number of collisions
A. increases but fewer are effective. B. decreases and fewer are effective.
C. increases and more are effective. D. decreases but more are effective.

40. B1 **Consider the following factors:**
I. reactant particles collide
II. sufficient kinetic energy is present
III. a favourable geometry exists
IV. catalysts are present

Which combination of the above factors is required for all successful collisions?
A. I only B. II and III only C. I, II and III only D. I, II, III and IV

41. B1 Consider the following:

I	frequency of successful collisions
II	volume of the reaction vessel
III	pressure of the system
IV	mass of the system

To increase the rate of a reaction there <u>must</u> be an increase in
A. I only.
B. I and III only.
C. I, III and IV only.
D. I, II, III and IV.

42. B1 Milk is refrigerated in order to slow the rate of decomposition by bacterial action.
The decrease in reaction rate is due to
A. a decrease in surface area.
B. a decrease in ΔH for the reaction.
C. a decrease in the fraction of particles possessing sufficient energy.
D. the introduction of an alternate pathway with greater activation energy.

43. B1 **Collision theory states that:**
A. all collisions lead to chemical reactions. B. most collisions lead to chemical reactions.
C. very few reactions involve particle collisions. D. effective collisions lead to chemical reactions.

44. B1 **For collisions to be successful, reactants must have**
A. favourable geometry only. B. sufficient heat of reaction only.
C. sufficient potential energy only. D. sufficient kinetic energy and favourable geometry.

45. B1 **To increase the rate of a reaction, there must be**
A. a decrease in the frequency of collisions.
B. an increase in the frequency of collisions.
C. a decrease in the frequency of successful collisions.
D. an increase in the frequency of successful collisions.

46. B1 **An increase in temperature increases the rate of a chemical reaction because**
A. the activation energy is lower.
B. exothermic reactions are always favoured.
C. a greater fraction of particles have sufficient kinetic energy.
D. the particles are more likely to have favourable collision geometry.

47. B1 **Which of the following will decrease the number of effective collisions during a chemical reaction?**
A. Adding a catalyst. B. Increasing the surface area.
C. Decreasing the temperature. D. Increasing reactant concentrations.

48. B1 When a collision occurs between two reactant species which possess between them the minimum kinetic energy, called activation energy, **a product does not always form**.
This may be a result of
A. low temperature. B. small surface area. C. low concentrations. D. unfavourable geometry.

49. B1 **The average kinetic energy of colliding particles can be increased by**
A. adding a catalyst. B. increasing pressure.
C. increasing temperature. D. increasing reactant concentration.

50. B2 **An activated complex has**
A. low potential energy and is stable. B. high potential energy and is stable.
C. low potential energy and is unstable. D. high potential energy and is unstable.

51. B2 **An activated complex is a chemical species that is**
A. stable and has low PE. B. stable and has high PE.
C. unstable and has low PE. D. unstable and has high PE.

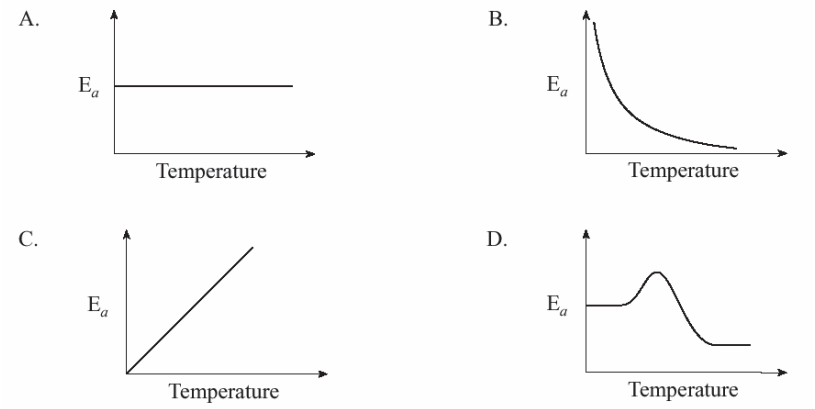
52. B3 **Activation energy can be described as the**
A. energy of motion.
B. energy of the activated complex.
C. energy difference between the reactants and the products.
D. energy difference between the reactants and the activated complex.

53. B3 **The minimum amount of energy needed to start a reaction is called the**
A. activation energy B. energy of reaction C. entropy of reaction D. reaction mechanism energy

54. B3 **The activation energy of a reaction in solution**
A. increases with the addition of a catalyst. B. decreases with a decrease in temperature.
C. increases if the solution is stirred vigorously. D. does not change with an increase in temperature.

55. B3 **The minimum amount of energy required to overcome the energy barrier in a chemical reaction is the**
A. heat of reaction. B. activation energy. C. KE of the reactants. D. enthalpy of the products.

