General Chemistry II Jasperse
Kinetics. Extra Practice Problems

General Types/Groups of problems:

Rates of Change in Chemical Reactions

1. For the reaction A + 3B → 2C, how does the rate of disappearance of B compare to the rate of production of C?

   a. the rate of disappearance of B is 1/2 the rate of appearance of C
   b. the rate of disappearance of B is 3/2 the rate of appearance of C
   c. the rate of disappearance of B is 2/3 the rate of appearance of C
   d. the rate of disappearance of B is 1/3 the rate of appearance of C

2. For the reaction 2A + 3B → 4C + 5D, the rate of the reaction in terms of ΔA would be written as:

   a. $-\Delta A/\Delta t$.
   b. $-1/2\ \Delta A/\Delta t$.
   c. $+\Delta A/\Delta t$.
   d. $+1/2\ \Delta A/\Delta t$.
   e. $-2\ \Delta A/\Delta t$.

3. For the reaction 2A + 3B → 4C + 5D, the rate of the reaction in terms of ΔB would be written as

   a. $-\Delta B/\Delta t$
   b. $+\Delta B/\Delta t$
   c. $-1/3\ \Delta B/\Delta t$
   d. $+1/3\ \Delta B/\Delta t$
   e. $-3\ \Delta B/\Delta t$

4. For the reaction 2A + 3B → 4C + 5D, the rate of the reaction in terms of ΔC would be written as

   a. $+\Delta C/\Delta t$ d.
   b. $+4\ \Delta C/\Delta t$
   c. $+1/4\ \Delta C/\Delta t$
   d. $-4\ \Delta C/\Delta t$
   e. $-1/4\ \Delta C/\Delta t$

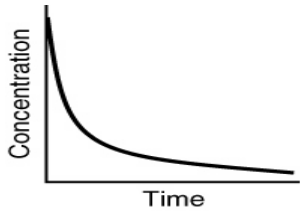
5. In the combustion of methane, $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O\ (g)$, which reactant has the greatest rate of disappearance?

   a. CH_4
   b. O_2
   c. CO_2
   d. H_2O
   e. CH_4 and O_2 have the same rate of disappearance.

The look of concentration/time graphs

6. Which of the following is not a possible graph of concentration versus time for a **reactant**?

a.



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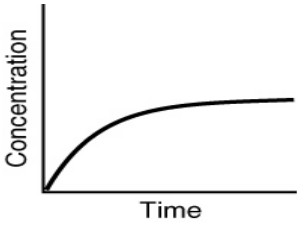

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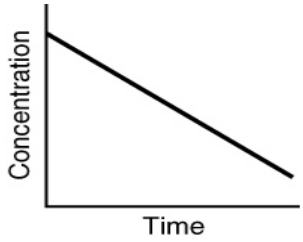

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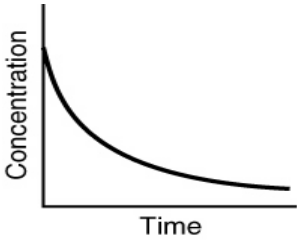
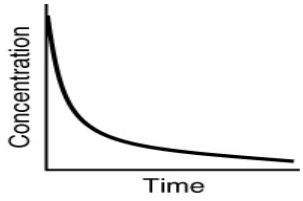


7. Assuming that each of the following graphs has the same concentration and time axes, which has the greatest initial rate of disappearance of reactant?

a.



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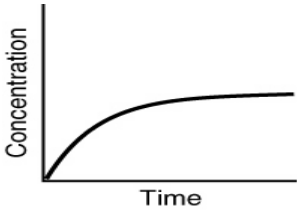

