CHAPTER 12 QUESTIONS

MULTIPLE-CHOICE QUESTIONS

Questions 1–3

$$A + B \rightarrow C$$

The following are possible rate laws for the hypothetical reaction given above.

(A) Rate = $k[A]$
(B) Rate = $k[A]^2$
(C) Rate = $k[A][B]$
(D) Rate = $k[A]^2[B]$
(E) Rate = $k[A]^2[B]^2$

1. This is the rate law for a first order reaction.

2. This is the rate law for a reaction that is second order with respect to B.

3. This is the rate law for a third order reaction.

Questions 4–6

$$A + B \rightarrow C$$

The following are possible rate laws for the hypothetical reaction given above.

(A) Rate = $k[A]$
(B) Rate = $k[B]^2$
(C) Rate = $k[A][B]$
(D) Rate = $k[A]^2[B]$
(E) Rate = $k[A]^2[B]^2$

4. When [A] and [B] are doubled, the initial rate of reaction will increase by a factor of eight.

5. When [A] and [B] are doubled, the initial rate of reaction will increase by a factor of two.

6. When [A] is doubled and [B] is held constant, the initial rate of reaction will not change.

7. A multistep reaction takes place by the following mechanism:

$$A + B \rightarrow C + D$$
$$A + C \rightarrow D + E$$

Which of the species shown above is an intermediate in the reaction?

(A) A
(B) B
(C) C
(D) D
(E) E

8. $$2\,NOCl \rightarrow 2\,NO + Cl_2$$

The reaction above takes place with all of the reactants and products in the gaseous phase. Which of the following is true of the relative rates of disappearance of the reactants and appearance of the products?

(A) NO appears at twice the rate that NOCl disappears.
(B) NO appears at the same rate that NOCl disappears.
(C) NO appears at half the rate that NOCl disappears.
(D) Cl_2 appears at the same rate that NOCl disappears.
(E) Cl_2 appears at twice the rate that NOCl disappears.

9. $$H_2(g) + I_2(g) \rightarrow 2\,HI(g)$$

When the reaction given above takes place in a sealed isothermal container, the rate law is

$$\text{Rate} = k[H_2][I_2]$$

If a mole of H_2 gas is added to the reaction chamber, which of the following will be true?

(A) The rate of reaction and the rate constant will increase.
(B) The rate of reaction and the rate constant will not change.
(C) The rate of reaction will increase and the rate constant will decrease.
(D) The rate of reaction will increase and the rate constant will not change.
(E) The rate of reaction will not change and the rate constant will increase.

10. $$A + B \rightarrow C$$

When the reaction given above takes place, the rate law is

$$\text{Rate} = k[A]$$

If the temperature of the reaction chamber were increased, which of the following would be true?

(A) The rate of reaction and the rate constant will increase.
(B) The rate of reaction and the rate constant will not change.
(C) The rate of reaction will increase and the rate constant will decrease.
(D) The rate of reaction will increase and the rate constant will not change.
(E) The rate of reaction will not change and the rate constant will increase.

11. $$A + B \rightarrow C$$

Based on the following experimental data, what is the rate law for the hypothetical reaction given above?

Experiment	[A] (*M*)	[B] (*M*)	Initial Rate of Formation of C (mol/L-sec)
1	0.20	0.10	3×10^{-2}
2	0.20	0.20	6×10^{-2}
3	0.40	0.20	6×10^{-2}

(A) Rate = $k[A]$
(B) Rate = $k[A]^2$
(C) Rate = $k[B]$
(D) Rate = $k[B]^2$
(E) Rate = $k[A][B]$

12. $A + B \rightarrow C + D$

The rate law for the hypothetical reaction shown above is as follows:

$$\text{Rate} = k[A]$$

Which of the following changes to the system will increase the rate of the reaction?

I. An increase in the concentration of A
II. An increase in the concentration of B
III. An increase in the temperature

(A) I only
(B) I and II only
(C) I and III only
(D) II and III only
(E) I, II, and III

13. $A + B \rightarrow C$

Based on the following experimental data, what is the rate law for the hypothetical reaction given above?