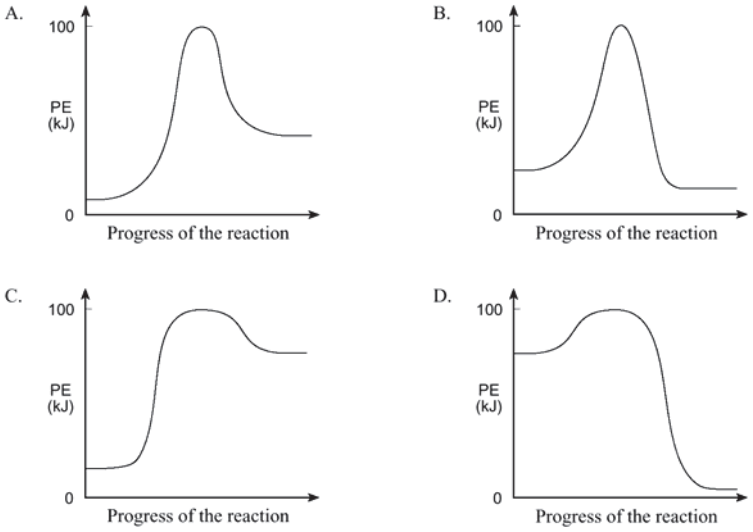
56. B3 **Which graph shows the relationship between activation energy (E_a) and temperature?**



57. B4 When a lit match is touched to the wick of a candle, the candle begins to burn. When the match is removed, the candle continues to burn. In this reaction, the match
A. behaves as a catalyst. B. supplies activation energy.
C. is part of the rate determining step. D. lowers the activation energy barrier.

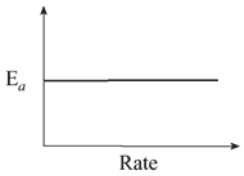
58. B4 **In general, a chemical reaction requiring a large activation energy will proceed**
A. at a fast rate. B. at a slow rate. C. only at low temperatures. D. only at low concentrations.

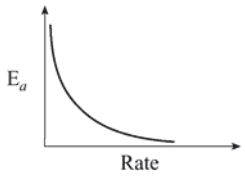
59. B4 **Which of the following corresponds to the fastest reaction at room temperature?**



60. B4 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.


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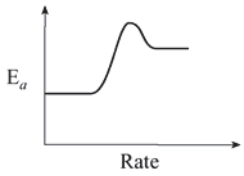


61. B5 Which of the following changes will increase the average kinetic energy of reactant molecules?
A. adding a catalyst
B. increasing the temperature
C. increasing the surface area
D. increasing the concentration

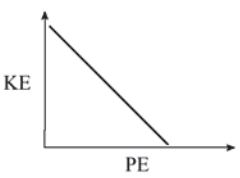
62. B5 **As reactant molecules approach each other**
A. heat is released.
B. a reaction intermediate forms.
C. kinetic energy changes to potential energy.
D. potential energy changes to kinetic energy.

63. B5 **As reactant particles approach one another, their**
A. kinetic energy increases and their potential energy increases.
B. kinetic energy increases and their potential energy decreases.
C. kinetic energy decreases and their potential energy increases.
D. kinetic energy decreases and their potential energy decreases.

64. B5 **Which of the following describes the energy of colliding particles as reacting molecules approach each other?**

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

65. B5 **The changes in PE and KE, as reactant molecules approach each other, can be represented by:**

A.


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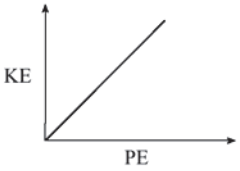

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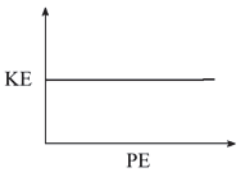

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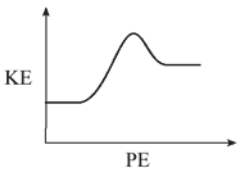
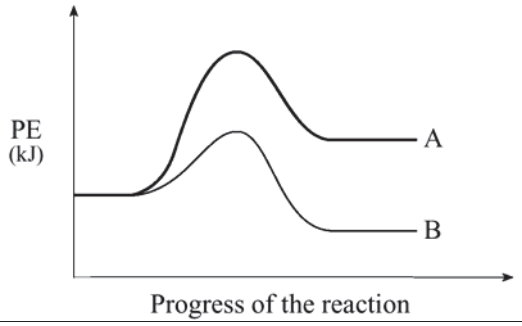


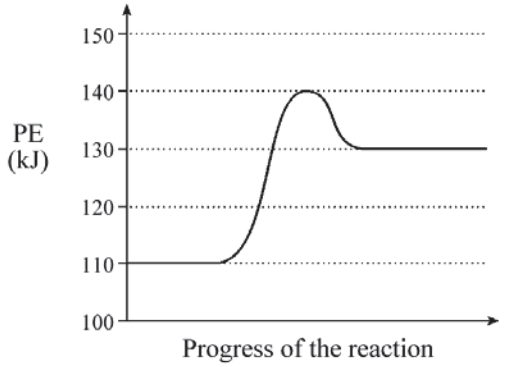
66. B6 Consider the following potential energy diagram that represents two different reactions.



