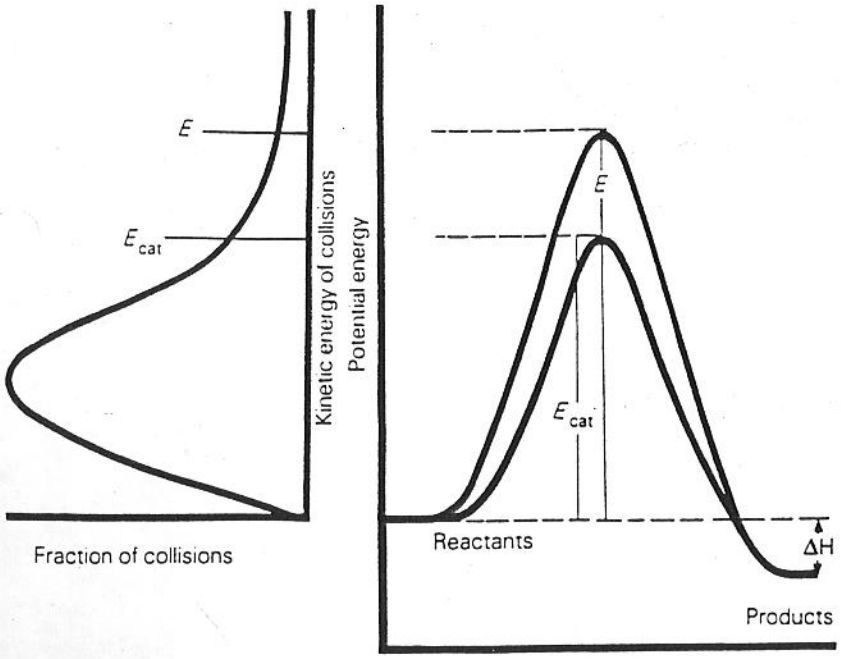

Figure 18-10 These graphs show another comparison of the curves in Figure 18-7 with the relationships for a catalyzed versus an uncatalyzed reaction. There are more collisions with sufficient kinetic energy to produce products for the catalyzed reaction. Note that the energy evolved in the reaction does not change. ΔH is the same for each, and is negative since the reaction is exothermic.

reaction will not occur. Preservatives used in foods and medical preparations are two examples of substances that contain inhibitors.

Do You Know?

Many very important industrial reactions could not occur without the presence of a catalyst. Some major catalysts are these:

i) finely divided iron (Fe) with small amounts of Al_2O_3 and K_2O, used in the manufacture of ammonia from nitrogen and hydrogen in the Haber Process

ii) platinum (Pt), used for the catalytic oxidation of ammonia to give NO, which, when reacted with more oxygen, as well as water, gives nitric acid

iii) platinum or vanadium pentoxide (V_2O_5), used in one step of the contact process for making sulfuric acid (in the reaction of SO_2 with O_2 to give SO_3)

iv) Al_2O_3 and SiO_2, used in the "cat-cracking" of heavy oils and kerosene to give gasoline

v) nickel (Ni), used for the hydrogenation of vegetable oils into solid fats in the manufacture of butter substitutes such as margarine

Review and Practice

look it up

2Na(s) + 2H2O(l) → 2NaOH(aq) + H2(g)

1. Write and balance the equation for the reaction of sodium and water.
2. Which reacts faster with water, lithium or potassium? K
3. Write the balanced equation for the reaction of magnesium with hydrochloric acid. Mg(s) + 2HCl(aq) → MgCl2(aq) + H2(g)
4. One piece of magnesium is reacted with 3.00*M* hydrochloric acid at 25°C. Another piece of magnesium of equal size and shape is reacted with 1.00*M* hydrochloric acid at 25°C. Predict which reaction occurs at a faster rate. 3M because ↑ [HCl]
5. A chunk of zinc is reacted with 3.00*M* hydrochloric acid at 25°C. An equal mass of powdered zinc is reacted with 3.00*M* hydrochloric acid at 25°C. Compare the reaction rates. ↑ powdered zinc faster ↑ surface area
6. State two ways that the number of effective collisions between reactants can be increased. ↑T or add a catalyst
7. How can the energy of collision be increased? ↑T
8. What is the name of the transitional structure formed during the process of breaking bonds and reforming new bonds? AC
9. How does a catalyst increase collision efficiency? by ↓E_A
10. How does increasing the concentration of a reactant affect the rate of a reaction? ↑ # coll ∴ ↑ rate

1. $2Na(s) + 2H_2O(l) \longrightarrow 2Na^+(aq) + 2OH^-(aq) + H_2(g) + \text{energy}$
2. potassium
3. $Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g) + \text{energy}$
4. the reaction in 3.00*M* HCl(*aq*)
5. Powdered zinc reacts faster.
6. increase temperature, use a catalyst
7. increase the temperature
8. activated complex
9. A catalyst provides a reaction pathway with a lower activation energy.
10. The rate is directly proportional to the concentration of the reactant.

complexes, and are therefore somewhat longer-lived. They correspond to the valleys in the potential energy diagram. Activated complexes occur at the peaks.