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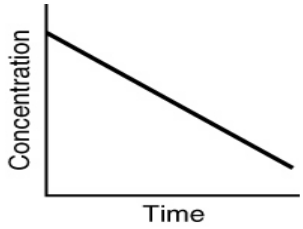
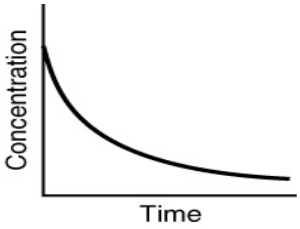
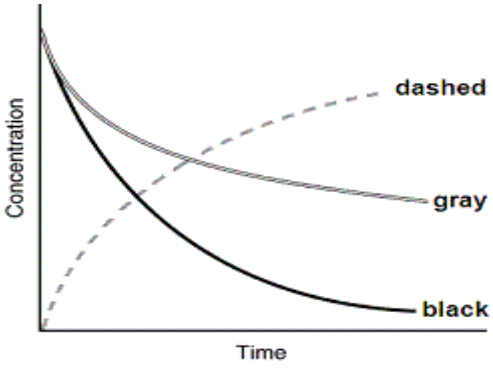


d.



8. The following graph shows the kinetics curves for the reaction of oxygen with hydrogen to form water: $O_2(g) + 2H_2(g) \rightarrow 2H_2O(g)$. Which curve is hydrogen?



a. the dashed curve
b. the gray curve
c. the black curve
d. either the gray or the black curve
e. Any of these curves could be hydrogen

Rates: Average Rates, Determination of Rates from Stoichiometry and Changes of Other Chemicals; Simple Rate Calculations

9. A scientist conducts an experiment to determine the rate of the following reaction:

$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$

If the initial concentration of N_2 was 0.500 *M* and the concentration of N_2 was 0.450 *M* after 0.100 s, what is the rate of the reaction?

a. 0.500 *M*/s
b. 1.00 *M*/s
c. 5.00 *M*/s
d. 10.0 *M*/s
e. 0.250 *M*/s

10. A scientist conducts an experiment to determine the rate of NO formation in the reaction:

$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$

If the initial concentration of N_2 was 0.500 *M* and the concentration of N_2 was 0.450 *M* after 0.100 s, what is the rate of NO formation?

a. 0.500 *M*/s
b. 1.00 *M*/s
c. 5.00 *M*/s
d. 10.0 *M*/s
e. 0.250 *M*/s

11. If the rate of appearance of O_2 in the reaction:

$$2O_3(g) \rightarrow 3O_2(g)$$

is 0.250 *M*/s over the first 5.50 s, how much oxygen will form during this time?

a. 1.38 *M*
b. 4.13 *M*
c. 0.69 *M*
d. 0.25 *M*
e. 0.46 *M*

12. HI dissociates to form I_2 and H_2:

$$2HI(g) \rightarrow H_2(g) + I_2(g)$$

If the concentration of HI changes at a rate of –0.45 *M*/s, what is the rate of appearance of $I_2(g)$?

a. 0.90 *M*/s
b. 0.45 *M*/s
c. 0.23 *M*/s
d. 1.00 *M*/s
e. 0.13 *M/s*

13. If the rate of formation of ammonia is 0.345 *M*/s, what is the rate of disappearance of N_2?

$$N_2\,(g) + 3\,H_2\,(g) \rightarrow 2\,NH_3\,(g)$$

a. 0.173 *M*/s
b. 0.345 *M*/s
c. 0.690 *M*/s
d. 245 *M*/s
e. 0.518 *M/s*

14. If the rate of formation of ammonia is 0.345 *M*/s, what is the rate of disappearance of H_2?

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

a. 0.173 *M*/s
b. 0.345 *M*/s
c. 0.522 *M*/s
d. 245 *M*/s
e. 0.518 *M/s*

Reactant Order and Overall Reaction Order

15. For the reaction $2A + B + 2C \rightarrow D + 2E$, the rate law is: $\text{rate} = k[A]^2[B]^1[C]^1$
Which of the following statements is false:

a. the reaction is second order in [A]
b. the reaction is first order in [B]
c. the reaction is second order in [C]
d. the reaction is 4th order overall

16. For the reaction $1A + 2B + 1C \rightarrow 2D + 1E$, the rate law is: $\text{rate} = k[B]^2[C]^1$
Which of the following statements is false:

a. the reaction is first order in [A]
b. the reaction is second order in [B]
c. the reaction is first order in [C]
d. the reaction is third order overall

17. For the rate law Rate = $k[A]^{1/2}[B]$, the partial order with respect to A is _____, the partial order with respect to B is _____, and the total order is _____.

a. 1/2; 0; 1/2
b. 1/2; 1; 1
c. 1/2; 1; 3/2
d. 1/2
e. The orders cannot be determined without a chemical reaction.