Which of the following statements is correct?

A. Reactions A and B are both exothermic.
B. Reactions A and B are both endothermic.
C. Reaction A is exothermic and reaction B is endothermic.
D. Reaction A is endothermic and reaction B is exothermic.

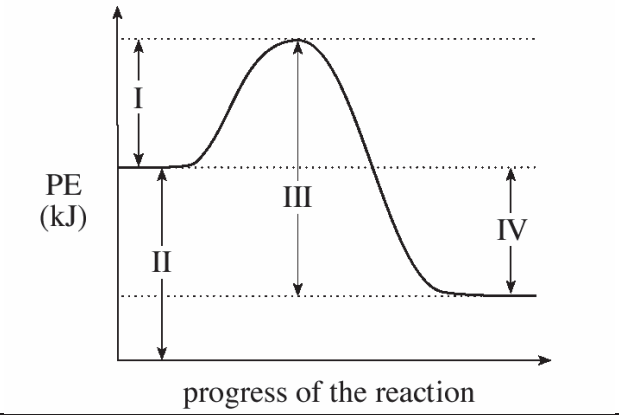
67. B6 Consider the following potential energy diagram for a reversible reaction:



Which of the following describes the system above?

	Reaction	Activation Energy (kJ)	ΔH (kJ)
A.	reverse	10	–20
B.	reverse	10	–30
C.	forward	30	+10
D.	forward	20	+30

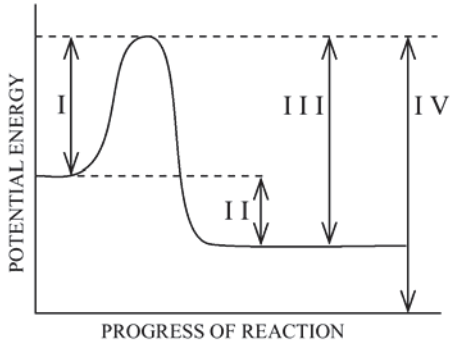
68. B6 Consider the following potential energy diagram:



Which of the following represents the heat of reaction, ΔH, for the forward reaction?

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

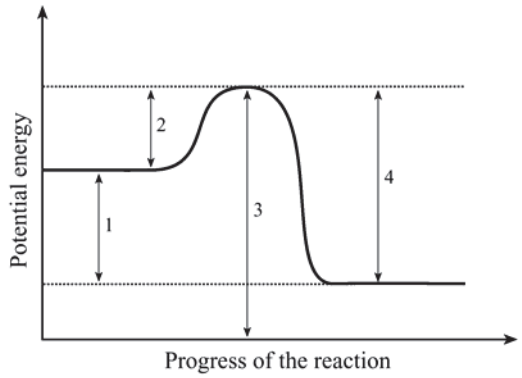
69. B6 Consider the following potential energy diagram:



The energy interval that represents the activation energy for the reverse reaction is:

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

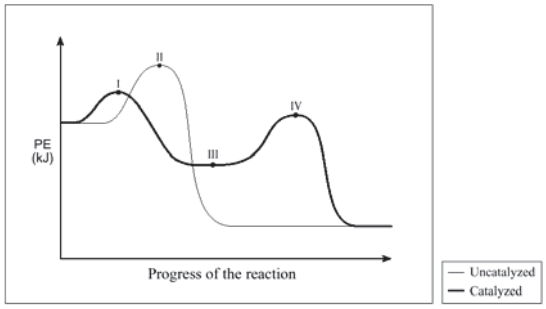
70. B6 Consider the following potential energy diagram.



The interval representing ΔH for the reverse reaction is

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

71. B6



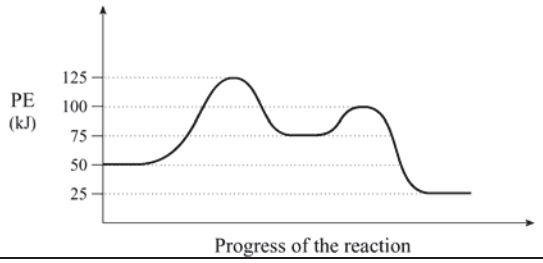
Select the **true** statement concerning the above potential energy diagram.

