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rate

Indicate whether the statement is true or false.

1. For many reactions, the conversion from reactants to products is reversible.
 - a. True
 - b. False

2. Chemists can change the rate of a reaction by changing the concentrations of the reactants.
 - a. True
 - b. False

3. The maximum amount of energy needed by the reactant to form the activated complex and lead to a reaction is known as the activation energy.
 - a. True
 - b. False

4. If the temperature at which a reaction occurs increases, the number of collisions decreases.
 - a. True
 - b. False

5. Orientation of molecules during a reaction does not affect the production of products.
 - a. True
 - b. False

6. According to the rate law, the reaction rate is directly proportional to the molar concentration of the reactant.
 - a. True
 - b. False

7. The collision theory states that atoms, ions, and molecules must collide in order to react.
 - a. True
 - b. False

8. If the temperature of the reactants is increased, the rate of the reaction will decrease.
 - a. True
 - b. False

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9. If the potential energy of the product is less than that of the reactants, the energy released when an activated complex forms a product will be more than the activation energy resulting in an exothermic reaction.
- a. True
 - b. False
10. The order of a reaction is defined as the sum of powers of the concentration in the rate law.
- a. True
 - b. False
11. The rate of a chemical reaction is unrelated to the spontaneity of the reaction.
- a. True
 - b. False
12. The potential energy of an activated complex is at a maximum.
- a. True
 - b. False
13. The rate of a chemical reaction is defined as the change in concentration of a reactant or product in a given time interval.
- a. True
 - b. False
14. A single piece of newspaper burns faster than a shredded piece.
- a. True
 - b. False
15. Most chemical reactions consist of sequences of two or more simpler reactions.
- a. True
 - b. False
16. Key factors that influence the rate of chemical reactions include reactivity, concentration, surface area, temperature and catalysts.
- a. True
 - b. False

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17. In an esterification reaction, $\text{RCOOH (l)} + \text{ROH (l)} \xrightarrow{\text{H}_2\text{SO}_4(\text{l})} \text{RCOOR (l)} + \text{H}_2\text{O (l)}$, sulfuric acid acts as a homogeneous catalyst.

- a. True
- b. False

18. The rate of a chemical reaction is defined as the change in concentration of a reactant or product in a given time interval.

- a. True
- b. False

19. The minimum amount of energy needed by the reactant to form the activated complex and lead to a reaction is known as the activation energy.

- a. True
- b. False

20. If the potential energy of the product is less than that of the reactants, the energy released when an activated complex forms a product will be more than the activation energy. The reaction will be endothermic.

- a. True
- b. False

21. If the temperature of the reactants is increased, the rate of the reaction will decrease.

- a. True
- b. False

22. The rate expression for the reaction $2\text{FeCl}_3(\text{aq}) + \text{SnCl}_2(\text{aq}) \longrightarrow 2\text{Fe}_2\text{Cl}_2 + \text{SnCl}_4$ is $r = k[\text{FeCl}_3]^2[\text{SnCl}_2]$. According to the rate expression, the order of the reaction will be two.

- a. True
- b. False

Indicate the answer choice that best completes the statement or answers the question.

23. Which of the following statements about a catalyst is true?

- a. A catalyst can initiate a reaction.
- b. A catalyst can accelerate a reaction.
- c. A catalyst can be consumed during a reaction.
- d. A catalyst can be changed during a reaction.

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24. Which of the following factors does NOT affect the rate of the reaction?
- a. the amount of the reactants
 - b. the physical state of the reactants
 - c. the size of the container used
 - d. temperature
25. A(n) _____ exists in the same physical state as that of the reaction it catalyzes.
- a. heterogeneous catalyst
 - b. homogeneous catalyst
 - c. inhibitor
 - d. product
26. A/An _____ is a substance that increases the rate of a chemical reaction.
- a. catalyst
 - b. inhibitor
 - c. reactant
 - d. product
27. A/An _____ is a substance that slows down the rate of a reaction.
- a. catalyst
 - b. inhibitor
 - c. reactant
 - d. product
28. A(n) _____ exists in a physical state different than that of the reaction it catalyzes.
- a. heterogeneous catalyst
 - b. homogeneous catalyst
 - c. inhibitor
 - d. product
29. A/An _____ lowers the activation energy required for a reaction to take place.
- a. catalyst
 - b. inhibitor
 - c. reactant
 - d. product
30. The sequence of steps that occurs in a reaction process is called the
- a. order of the reaction.
 - b. rate law.
 - c. overall reaction.
 - d. reaction mechanism.