18. For the rate law Rate = $k[A][B]^{3/2}$, the order with respect to A is _____, the order with respect to B is _____, and the overall reaction order is _____.

a. 0; 3/2; 3/2
b. 1; 3/2 ; 1
c. 1; 3/2 ; 5/2
d. 1; 3/2; 7/2
e. The orders cannot be determined without a chemical reaction.

19. The reaction $A + 2B \rightarrow C$
is first order in B and A. The overall order of the reaction is _____

a. first.
b. second.
c. third.
d. zero.
e. fourth.

Given a Rate Law, How much will rate change with change in concentration

20. The reaction $CHCl_3(g) + Cl_2(g) \rightarrow CCl_4(g) + HCl(g)$ has the following rate law: Rate = $k[CHCl_3][Cl_2]$. If the concentration of $CHCl_3$ is increased by a factor of five while the concentration of Cl_2 is kept the same, the rate will

a. double.
b. triple.
c. stay the same.
d. increase by a factor of five.
e. decrease by a factor of one-fifth.

21. The reaction $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ has the following rate law: Rate = $k[O_2][NO]^2$. If the concentration of NO is reduced by a factor of two, the rate will _____

a. double.
b. quadruple.
c. be reduced by one-quarter.
d. be reduced by one-half.
e. remain the same.

22. The rate of a reaction is found to double when the concentration of one reactant is quadrupled. The order of the reaction with respect to this reactant is _____

a. first.
b. second.
c. one-quarter.
d. one-half.
e. third.

Determining Reactant Orders from Actual Data

23. Given the following data, determine the order of the reaction with **respect to Cl_2**.

$$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$$

Experiment	[NO] (*M*)	[Cl_2] (*M*)	*Rate* (*M*/s)
1	0.0300	0.0100	3.4×10^{-4}
2	0.0150	0.0100	8.5×10^{-5}
3	0.0150	0.0400	3.4×10^{-4}

a. first
b. second
c. third
d. fourth
e. fifth

24. Given the following data, determine the order of the reaction **with respect to H_2.**

$$H_2(g) + 2ICl(g) \rightarrow I_2(g) + 2HCl(g)$$

Experiment	[H_2] (torr)	[ICl] (torr)	*Rate* (*M*/s)
1	250	325	1.34
2	250	81	0.331
3	50	325	0.266

a. one-half
b. second
c. first
d. third
e. three-halves

25. Given the following data, determine the order of the reaction **with respect to NO(*g*).**

$$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$$

Experiment	[NO] (*M*)	[Cl_2] (*M*)	*Rate* (*M*/s)
1	0.0300	0.0100	3.4×10^{-4}
2	0.0150	0.0100	8.5×10^{-5}
3	0.0150	0.0400	3.4×10^{-4}

a. first
b. second
c. third
d. fourth
e. fifth

26. Determine **the overall order** of the reaction: $H_2(g) + 2ICl(g) \rightarrow I_2(g) + 2HCl(g)$ from the following data:

Experiment	P_H (torr)	P_{ICl} (torr)	*Rate* (torr/s)
1	250	325	1.34
2	250	81	0.331
3	50	325	0.266

a. first
b. second
c. third
d. fourth
e. zeroth

27. Determine **the overall order** of the reaction $2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$ from the following data:

Experiment	[NO] (*M*)	[Cl_2] (*M*)	*Rate* (*M*/s)
1	0.0300	0.0100	3.4×10^{-4}
2	0.0150	0.0100	8.5×10^{-5}
3	0.0150	0.0400	3.4×10^{-4}

a. first
b. second
c. third
d. fourth
e. fifth

Actual Rate Law from a Table of Concentration/Rate Data

28. Given the following data, determine the rate law for the reaction

$$NH_4^+(aq) + NO_2^-(aq) \rightarrow N_2(g) + 2H_2O()$$

Experiment	$[NH_4^+]$ (*M*)	$[NO_2^-]$ (*M*)	*Rate* (*M*/s)
1	0.2500	0.2500	1.25×10^{-3}
2	0.5000	0.2500	2.50×10^{-3}
3	0.2500	0.1250	6.25×10^{-4}

a. $k[NH_4^+][NO_2^-]$
b. $k[NH_4^+]^2[NO_2^-]$
c. $k[NH_4^+][NO_2^-]^{1/2}$
d. $k[NH_4^+]^{1/2}[NO_2^-]^2$
e. $k[NH_4^+][NO_2^-]^2$

29. Given the following data, determine the rate law for the reaction

$$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$$

Experiment	[NO] (*M*)	$[Cl_2]$ (*M*)	*Rate* (*M*/s)
1	0.0300	0.0100	3.4×10^{-4}
2	0.0150	0.0100	8.5×10^{-5}
3	0.0150	0.0400	3.4×10^{-4}

a. Rate = $k[NO][Cl_2]$
b. Rate = $k[NO][Cl_2]^2$
c. Rate = $k[NO]^2[Cl_2]$
d. Rate = $k[NO]^2[Cl_2]^2$
e. Rate = $k[NO][Cl_2]^{1/2}$

30. What is the rate law for the reaction $2A + 2B + 2C \rightarrow$ products

Initial [A]	Initial [B]	Initial [C]	rate
0.273	0.763	0.400	3.0
0.819	0.763	0.400	9.0
0.273	1.526	0.400	12.0
0.273	0.763	0.800	6.0

a. rate = $k[A][B][C]$
b. rate = $k[A][B]^2[C]$
c. rate = $k[A]^3[B]^4[C]^2$
d. rate = $k[A]^2[B]^2[C]^2$

Determining Rate Constant from Rate Law and Actual Data. Where you yourself need to first deduce the rate law, then plug in the values to solve for "k".

31. The initial rate data for the reaction $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$ is shown in the following table. Determine the value of the **rate constant** for this reaction.

Experiment	$[N_2O_5](M)$	Rate (M/s)
1	1.28×10^2	22.5
2	2.56×10^2	45.0

a. $4.09\ s^{-1}$
b. $0.176\ s^{-1}$
c. $0.0569\ s^{-1}$
d. $0.225\ s^{-1}$
e. $80.1\ s^{-1}$

32. Given the following data, determine the rate constant of the reaction

$$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$$

Experiment	**[NO] (*M*)**	**[Cl_2] (*M*)**	***Rate* (*M*/s)**
1	0.0300	0.0100	3.4×10^{-4}
2	0.0150	0.0100	8.5×10^{-5}
3	0.0150	0.0400	3.4×10^{-4}

a. $1.13\ M^{-2}s^{-1}$
b. $9.44\ M^{-2}s^{-1}$
c. $37.8\ M^{-2}s^{-1}$
d. $0.0265\ M^{-2}s^{-1}$
e. $59.6\ M^{-2}s^{-1}$

First Order Rate Law Calculations

Formulas for First Order Reactions: $kt = \ln([A_o]/[A_t])$ $kt_{1/2} = 0.693$

-these formulas will be provided for you on the test

33. The first-order reaction A → B, has $k = 8.00\ s^{-1}$. If $[A]_0 = 0.500\ M$, how long will it take [A] = 0..200 *M*?

a. 0.115 s
b. 0.100 s
c. 8.18 s
d. 0.244 s.
e. 0.488 s

34. The first-order reaction A → B, has $k = 5.67\ s^{-1}$. If $[A]_0 = 0.500\ M$, how long will it take [A] = 0.124 *M*?

a. 0.122 s
b. 0.100 s
c. 8.18 s
d. 0.244 s
e. 0.488 s

35. A reaction is first order in A. If the rate constant of the reaction is $6.00 \times 10^{-3}\ s^{-1}$, what is the half-life ($t_{1/2}$) of the reaction?