Experiment	[A] (*M*)	[B] (*M*)	Initial Rate of Formation of C (*M*/sec)
1	0.20	0.10	2.0×10^{-6}
2	0.20	0.20	4.0×10^{-6}
3	0.40	0.40	1.6×10^{-5}

(A) Rate = $k[A]$
(B) Rate = $k[A]^2$
(C) Rate = $k[B]$
(D) Rate = $k[B]^2$
(E) Rate = $k[A][B]$

14. $A + B \rightarrow C$

Based on the following experimental data, what is the rate law for the hypothetical reaction given above?

Experiment	[A] (*M*)	[B] (*M*)	Initial Rate of Formation of C (*M*/sec)
1	0.10	0.10	1.5×10^{-3}
2	0.40	0.10	6.0×10^{-3}
3	0.40	0.20	2.4×10^{-2}

(A) Rate = $k[A]$
(B) Rate = $k[A]^2$
(C) Rate = $k[A][B]^2$
(D) Rate = $k[B]^2$
(E) Rate = $k[A]^2[B]^2$

15.

Time (Hours)	[A] *M*
0	0.40
1	0.20
2	0.10
3	0.05

Reactant A underwent a decomposition reaction. The concentration of A was measured periodically and recorded in the chart above. Based on the data in the chart, which of the following is the rate law for the reaction?

(A) Rate = $k[A]$
(B) Rate = $k[A]^2$
(C) Rate = $2k[A]$
(D) Rate = $\frac{1}{2}k[A]$
(E) Rate = k

PROBLEMS

1. $$A + 2B \rightarrow 2C$$

The following results were obtained in experiments designed to study the rate of the reaction above:

Experiment	Initial Concentration (mol/L) [A]	[B]	Initial Rate of Disappearance of A (*M*/sec)
1	0.05	0.05	3.0×10^{-3}
2	0.05	0.10	6.0×10^{-3}
3	0.10	0.10	1.2×10^{-2}
4	0.20	0.10	2.4×10^{-2}

(a) Determine the order of the reaction with respect to each of the reactants, and write the rate law for the reaction.

(b) Calculate the value of the rate constant, k, for the reaction. Include the units.

(c) If another experiment is attempted with [A] and [B], both 0.02-molar, what would be the initial rate of disappearance of A?

(d) The following reaction mechanism was proposed for the reaction above:

$$A + B \rightarrow C + D$$
$$D + B \rightarrow C$$

(i) Show that the mechanism is consistent with the balanced reaction.

(ii) Show which step is the rate-determining step, and explain your choice.

2. $$2\,NO(g) + Br_2(g) \rightarrow 2\,NOBr(g)$$

The following results were obtained in experiments designed to study the rate of the reaction above:

Experiment	Initial Concentration (mol/L) [NO]	[Br_2]	Initial Rate of Appearance of NOBr (*M*/sec)
1	0.02	0.02	9.6×10^{-2}
2	0.04	0.02	3.8×10^{-1}
3	0.02	0.04	1.9×10^{-1}

(a) Write the rate law for the reaction.

(b) Calculate the value of the rate constant, k, for the reaction. Include the units.

(c) In experiment 2, what was the concentration of NO remaining when half of the original amount of Br_2 was consumed?

(d) Which of the following reaction mechanisms is consistent with the rate law established in (a)? Explain your choice.

I. $NO + NO \rightleftharpoons N_2O_2$ (fast)

$N_2O_2 + Br_2 \rightarrow 2\,NOBr$ (slow)

II. $Br_2 \rightarrow Br + Br$ (slow)

$2(NO + Br \rightarrow NOBr)$ (fast)

3. $$N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

Dinitrogen pentoxide gas decomposes according to the equation above. The first-order reaction was allowed to proceed at 40°C and the data below were collected.

$[N_2O_5]$ (*M*)	Time (min)
0.400	0.0
0.289	20.0
0.209	40.0
0.151	60.0
0.109	80.0

(a) Calculate the rate constant for the reaction using the values for concentration and time given in the table. Include units with your answer.

(b) After how many minutes will $[N_2O_5]$ be equal to 0.350 *M*?

(c) What will be the concentration of N_2O_5 after 100 minutes have elapsed?

(d) Calculate the initial rate of the reaction. Include units with your answer.

(e) What is the half-life of the reaction?

4. $$2\,A + B \rightarrow C + D$$

The following results were obtained in experiments designed to study the rate of the reaction above:

Experiment	Initial Concentration (moles/L) [A]	[B]	Initial Rate of Formation of D (*M*/min)
1	0.10	0.10	1.5×10^{-3}
2	0.20	0.20	3.0×10^{-3}
3	0.20	0.40	6.0×10^{-3}

(a) Write the rate law for the reaction.