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31. A reaction collision requires _____ to be effective.
- only enough energy
 - favorable orientation
 - enough energy and favorable orientation
 - a reaction mechanism
32. If a collision between molecules is very gentle, the molecules are
- more likely to be oriented favorably.
 - less likely to be oriented favorably.
 - likely to react.
 - likely to rebound without reacting.
33. A rate law relates
- reaction rate and temperature.
 - reaction rate and concentration.
 - temperature and concentration.
 - energy and concentration.
34. A _____ reaction is one that consists of two or more elementary reactions.
- simpl e
 - comple x
 - single
 - double
35. Which of the following factors does not affect the rate of reaction?
- The physical state of the reactants.
 - The amount of the reactants.
 - The size of the container used.
 - The temperature at which the reaction is carried out.
36. Hydrogen iodide (HI) decomposes as $2\text{HI} \rightarrow \text{H}_2 + \text{I}_2$. The average reaction rate is expressed as:
- $$\text{Average rate} = - \frac{1 \Delta[\text{HI}]}{2 \Delta t}$$
- The negative sign used in the rate expression indicates that:
- There are repulsive forces between the reactants.
 - The concentration of HI decreases with time.

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- c. The concentration of the reactants is less than that of the product.
- d. The reaction rate is decreasing with time.

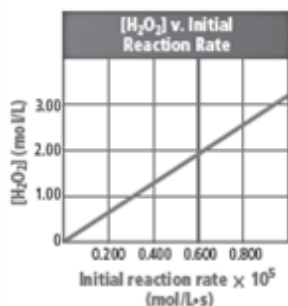
37. Which of the following statements about a catalyst is true?

- a. A catalyst can initiate a reaction.
- b. A catalyst can accelerate the rate of a reaction.
- c. A catalyst can be consumed during a reaction.
- d. A catalyst can be changed chemically during a reaction.

38. In the reaction $2A \rightarrow B$, the rate of a reaction is quadrupled when the concentration of A is doubled. The rate expression of the reaction is $r = k[A]^n$. Define the value of n .

- a. zero
- b. one
- c. two
- d. three
- e.

39. The upward-sloped straight line of the graph below indicates which type of relationship between the concentration of H_2O_2 and the initial reaction rate?



- a. absolute
- b. direct
- c. indirect
- d. inverse
- e.

Enter the appropriate word(s) to complete the statement.

40. A reaction mechanism for the formulation of NO_2 is given as:

- (a) $2NO_2 \longrightarrow N_2O_2$ fast step
- (b) $N_2O_2 + H_2 \longrightarrow N_2O + H_2O$ slow step
- (c) $N_2O + H_2 \longrightarrow N_2 + H_2O$ fast step

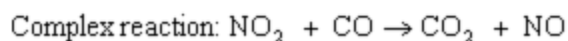
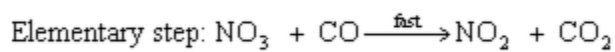
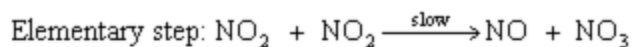
From the above information we can infer that _____ is the rate-determining step.

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41. The _____ of a reaction is defined as the sum of powers of the concentration in the rate law.