A. The catalyzed reaction has a larger ΔH.
B. The uncatalyzed reaction has a larger ΔH.
C. The catalyzed reaction has a greater rate of reaction.
D. The uncatalyzed reaction has a greater rate of reaction.

Which point on the diagram above represents the potential energy of the activated complex formed in the uncatalyzed reaction?

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

72. B6 Consider the following potential energy diagram:

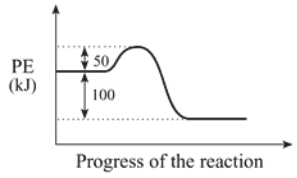


The activation energy for the forward reaction is

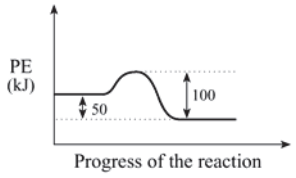
A. 25 kJ B. 50 kJ C. 75 kJ D. 125 kJ

73. B6 A forward reaction has an activation energy of 50 kJ and a ΔH of -100 kJ. The PE diagram which describes this reaction is:

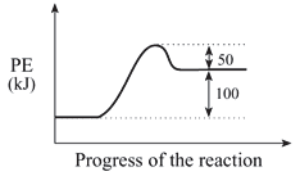
A.



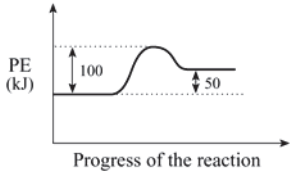
B.



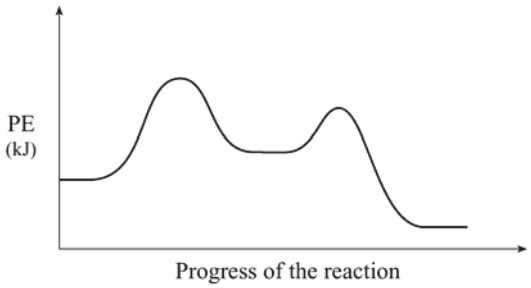
C.



D.



74. B6 Consider the following potential energy diagram:



The above potential energy diagram represents an:

A. exothermic reaction involving one step.
B. exothermic reaction involving two steps.
C. endothermic reaction involving one step.
D. endothermic reaction involving two steps.

75. B6 Consider the following reaction:

$$\tfrac{1}{2}H_{2(g)} + \tfrac{1}{2}I_{2(g)} \rightarrow HI_{(g)} \qquad \Delta H = +28\ kJ$$

The activation energy for the formation of HI is 167 kJ. The activation energy for the decomposition of HI is

A. 28 kJ B. 139 kJ C. 167 kJ D. 195 kJ

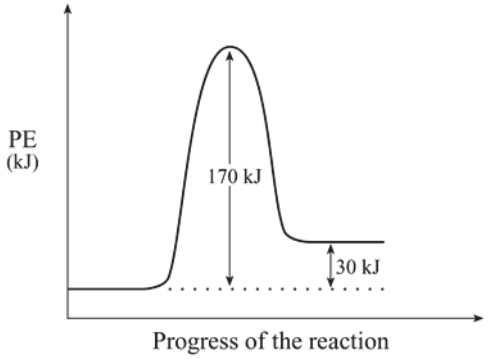
76. B6 Consider the following reaction:

$$\tfrac{1}{2}H_{2(g)} + \tfrac{1}{2}I_{2(g)} \rightarrow HI_{(g)}$$

The activation energy for the formation of HI is 167 kJ and for the decomposition of HI is 139 kJ.
The reaction for the formation of HI is:

A. exothermic and the $\Delta H = -28$ kJ B. exothermic and the $\Delta H = +28$ kJ
C. endothermic and the $\Delta H = -28$ kJ D. endothermic and the $\Delta H = +28$ kJ

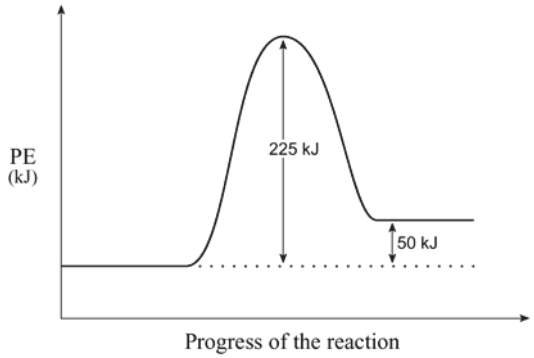
77. B6 Consider the following potential energy diagram:



The activation energy for the reverse reaction is

A. 30 kJ B. 140 kJ C. 170 kJ D. 200 kJ

78. B6 Consider the following potential energy diagram:



The forward reaction is

A. exothermic and the $\Delta H = -50$ kJ
B. endothermic and the $\Delta H = +50$ kJ
C. exothermic and the $\Delta H = -225$ kJ
D. endothermic and the $\Delta H = +225$ kJ