(b) Calculate the value of the rate constant, *k*, for the reaction. Include the units.

(c) If experiment 2 goes to completion, what will be the final concentration of D? Assume that the volume is unchanged over the course of the reaction and that no D was present at the start of the experiment.

(d) Which of the following possible reaction mechanisms is consistent with the rate law found in (a)?

I. $A + B \rightarrow C + E$ (slow)

$A + E \rightarrow D$ (fast)

II. $B \rightarrow C + E$ (slow)

$A + E \rightarrow F$ (fast)

$A + F \rightarrow D$ (fast)

(e) Calculate the half-life of reactant B.

Essays

5. $$A(g) + B(g) \rightarrow C(g)$$

The reaction above is second order with respect to A and zero order with respect to B. Reactants A and B are present in a closed container. Predict how each of the following changes to the reaction system will affect the rate and rate constant and explain why.

(a) More gas A is added to the container.

(b) More gas B is added to the container.

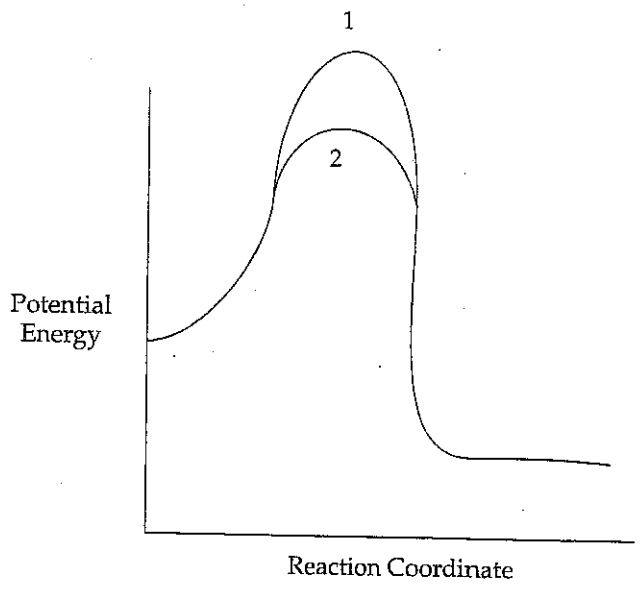
(c) The temperature is increased.

(d) An inert gas D is added to the container.

(e) The volume of the container is decreased.

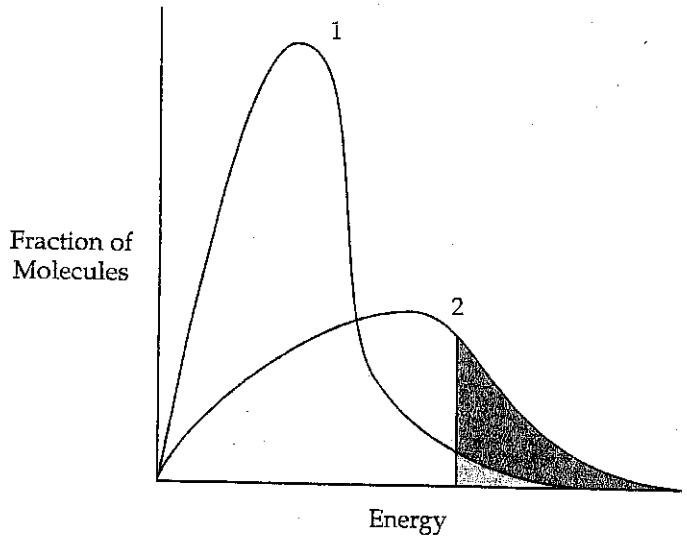
6. Use your knowledge of kinetics to answer the following questions. Justify your answers.

(a)



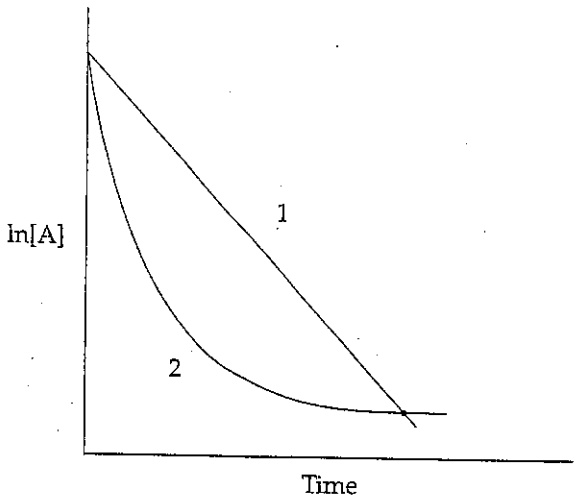
The two lines in the diagram above show different reaction pathways for the same reaction. Which of the two lines shows the reaction when a catalyst has been added?