a. 4.98×10^{-3} s
b. 200 s
c. 3.45×10^{-3} s
d. 115 s
e. 1.73×10^{-3} s

36. A reaction is first order in A. If the rate constant of the reaction is $3.45 \times 10^{-3}\ s^{-1}$, what is the half-life ($t_{1/2}$) of the reaction?

a. 4.98×10^{-3} s
b. 201 s
c. 3.45×10^{-3} s
d. 100 s
e. 1.73×10^{-3} s

37. The half-life ($t_{1/2}$) of a first-order reaction is 0.100 s. What is the rate constant?

a. $6.93\ s^{-1}$
b. $0.693\ s^{-1}$
c. $0.0693\ s^{-1}$
d. $0.144\ s^{-1}$
e. $3.01\ s^{-1}$

38. The half-life ($t_{1/2}$) of a first-order reaction is 0.950 s. What is the rate constant?

a. $6.93\ s^{-1}$
b. $0.729\ s^{-1}$
c. $0.0693\ s^{-1}$
d. $0.144\ s^{-1}$
e. $3.01\ s^{-1}$

39. What percentage of a material will persist after 60 minutes if it's half life is 30 minutes?

a. 50%
b. 33%
c. 25%
d. 12.5%
e. none of the above

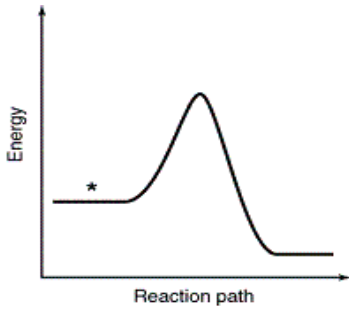
40. What percentage of a material will persist after 80 minutes if it's half life is 20 minutes?

a. 50%
b. 33%
c. 25%
d. 12.5%
e. 6.25%

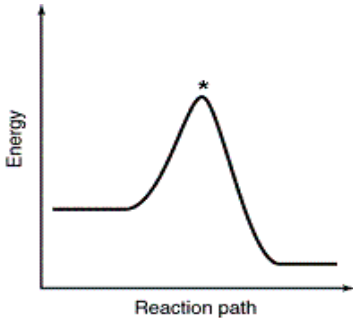
Reaction Energy Diagrams, Activation Energy, Transition States…

41. Which point as labeled by an asterisk (*) on the following energy profile is the transition state?

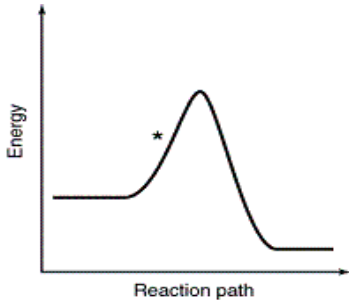
a.



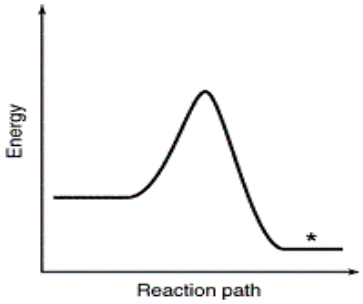
c.



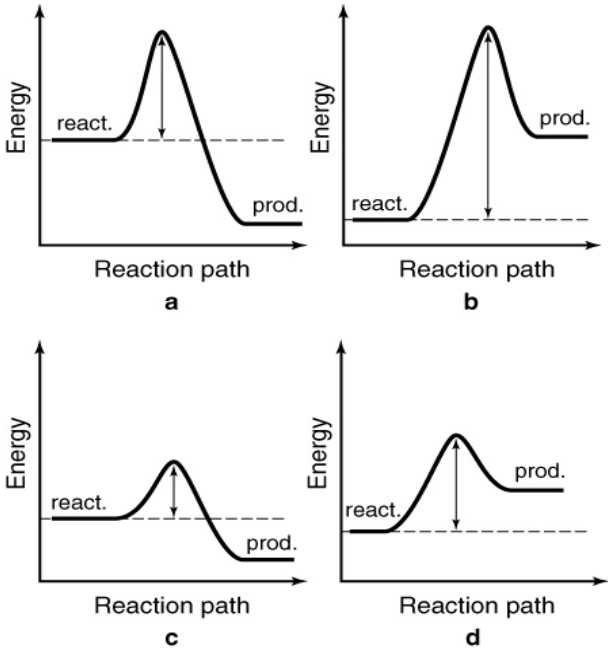
b.



d.