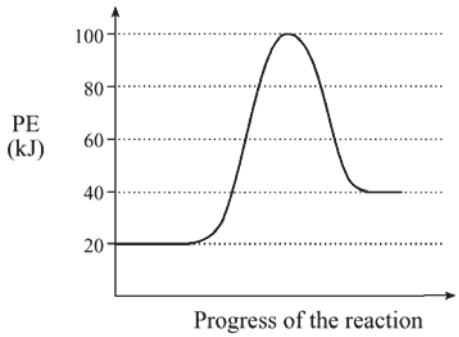
79. B6 Consider the following reaction:

$CO + NO_2 \rightarrow CO_2 + NO \qquad \Delta H = -234\ kJ$

The activation energy of the forward reaction is 134 kJ. **What is the activation energy for the reverse reaction?**

A. -134 kJ B. -100 kJ C. 234 kJ D. 368 kJ

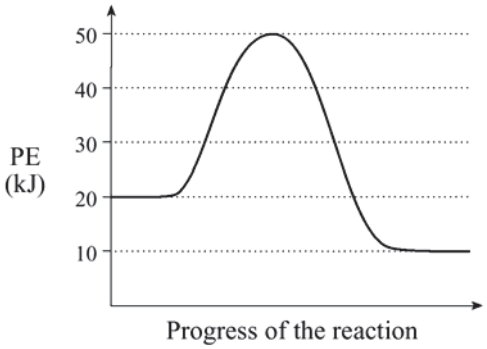
80. B6 Consider the following PE diagram:



The forward reaction can be described as

	ΔH (kJ)	ACTIVATION ENERGY (kJ)	TYPE OF REACTION
A.	+20	80	endothermic
B.	+20	60	exothermic
C.	–20	80	exothermic
D.	–20	100	endothermic

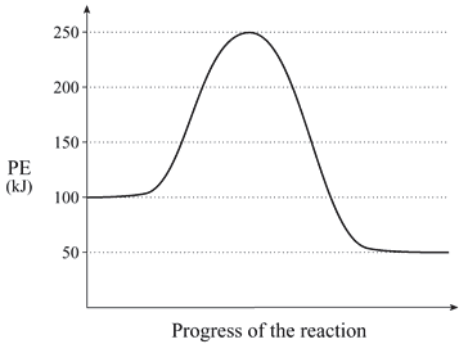
81. B6 Consider the following PE diagram for a reversible reaction:



Which of the following describes this reaction?

	DIRECTION	ACTIVATION ENERGY (kJ)	ΔH (kJ)
A.	reverse	30	–10
B.	forward	40	–10
C.	forward	30	+10
D.	reverse	40	+10

82. B6 Consider the following PE diagram:



Which of the following describes the forward reaction?

	ΔH (kJ)	ACTIVATION ENERGY (kJ)
A.	+50	250
B.	–50	200
C.	–50	150
D.	+50	150

83. B7 Consider the following reaction:

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

The ΔH for the above reaction is:

A. positive and the reaction is exothermic.
B. negative and the reaction is exothermic.
C. positive and the reaction is endothermic.
D. negative and the reaction is endothermic.

84. B7 Which of the following equations represents an endothermic reaction?

A. $N_2O_{4(g)} + 59\ kJ \rightarrow 2NO_{2(g)}$

B. $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)} + 572\ kJ$

C. $2BrCl_{(g)} - 29.3\ kJ \rightarrow Br_{2(g)} + Cl_{2(g)}$

D. $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} \qquad \Delta H = -394\ kJ$

85. B7 A chemical reaction that gives off energy is

A. exothermic and ΔH is positive
B. exothermic and ΔH is negative
C. endothermic and ΔH is positive
D. endothermic and ΔH is negative

86. B8 Consider the following:

$$\tfrac{1}{2}N_{2(g)} + \tfrac{1}{2}O_{2(g)} \rightarrow NO_{(g)} \qquad \Delta H = +90\ kJ/mol\ NO$$

The correct equation including the heat term is

A. $N_{2(g)} + O_{2(g)} + 90\ kJ \rightarrow 2NO_{(g)}$

B. $N_{2(g)} + O_{2(g)} + 180\ kJ \rightarrow 2NO_{(g)}$

C. $N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)} + 90\ kJ$

D. $N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)} + 180\ kJ$

87. B9 Consider the following reaction involving 1.0 g of powdered zinc:

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

Trial	Temperature (°C)	Concentration of HCl
1	40	3.0
2	20	3.0
3	40	6.0

The rates, in order of fastest to slowest, are
A. 1, 2, 3 B. 2, 1, 3 C. 3, 1, 2 D. 3, 2, 1

