

6.4 COLLISION THEORY AND RATE OF REACTION

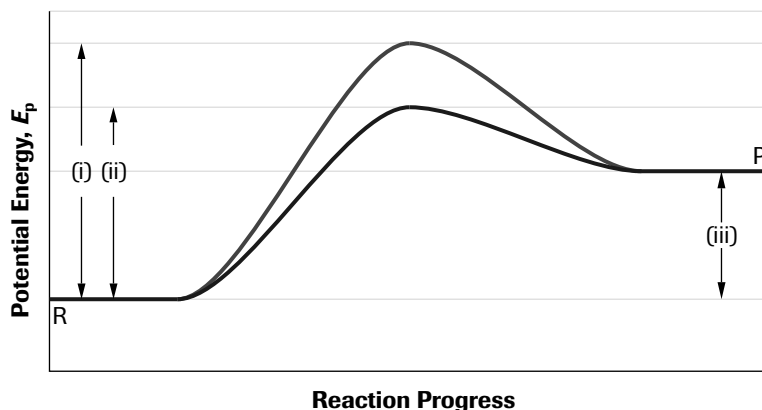
PRACTICE

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Understanding Concepts

1. (a)

Potential Energy Diagram for System R→P



- (b) The lower curve represents a catalyzed reaction; the upper curve represents the uncatalyzed reaction.
(c) The reaction is endothermic so heat flows from the surroundings into the system.
(d) (i) is the activation energy for the uncatalyzed reaction; (ii) is the activation energy for the catalyzed reaction; (iii) is the enthalpy change.

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Understanding Concepts

2. (a) When we compare Trials 1 and 2, we see that as $[A_2]$ is doubled, rate is multiplied by 2; therefore, rate depends on $[A_2]^1$.
When we compare Trials 1 and 3, we see that as $[B]$ is doubled, rate is multiplied by 1; therefore, rate depends on $[B]^0$.
Overall, rate, $r = k[A_2]^1$.
(b) The rate-determining step is $A_2 \rightarrow \text{product}$.
(c) $A_2 \rightarrow A + A$ (slow step)
 $A + B \rightarrow AB$ (fast step)

SECTION 6.4 QUESTIONS

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Understanding Concepts

1. An elementary step involves one, two, or three molecule collisions in a mechanism. The slowest elementary step in a mechanism is the rate-determining step.
2. (a) $2A + B + E \rightarrow F$
(b) The first step involves the most molecules and is probably the slowest, or rate-determining, step.
3. (a) 60 kJ (from reactants to highest activated complex)
(b) -35 kJ
(c) $R \rightarrow W$ (biggest individual activation energy)
(d) exothermic overall
(e) V, X, Z
(f) W, Y

Making Connections

4. (a) (Answers will vary.) The mechanism of the reaction involves collisions of octane and oxygen molecules in which single carbon–carbon and single carbon–hydrogen bonds are broken in succession down the hydrocarbon chain with reformation of bonds to form carbon dioxide and water molecules at each step.
(b) (Answers will vary.) Rates can be explained and predicted on the basis of collisions of molecules.
5. (a) (Answers will vary.) Ground-level ozone can damage lung tissue.
(b) Ground-level ozone is produced in the atmosphere by a photochemical smog mechanism, which involves the oxidations of volatile organic compounds in the presence of nitrogen oxides and sunlight.
(c) The reaction is catalyzed by the partially combusted hydrocarbon molecules that are produced in automobile exhausts.
6. (Answers will vary, but should include information about award-winning and more recent research and discoveries.)

6.5 EXPLAINING AND APPLYING CHEMICAL KINETICS

PRACTICE

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Understanding Concepts

1. (a) temperature, concentration, surface area
(b) temperature, catalysis, chemical nature of reactants
2. (a) $2 \text{H}_{2(g)} + \text{O}_{2(g)} \rightarrow 2 \text{H}_2\text{O}_{(g)}$
This reaction is unlikely to occur in a single step because it would involve the collision of three molecules simultaneously.
(b) (Answers will vary.) The actual mechanism appears to be:
$$\text{H}_2 + 2 \text{Pt} \rightarrow 2 \text{Pt-H}$$
$$\text{O}_2 + 2 \text{Pt} \rightarrow 2 \text{Pt-O}$$
$$\text{Pt-H} + \text{Pt-O} \rightarrow \text{Pt} + \text{Pt-OH}$$
$$\text{Pt-OH} + \text{Pt-H} \rightarrow 2 \text{Pt} + \text{H}_2\text{O}$$

(from <http://www.iupac.org/news/prize/2001/michaelides.html>)
3. (a) heterogeneous
(b) homogeneous (all gases)
(c) homogeneous (all aqueous)
(d) heterogeneous
4. (a) Oxalate ions are more complex than ferrous ions, requiring more precise collision geometry and a higher activation energy. The fraction of successful collisions is lower.
(b) Steel wool has a larger surface area than a nail. The collision frequency (i.e., the number of collisions per second among reactant molecules) is higher.
(c) Nitroglycerin tablets have a much lower concentration. The collision frequency (i.e., the number of collisions per second among reactant molecules) is higher.

Making Connections

5. (a) $\text{Cl}_{2(g)} + \text{H}_{2(g)} \rightarrow 2 \text{HCl}_{(g)}$
(b) $\text{Cl}_{(g)}$ and $\text{H}_{(g)}$
(c) Because a smaller activation energy barrier indicates a faster reaction rate, the collision with atomic chlorine must have a much smaller activation energy than that for molecular chlorine.
6. (Answers will vary, and should include specific reference to industrial applications catalyzed by platinum.) Examples include hydrogenation of ethene to ethane, formation of sulfur trioxide in sulfuric acid production, and even application in setting of dental impression compounds.
7. (Answers might include the following:)
 - addition of chemicals like salt or sugar (somewhat like inhibition or negative catalysis)
 - sealing (reducing concentration of oxygen in air)