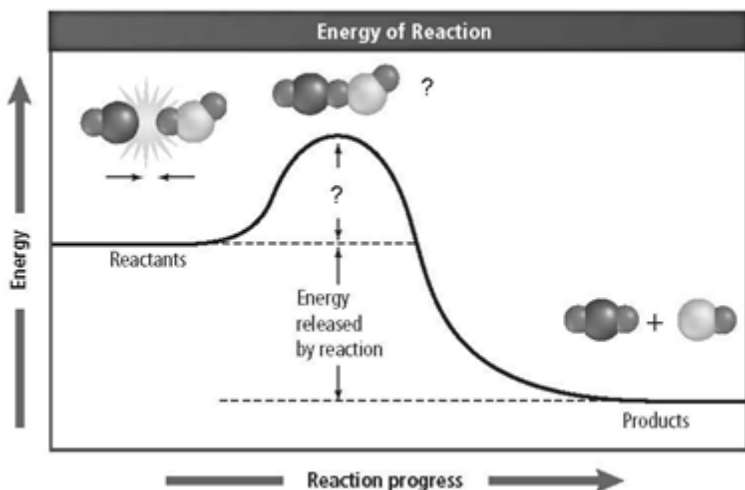
42. In the reaction, $\text{NO}_2 + \text{CO} \rightarrow \text{CO}_2 + \text{NO}$, the mechanism is:



The intermediate compound for the mechanism above is _____.

43. According to the rate law, the reaction rate is directly proportional to the _____ of the reactant.

44. If the temperature at which a reaction occurs increases, the number of collisions _____.



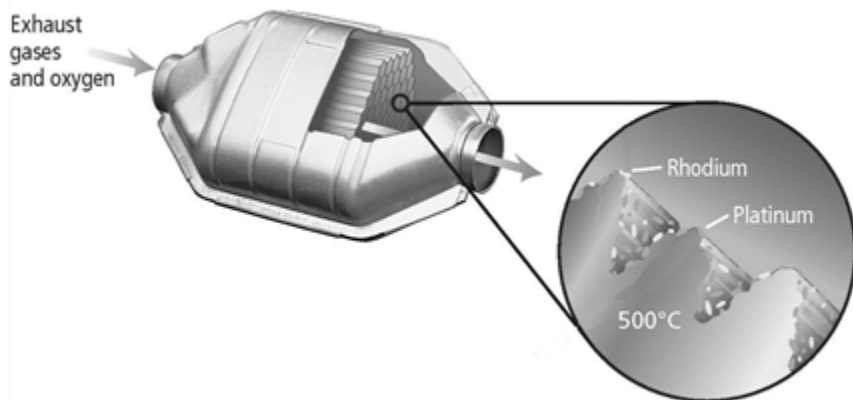
45. When a chemical reaction occurs, such as the one illustrated in the diagram, molecules collide with enough energy to overcome the _____ barrier.

46. For a chemical reaction to occur, such as the one illustrated in the diagram, molecules must collide with sufficient energy to form a(n) _____.

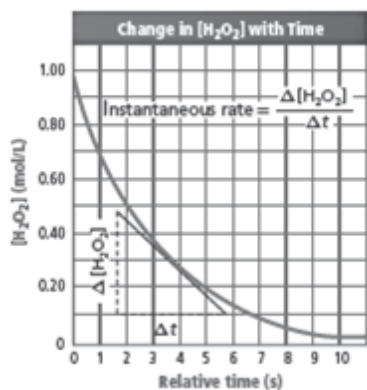
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47. Catalytic converters in the exhaust systems of automobiles catalyze the conversion of _____ to N_2 and O_2 . Catalytic converters also increase the conversion of CO and _____ to CO_2 and H_2O .



48. Look at the graph below. The instantaneous rate for a specific point in the reaction progress can be determined from the _____ to the curve that passes through that point.



49. A/An _____ is a temporary, unstable arrangement of atoms in which old bonds are breaking and new bonds are forming.

50. At point A, is the activation energy high or low?

51. What does the symbol E_a represent?

52. In a reaction of butyl chloride and water, the concentration of butyl chloride is 0.220M at the beginning of the reaction. After 4.00 seconds, the concentration of butyl chloride is 0.100M. Calculate the average reaction rate over the given time period expressed as moles of butyl chloride consumed per liter per second.

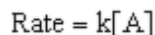
$$\text{Rate} = k[\text{A}]^m[\text{B}]^n$$

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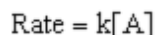
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53. The _____ for a reactant defines how the rate is affected by the concentration of that reactant.

54. Identify “k” in the equation.



55. Identify “[A]” in the equation.

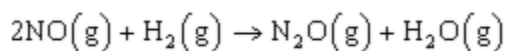


56. The overall order of a reaction is the _____ of the orders for the individual reactants.

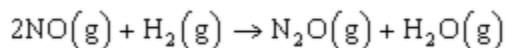
57. Two molecules collide but bounce apart unchanged. What two reasons could account for their failure to react?