88. B9 At 25°C, which of the following reactions is fastest?

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

B. $Ag^+_{(aq)} + I^-_{(aq)} \rightarrow AgI_{(s)}$

C. $C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(g)}$

D. $5C_2O_4^{2-}{}_{(aq)} + 2MnO_4^-{}_{(aq)} + 16H^+_{(aq)} \rightarrow 10CO_{2(g)} + 2Mn^{2+}_{(aq)} + 8H_2O_{(\ell)}$

89. B9 Which of the following is most likely to have the **greatest** reaction rate at room temperature?

A. $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(\ell)}$

B. $2Ag^+_{(aq)} + CrO_4^{2-}{}_{(aq)} \rightarrow Ag_2CrO_{4(s)}$

C. $Pb_{(s)} + 2HCl_{(aq)} \rightarrow PbCl_{2(aq)} + H_{2(g)}$

D. $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$

90. B9 Which of the following reactions is **slowest** at room temperature?

A. $Zn_{(s)} + S_{(s)} \rightarrow ZnS_{(s)}$

B. $Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)}$

C. $NH_{3(g)} + HC1_{(g)} \rightarrow NH_4C1_{(s)}$

D. $2Ag^+_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow Ag_2CO_{3(s)}$

91. B9 Consider the following reactions:

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

II. $2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$

III. $CaCO_{3(s)} + 2H^+_{(aq)} \rightarrow Ca^{2+}_{(aq)} + H_2O_{(\ell)} + CO_{2(g)}$

Increasing the surface area will increase the reaction rate in

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

92. B9 **Which of the following reactions occurs most rapidly at room temperature?**

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

B. $2Fe_{(s)} + O_{2(g)} \rightarrow 2FeO_{(s)}$

C. $Cu^{2+}_{(aq)} + S^{2-}_{(aq)} \rightarrow CuS_{(s)}$

D. $C_6H_{12}O_{6(aq)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(g)}$

93. B9 **Which of the following would react most rapidly?**

A. Powdered Zn in 1.0 M HCl at 25° C B. Powdered Zn in 2.0 M HCl at 40° C

C. A lump of Zn in 2.0 M HCl at 25° C D. A lump of Zn in 1.0 M HCl at 40° C

94. B9 The slowest of the following reactions is

A. $Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$

B. $H_3O^+_{(aq)} + OH^-_{(aq)} \rightarrow 2H_2O_{(\ell)}$

C. $3Ba^{2+}_{(aq)} + 2PO_4^{3-}{}_{(aq)} \rightarrow Ba_3(PO_4)_{2(s)}$

D. $Cu_{(s)} + 2Ag^+_{(aq)} \rightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$

95. B9 Consider the following reaction:

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

The rate of this reaction increases when more magnesium is added.
This change is caused by the

A. addition of a catalyst.
B. increase in surface area.
C. change in nature of the reactants.
D. increase in concentration of reactants.

96. B9 **At room temperature, which of the following reactions is fastest?**

A. $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$

B. $Pb^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)}$

C. $4Fe_{(s)} + 3O_{2(g)} \rightarrow 2Fe_2O_{3(s)}$

D. $Cu_{(s)} + 2Ag^+_{(aq)} \rightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$

REACTION MECHANISMS AND CATALYSTS

97. C2 Consider the following two-step reaction mechanism:

step one $NO_{2(g)} + NO_{2(g)} \longrightarrow NO_{(g)} + NO_{3(g)}$ slow

step two $NO_{3(g)} + CO_{(g)} \longrightarrow CO_{2(g)} + NO_{2(g)}$ fast

Which one of the following changes would result in the greatest increase in reaction rate?
A. increase [CO] B. decrease [NO] C. increase [NO_2] D. decrease [NO_3]

98. C2 Consider the following reaction mechanism:

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

The overall reaction is

A. $2NO_2 \rightarrow NO_3 + NO$
B. $NO_2 + CO \rightarrow NO + CO_2$
C. $NO_3 + CO \rightarrow NO_2 + CO_2$
D. $NO_2 + NO_3 + CO \rightarrow NO_3 + NO_2 + NO + CO_2$

99. C2 **In a reaction mechanism, the rate determining step is the**
A. fastest and has the lowest activation energy.
B. fastest and has the highest activation energy.
C. slowest and has the lowest activation energy.
D. slowest and has the highest activation energy.

100. C3 **What effect does a catalyst have on a reaction?**
A. It changes the ΔH of a reaction.
B. It increases the kinetic energy of the reactants.
C. It decreases the potential energy of the products.
D. It provides a reaction mechanism with a lower activation energy.