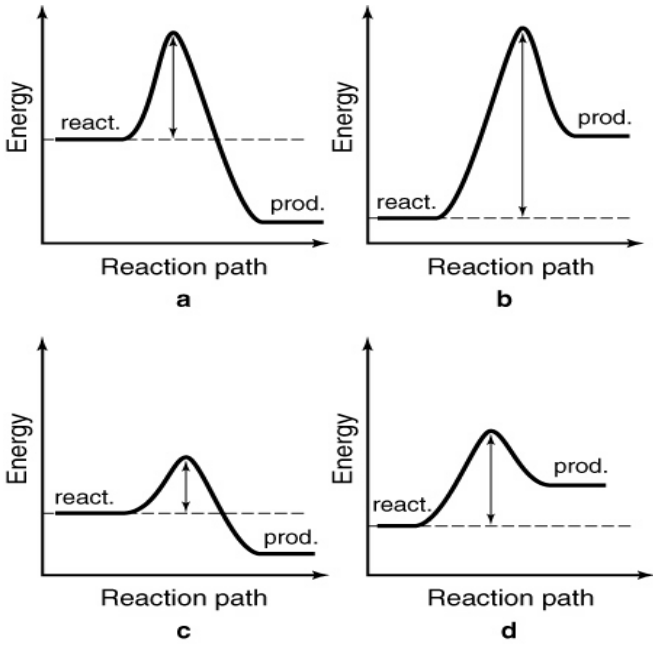


42. The energy profiles for four different reactions are shown. Which reaction requires the most energetic collisions to reach the transition state?