58. The method of _____ determines reaction order by comparing the initial rates of a reaction carried out with varying reactant concentrations.

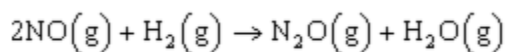
59. Using the equation, calculate the instantaneous reaction rate when the reactant concentrations are $[\text{NO}] = 0.00200\text{M}$ and $[\text{H}_2] = 0.00400\text{M}$. The rate constant is $2.9 \times 10^2 \text{ (L}^2/(\text{mol}^2\cdot\text{s))}$.



60. Using the equation, calculate the instantaneous reaction rate when the reactant concentrations are $[\text{NO}] = 0.00500\text{M}$ and $[\text{H}_2] = 0.00200\text{M}$. The rate constant is $2.9 \times 10^2 \text{ (L}^2/(\text{mol}^2\cdot\text{s))}$.

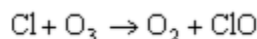


61. Using the equation, calculate the instantaneous reaction rate when the reactant concentrations are $[\text{NO}] = 0.0100\text{M}$ and $[\text{H}_2] = 0.00125\text{M}$. The rate constant is $2.9 \times 10^2 \text{ (L}^2/(\text{mol}^2\cdot\text{s))}$.

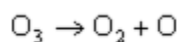


62. Each of these reactions are _____ steps.

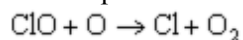
1. Chlorine atoms decompose ozone according to the equation:



2. Ultraviolet radiation causes the decomposition reaction:



3. ClO produced in the reaction in Step 1 reacts with O produced in Step 2 according to the equation:

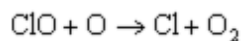
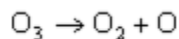
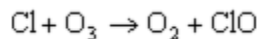


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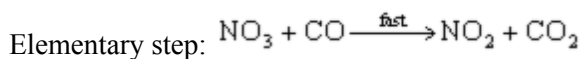
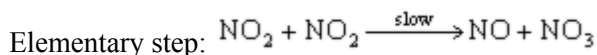
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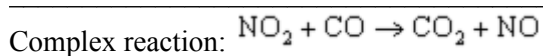
63. Combine the steps to complete the complex reaction.



_____ $\rightarrow$ _____

64. A/An _____ is a substance produced in one elementary step and consumed in a subsequent elementary step.



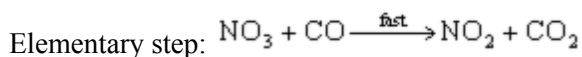
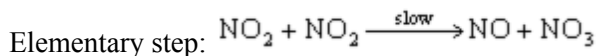


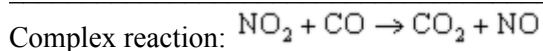
65. The slowest elementary step in a complex reaction is called the _____ step.

Reaction Mechanism		
A	$2\text{NO}_2 \rightarrow \text{N}_2\text{O}_2$	FAST STEP
B	$\text{N}_2\text{O}_2 + \text{H}_2 \rightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$	SLOW STEP
C	$\text{N}_2\text{O} + \text{H}_2 \rightarrow \text{N}_2 + \text{H}_2\text{O}$	FAST STEP

66. A reaction mechanism for the formulation of NO_2 is given. Which of these reactions is the rate-determining step?

67. The intermediate compound for the mechanism below is _____.





68. Explain which solid would react more quickly with a gas. Hint: Both samples have the same mass.

69. What is the role of the activated complex in a chemical reaction?

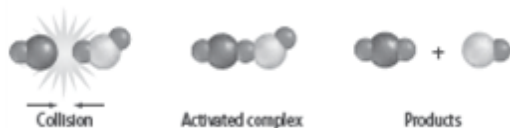
70. At which point (A or B) is the activation energy higher?