101. C3 When a catalyst is added to a reaction:
I. the heat of reaction increases
II. a new mechanism is provided
III. the equilibrium constant increases

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

102. C3 Consider the following reaction:

$$2H_2O_{2(aq)} \rightarrow 2H_2O_{(\ell)} + O_{2(g)}$$

When 1.0 g of KI is added to the H_2O_2 , bubbles of O_2 are produced at an increased rate.
When the reaction is complete, the mass of KI is 1.0 g. The KI is a
A. product. B. catalyst. C. reactant. D. reaction intermediate.

103. C3 **The addition of a catalyst to a reaction provides an alternate mechanism with**
A. lower activation energy and lower reaction rate. B. lower activation energy and higher reaction rate.
C. higher activation energy and lower reaction rate. D. higher activation energy and higher reaction rate.

104. C3 **A catalyst increases the rate of a reaction by providing an alternate reaction mechanism that has a:**
A. lower ΔH. B. higher ΔH. C. lower activation energy. D. higher activation energy.

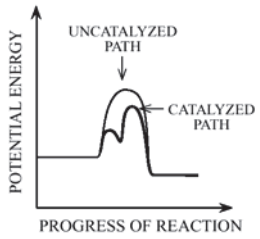
105. C3 **A catalyst increases the rate of a chemical reaction by**
A. increasing kinetic energy B. decreasing the heat of reaction
C. changing the concentration of reactants D. providing an alternate reaction mechanism

106. C3 **Addition of a catalyst to a reaction increases the rate because it**
A. increases the value of ΔH.
B. decreases the value of ΔH.
C. provides an alternate reaction mechanism with a lower activation energy.
D. provides an alternate reaction mechanism with a higher activation energy.

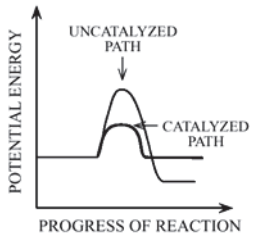
107. C3 **A catalyst changes the rate of a reaction by**
A. changing ΔH. B. increasing the temperature.
C. decreasing the energy of the products. D. providing an alternate reaction mechanism.

108. C4 An uncatalyzed reaction was found to produce 40 kJ of energy in 10 minutes. When catalyzed, the same reaction produced 40 kJ of energy in 2 minutes. Which one of the following potential energy diagrams is consistent with the above data?

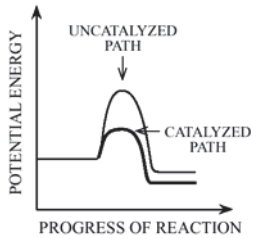
A.



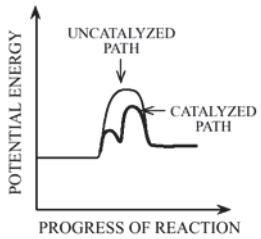
B.



C.



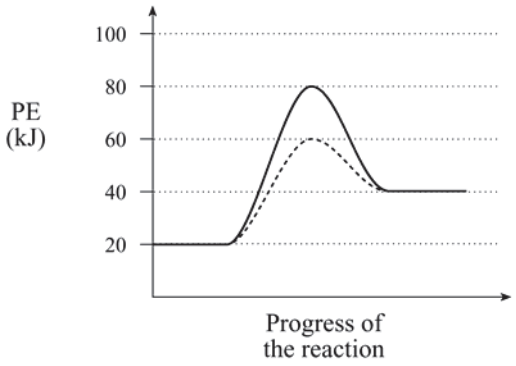
D.



109. C4 **When a catalyst is added to a reaction, ΔH will**
A. increase slowly. B. remain constant.
C. decrease slowly D. increase rapidly due to the alternate pathway.

110. C4 **A catalyst increases the rate of a reaction by**
A. increasing the concentration of the reactant(s).
B. decreasing the concentration of the reactant(s).
C. increasing the activation energy of the overall reaction.
D. decreasing the activation energy of the overall reaction.

111. C4 Consider the following PE diagram:



Which of the following describes this reaction?

	ΔH (kJ)	ACTIVATION ENERGY (kJ)	REACTION
A.	–20	40	catalyzed
B.	–20	60	catalyzed
C.	+20	40	uncatalyzed
D.	+20	60	uncatalyzed

112. C5 Consider the following mechanism for a reaction:

Step 1	$HBr + O_2 \rightarrow HOOBr$
Step 2	$HBr + HOOBr \rightarrow 2HOBr$
Step 3	$2HBr + 2HOBr \rightarrow 2H_2O + 2Br_2$

Which of the following statements is correct?
A. Br_2 is a reactant.
B. HBr is a product.
C. HOBr is a catalyst.
D. HOOBr is a reaction intermediate.