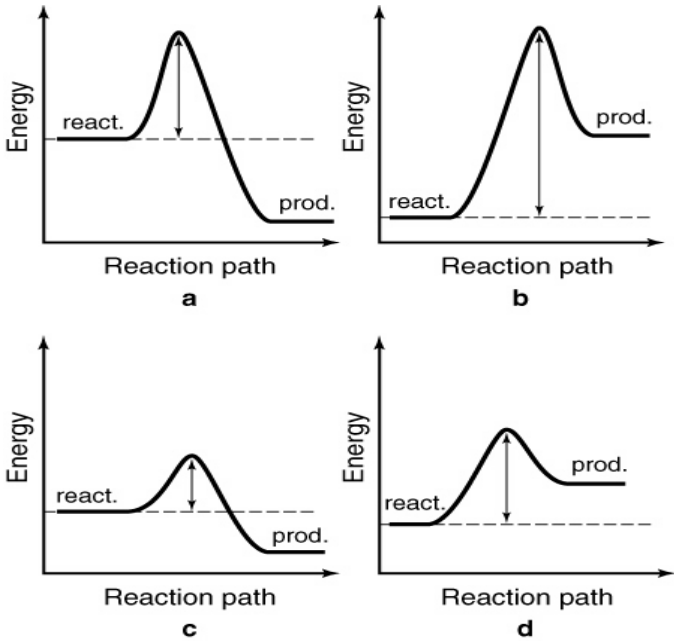
a. a
b. b
c. c
d. d

43. The following energy profiles for four different reactions are shown. Which reaction is the most endothermic?



a. a
b. b
c. c
d. d

44. The following energy profiles for four different reactions are shown. Which reaction is the most exothermic?



a. a
b. b
c. c
d. d

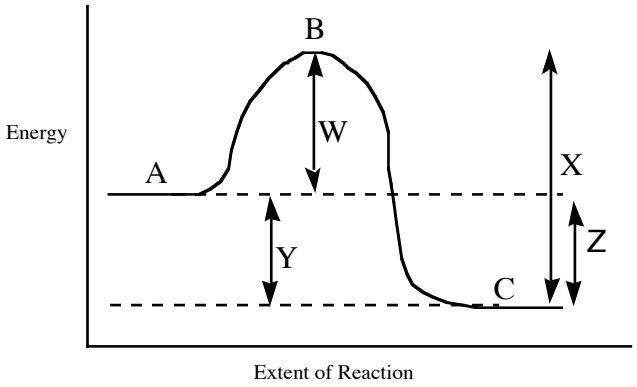
45. Collision theory assumes that the rate of a reaction depends on _____

a. the energy of collisions.
b. the orientation of colliding molecules.
c. the energy of collisions and the orientation of colliding molecules.
d. the change in energy between the products and the reactants.
e. the change in free energy between the reactants and products.

46. The energy needed for a reaction to proceed from reactants to products is called _____

a. collision energy.
b. kinetic energy.
c. activation energy.
d. potential energy.
e. thermodynamic energy.

47. For the reaction diagram shown, which of the following statements is true?



a. Line W represents the ΔH for the forward reaction; point B represents the transition state
b. Line W represents the activation energy for the forward reaction; point B represents the transition state
c. Line Y represents the activation energy for the forward reaction; point C represents the transition state
d. Line X represents the ΔH for the forward reaction; point B represents the transition state

Reaction Mechanisms, Intermediates…

48. A proposed mechanism for the photodecomposition of ozone in the atmosphere is

Step 1: $O_3(g) + h\nu \rightarrow O_2(g) + O(g)$
Step 2: $O_3(g) + O(g) \rightarrow 2\ O_2(g)$

Which of the following species is an intermediate?

a. O_3
b. $h\nu$
c. O_2
d. O
e. This mechanism has no intermediates.

49. A proposed mechanism for the decomposition of ozone in the atmosphere is

Step 1: $Cl(g) + O_3(g) \rightarrow ClO(g) + O_2(g)$
Step 2: $ClO(g) + O_3(g) \rightarrow Cl(g) + 2\ O_2(g)$

Which of the following species is an intermediate?

a. Cl
b. O_3
c. ClO
d. O_2
e. This mechanism has no intermediates.

50. The reaction $NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$ is thought to occur by the following mechanism:

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

Which of the following species is an intermediate?

a. NO_2
b. NO
c. NO_3
d. CO_2
e. This mechanism has no intermediates.

Mechanism Steps, Slow Steps, and Rate Laws

51. A proposed mechanism for the decomposition of ozone in the stratosphere is:

Step 1: $Cl(g) + O_3(g) \rightarrow ClO(g) + O_2(g)$
Step 2: $ClO(g) + O_3(g) \rightarrow Cl(g) + 2O_2(g)$

What is the **molecularity of Step 1**?

a. zeromolecular
b. unimolecular
c. bimolecular
d. termolecular
e. More information is needed to answer this question.

52. A proposed mechanism for the reduction of nitrogen as NO by hydrogen is:

Step 1: $H_2(g) + 2\ NO(g) \rightarrow N_2O(g) + H_2O(g)$
Step 2: $N_2O(g) + H_2(g) \rightarrow N_2(g) + H_2O(g)$

What is the **molecularity of Step 1**?

a. unimolecular
b. bimolecular
c. termolecular
d. zero molecular (spontaneous)
e. More information is needed to answer this question.

53. The mechanism for the reaction $2H_2O_2(aq) \rightarrow 2H_2O() + O_2(g)$ in the presence of $I^-(aq)$ is proposed to be:

Step 1: $H_2O_2(aq) + I^-(aq) \rightarrow H_2O() + OI^-(aq)$ (slow)
Step 2: $H_2O_2(aq) + OI^-(aq) \rightarrow H_2O() + O_2(g) + I^-(aq)$ (fast)

What is the **molecularity of the rate-determining step**?

a. zeromolecular
b. unimolecular
c. bimolecular
d. termolecular
e. More information is needed to answer this question.