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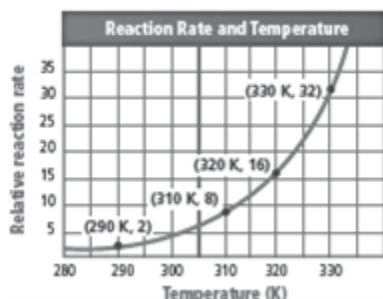
71. In the reaction illustrated below, what two conditions are met which allow the reaction to occur?



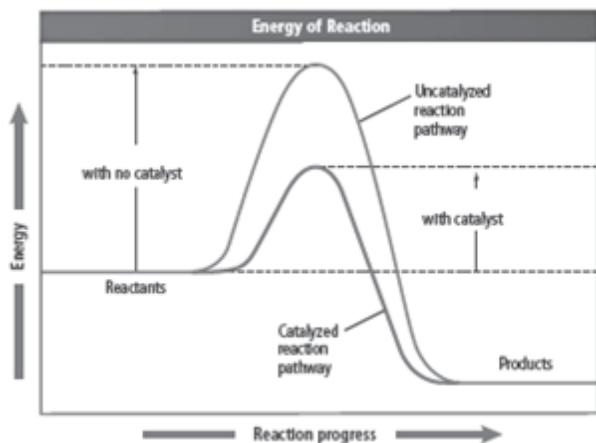
72. In the reaction illustrated below, the molecules are properly oriented for a reaction to occur between them. However, a reaction does not take place. What condition is NOT met which would allow the reaction to occur?



73. Increasing the temperature of a reaction increases the rate of the reaction, as illustrated in the graph below. Explain the two main reasons for this phenomenon.



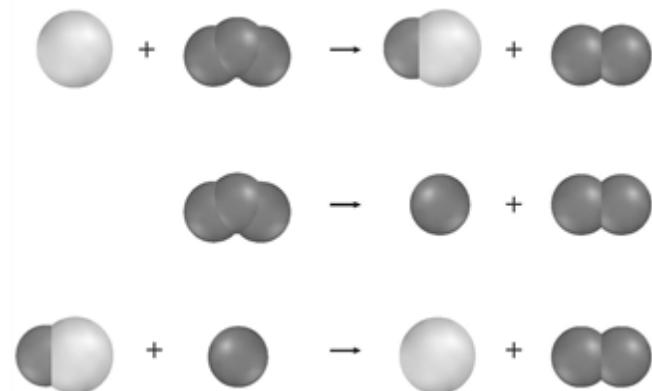
74. The graph below illustrates two chemical reactions: one catalyzed, one not catalyzed. The _____ of the catalyzed reaction is _____ than that of the uncatalyzed reaction.



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75. ClO and O are intermediates in the three elementary steps of the complex reaction producing oxygen gas (O₂) from ozone (O₃). What is the function of chlorine (Cl) in the complex reaction? How would the reaction be different if Cl was not present?



76. The rate law expression for the reaction $2A + B \rightarrow C + D$ is $r = k[A]^2[B]$. If the concentrations of both the reactants are doubled, by how many times will the reaction rate increase?

77. Propane on reaction with chlorine (Cl₂) produces propyl chloride and hydrogen chloride (HCl). Calculate the final concentration of propyl chloride when the initial concentration of the product is 0.79 and the average reaction rate is 0.55 mol/(L · s). The data of time is given below .

Time (s)
Initial time = 5.00
Final time = 11.4

78. The reaction between sulfur and oxygen produces sulfur dioxide. The data is given in the table below:

Time (s)	[S] (M)	[O ₂] (M)	[SO ₂] (M)
$t_1 = 12$	0.082	0.067	0.000
$t_2 = 18$	0.040	0.020	0.041

- Calculate the average reaction rate expressed in moles of sulfur consumed per liter per second.
- Calculate the average reaction rate expressed in moles of oxygen consumed per liter per second.
- Calculate the average reaction rate expressed in moles of sulfur dioxide produced per liter per second.

79. Calculate the instantaneous reaction rate of the reaction, $2E + F \longrightarrow C + D$, if the rate constant, k , is $1.09 \times 10^{-2} \text{ (L}^2 \text{ / (mol}^2 \cdot \text{s))}$. The concentration of E is 0.59 M and the concentration of F is 0.33 M.