113. C5 Consider the following reaction mechanism:
Step 1: $M + X \rightarrow MX$
Step 2: $MX + A \rightarrow D + X$
The chemical species MX is a(n)
A. catalyst. B. inhibitor. C. final product. D. reaction intermediate.

114. C5 Consider the following reaction mechanism:

Step 1: $ICl + H\,2 \rightarrow HI + HCl$ (slow)
Step 2: $ICl + HI \rightarrow HCl + I_2$ (fast)

The species HCl is a
A. product. B. catalyst. C. reactant. D. reaction intermediate.

115. C5 Consider the following reaction mechanism:
Step 1: $H_2O_2 + I^- \rightarrow H_2O + IO^-$
Step 2: $H_2O_2 + IO^- \rightarrow H_2O + O_2 + I^-$
The reaction intermediate is
A. I – B. IO^- C. H_2O D. H_2O_2

116. C5 Consider the following reaction mechanism:

Step 1: $V^{3+} + Cu^{2+} \rightarrow V^{4+} + Cu^{+}$ (slow)

Step 2: $Cu^{+} + Fe^{3+} \rightarrow Cu^{2+} + Fe^{2+}$ (fast)

The reaction intermediate is
A. Cu^+ B. Cu^{2+} C. V^{3+} D. Fe^{3+}

117. C5 Consider the following reaction mechanism:

Step 1: $NO_{(g)} + O_{3(g)} \rightarrow NO_{2(g)} + O_{2(g)}$

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

The catalyst is:
A. O_2 B. O_3 C. NO D. NO_2

118. C5 Consider the following reaction mechanism:

Step 1: $N_2O_{(g)} \rightarrow N_{2(g)} + O_{(g)}$

Step 2: $N_2O_{(g)} + O_{(g)} \rightarrow N_{2(g)} + O_{2(g)}$

A reactant in the overall reaction is:

A. O B. O_2 C. N_2 D. N_2O

119. C5 Consider the following reaction mechanism:

Step 1: $Cl_{(g)} + O_{3(g)} \rightarrow ClO_{(g)} + O_{2(g)}$

Step 2: $O_{(g)} + ClO_{(g)} \rightarrow Cl_{(g)} + O_{2(g)}$

The reaction intermediate is

A. Cl B. O_2 C. O_3 D. ClO

120. C5 Consider the following reaction mechanism:

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

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

The product in the overall reaction is

A. O_2 B. O_3 C. NO D. NO_2

121. C5 Consider the following reaction mechanism:

Step 1: $NO_2 + NO_2 \rightarrow N_2O_4$

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

In the overall reaction, N_2O_4 is a

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

122. C5 Consider the following reaction mechanism:

Step 1	$2NO + H_2 \rightarrow N_2 + H_2O_2$
Step 2	$H_2O_2 + H_2 \rightarrow 2H_2O$

In this reaction, H_2 is a

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

123. C5 **A substance that increases the rate of a chemical reaction and may be recovered unchanged at the end of the reaction is a(n)**

A. product. B. catalyst. C. activated complex. D. reaction intermediate.

ANSWER KEY:

Introduction:

THE OFFICIAL STUDY GUIDE FOR:
"CHEMICAL KINETICS"

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

7.	D
8.	D
9.	A
10.	B
11.	A
12.	A

13.	B
14.	C
15.	A
16.	C
17.	D
18.	A

19.	C
20.	A
21.	A
22.	D
23.	A
24.	B

25.	D
26.	D
27.	C
28.	C
29.	A
30.	B

31.	A
32.	B
33.	D
34.	C
35.	D
36.	D

Collision Theory:

37.	B
38.	B
39.	C
40.	C
41.	A
42.	C
43.	D
44.	D
45.	D
46.	C

47.	C
48.	D
49.	C
50.	D
51.	D
52.	D
53.	A
54.	D
55.	B
56.	A

57.	B
58.	B
59.	D
60.	C
61.	B
62.	C
63.	C
64.	A
65.	A
66.	D

67.	A
68.	D
69.	C
70.	A
71.	C B
72.	C
73.	A
74.	B
75.	B
76.	D

77.	B
78.	B
79.	D
80.	A
81.	D
82.	C
83.	B
84.	A
85.	B
86.	B

87.	C
88.	B
89.	B
90.	A
91.	C
92.	C
93.	B
94.	D
95.	B
96.	B

Reaction Mechanisms and Catalysts:

97.	C
98.	B
99.	D
100.	D
101.	A

102.	B
103.	B
104.	C
105.	D
106.	C

107.	D
108.	A
109.	B
110.	D
111.	D

112.	D
113.	D
114.	A
115.	B
116.	A

117.	C
118.	D
119.	D
120.	A
121.	D

122.	C
123.	B