54. A proposed mechanism for the reduction of nitrogen as NO by hydrogen is:

Step 1: $H_2(g) + 2NO(g) \rightarrow N_2O(g) + H_2O(g)$ (slow)
Step 2: $N_2O(g) + H_2(g) \rightarrow N_2(g) + H_2O(g)$ (fast)

What is the rate law?

a. Rate = $k[H_2][NO]$
b. Rate = $k[H_2]^2[NO]$
c. Rate = $k[H_2][NO]^2$
d. Rate = $k[H_2]^2[NO]^2$
e. More information is needed to answer this question.

55. The mechanism for the reaction $2H_2O_2(aq) \rightarrow 2H_2O() + O_2(g)$ in the presence of $I^-(aq)$ is proposed to be
Step 1: $H_2O_2(aq) + I^-(aq) \rightarrow H_2O() + OI^-(aq)$ (slow)
Step 2: $H_2O_2(aq) + OI^-(aq) \rightarrow H_2O() + O_2(g) + I^-(aq)$ (fast)

What is the rate law for the overall reaction?

a. Rate = $k[H_2O_2]$
b. Rate = $k[H_2O_2]^2$
c. Rate = $k[H_2O_2][I^-]$
d. Rate = $k[H_2O_2][OI^-]$
e. Rate = $k[H_2O_2]^2[I^-]/[H_2O]$

Catalysts

56. Which of the following statements about catalysts is false:

a. catalysts do not appear in the balanced equation
b. catalysts reduce the activation energy for a reaction
c. biological catalysts are called enzymes
d. catalysts do not alter the mechanism of the reaction and never appear in the rate law
e. since catalysts are recycled, even a small amount of catalyst can accelerate a reaction

57. Which of the following statements is false:

a. Changing the temperature does not change the activation energy for a reaction
b. At higher temperature a higher percentage of reactants have enough energy to get over the transition state
c. The mechanism, rate law, and activation energy will all change when a catalyst is added.
d. The general rate law for a reaction does not changes with temperature, but the rate constant does change
e. The rate constant "k" for a reaction does not change when the temperature increases.

58. A proposed mechanism for the following reaction is shown below. Identify the catalyst in the reaction.

$2H_2O_2(aq) \rightarrow 2H_2O(aq) + O_2$ in the presence of $I^-(aq)$

Step 1: $H_2O_2(aq) + I^-(aq) \rightarrow H_2O() + OI^-(aq)$ (slow)
Step 2: $H_2O_2(aq) + OI^-(aq) \rightarrow H_2O() + O_2(g) + I^-(aq)$ (fast)

a. H_2O_2
b. OI^-
c. I^-
d. H_2O
e. O_2

59. The steps in a reaction mechanism are as follows. Which species is acting as a catalyst?

Step 1: $Ag^+(aq) + Ce^{4+}(aq) \leftrightarrow Ag^{2+}(aq) + Ce^{3+}(aq)$
Step 2: $Tl^+(aq) + Ag^{2+}(aq) \rightarrow Tl^{2+}(aq) + Ag^+(aq)$
Step 3: $Tl^{2+}(aq) + Ce^{4+}(aq) \rightarrow Tl^{3+}(aq) + Ce^{3+}(aq)$

a. Ag^+
b. Tl^+
c. Ce^{3+}
d. Ag^{2+}
e. Tl^{3+}

General Chemistry II Jasperse ANSWERS
Kinetics. Extra Practice Problems

1. B	31. B
2. B	32. C
3. C	33. A
4. C	34. D
5. B	35. D
6. C	36. B
7. A	37. A
8. C	38. B
9. A	39. C
10. B	40. E
11. A	41. C
12. C	42. B
13. A	43. B
14. C	44. A
15. C	45. C
16. A	46. C
17. C	47. B
18. C	48. D
19. B	49. C
20. D	50. C
21. C	51. C
22. D	52. C
23. A	53. C
24. C	54. C
25. B	55. C
26. B	56. D
27. D	57. E
28. A	58. C
29. C	59. A
30. B	