80. The decomposition of hydrogen peroxide in the presence of iodide ion is of the first order. The reaction is $2\text{H}_2\text{O}_2(\text{aq}) \longrightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$. Calculate the concentration of H₂O₂ when the rate of the reaction is $1.12 \times 10^{-2} \text{ (mol/(L s))}$ and the rate constant is $1.01 \times 10^{-2} \text{ s}^{-1}$.

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81. For a hypothetical reaction, $1.2A + 2.5K + 4.4X$, give the rate law expression and calculate the order of the reaction.

Experimental Data for $H_2 + Cl_2 \rightarrow 2HCl$			
Time (s)	$[H_2]$ (M)	$[Cl_2]$ (M)	$[HCl]$ (M)
0.00	0.045	0.065	0.000
5.00	0.035	0.055	

82. Using information from the reaction rate table, calculate the average reaction rate expressed in moles H_2 consumed per liter per second.

83. Using information from the reaction rate table, calculate the average reaction rate expressed in moles Cl_2 consumed per liter per second.

84. If the average reaction rate for the reaction, described with the table, expressed in moles of HCl formed, is $0.0075 \text{ mol/(L}\cdot\text{s)}$, what concentration of HCl would be present after 5 seconds?

85. List the three points that make up the Collision Theory Summary.

Collision Theory Summary
1.
2.
3.

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Answer Key

1. True
2. True
3. False
4. False
5. False
6. True
7. True
8. False
9. True
10. True
11. True
12. True
13. True
14. False
15. True
16. True
17. True
18. True
19. True
20. False
21. False
22. False
23. b

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24. c

25. b

26. a

27. b

28. a

29. a

30. d

31. c

32. d

33. b

34. b

35. c

36. b

37. b

38. c

39. b

40. step (b)

41. order

42. NO_3
Nitrogen trioxide

43. molar concentration

44. increases

45. activation

46. activated complex

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47. NO (Nitric Oxide), unburned gasoline

48. tangent

49. activated complex

50. High

51. Activation energy

52. 0.0300 mol/L·s

$-(0.001\text{M} - 0.220\text{M} / 4\text{ s} - 0\text{ s})$

53. reaction order

54. k = specific rate constant

55. $[A]$ = concentration of a reactant

56. sum

57. Not enough energy
Unfavorable orientation

58. initial rates

59. $4.64 \times 10^{-6} \text{ mol/(L}\cdot\text{s)}$

Rate = $k[\text{NO}]^2[\text{H}_2]$

60. $1.45 \times 10^{-5} \text{ mol/(L}\cdot\text{s)}$

61. $3.625 \times 10^{-5} \text{ mol/(L}\cdot\text{s)}$

62. elementary

63. $2\text{O}_3 \rightarrow 3\text{O}_2$

64. intermediate

65. rate-determining

66. Step B

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67. Nitrogen Trioxide NO₃

68. The crushed solid would react more quickly due to increased surface area.

69. The activated complex allows old bonds to break and new bonds to form.

70. B

71. 1) The molecules are properly aligned (oriented), and 2) the molecules have sufficient energy to cause a reaction when they collide.

72. The molecules must have insufficient energy to react upon collision.

73. Increasing the temperature increases the frequency of collisions. Also, increasing the temperature causes more particles to have sufficient energy to overcome the activation barrier.

74. activation energy/ lower

75. Cl is a catalyst in the decomposition of O₃. Without the presence of Cl, the decomposition of O₃ would progress more slowly.

76. If the concentrations of both the reactants are doubled, the reaction rate will increase by 8 times.

77. 4.3 mol/(L·s)

78. a. 0.0070 mol/(L·s)

b. 0.0079 mol/(L·s)

c. 0.0068 mol/(L·s)

79. 0.13×10^2 mol/(L·s)

80. 1.11 mol/L

81. The rate law expression is $r = k[A]^{1.2} [K]^{2.5} [X]^{4.4}$.

The order of the reaction = 8.1.

82. 0.0020 mol/(L·s)

83. 0.0020 mol/(L·s)

84. 0.038 mol/L

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85. 1. The particles of the reacting substances must collide.
2. Reacting substances must collide in the correct orientation.
3. Reacting substances must collide with sufficient energy to form an activated complex.