(b)



Which of the two lines in the energy distribution diagram shows the conditions at a higher temperature?

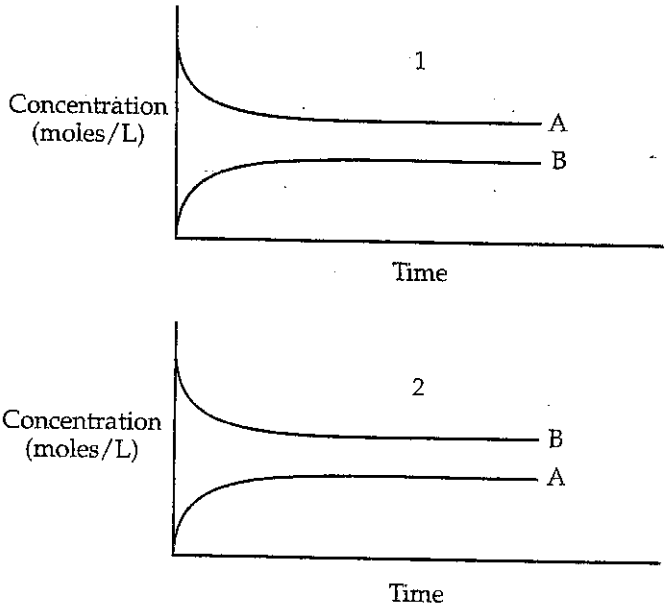
(c)



Which of the two lines in the diagram above shows the relationship of ln[A] to time for a first order reaction with the following rate law?

$$\text{Rate} = k[A]$$

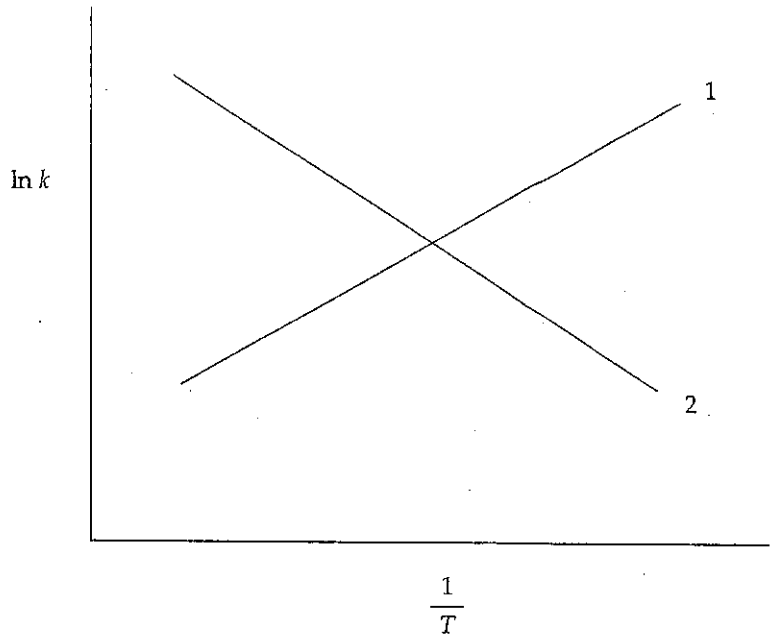
(d)



Which of the two graphs above shows the changes in concentration over time for the following reaction?

$$A \rightarrow B$$

(e)



Which of the two lines in the diagram above shows the relationship of ln k to $\frac{1}{T}$ for a reaction? How is the slope of the line related to the activation energy for the reaction?

7. Use your knowledge of kinetics to explain each of the following statements:

   (a) An increase in the temperature at which a reaction takes place causes an increase in reaction rate.

   (b) The addition of a catalyst increases the rate at which a reaction will take place.

   (c) A catalyst that has been ground into powder will be more effective than a solid block of the same catalyst.

   (d) Increasing the concentration of reactants increases the rate of a reaction.