The ΔH for the reaction (potential energy of the products minus the potential energy of the reactants) is the same for both the catalyzed and the uncatalyzed reaction mechanisms. This is true for all reactions.

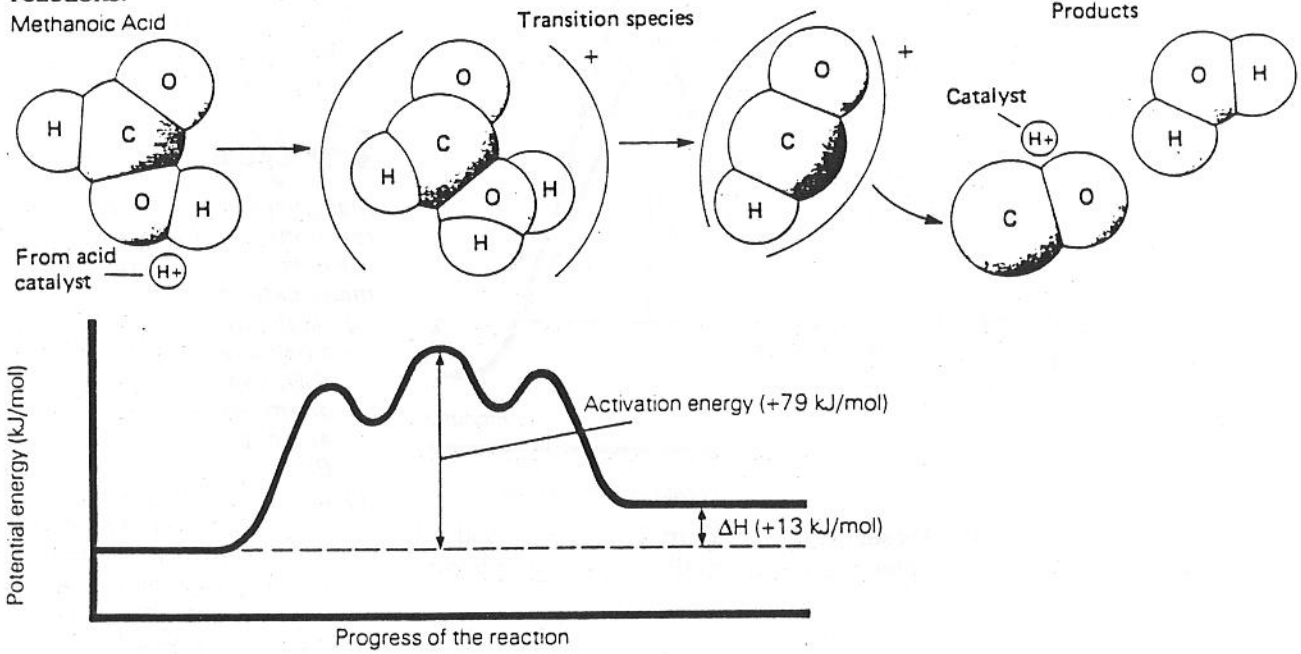

Figure 18-13 The reaction mechanism for the catalyzed decomposition of methanoic acid (top), and the corresponding potential energy diagram

Review and Practice

1. For the dishwashing analogy in Section 18-8, describe the effects on the reaction rate if a sixth person is added to
   a. clear the tables. b. wash dishes. c. dry dishes.

2. The P.E. diagram in Figure 18-14 shows an uncatalyzed exothermic reaction (solid line) and the corresponding catalyzed reaction (dotted line).
   a. Which step in the catalyzed reaction mechanism is the rate-determining step? 3rd step
   b. What is the activation energy for the forward uncatalyzed reaction?
   c. What is the activation energy for the forward catalyzed reaction?
   d. What is the ΔH for the reaction?

75 - 20 = 55 kJ

59 - 20 = 39 kJ

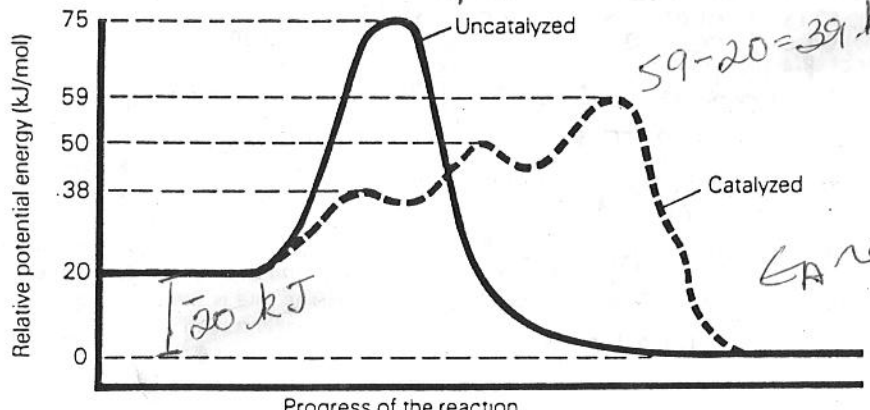

Figure 18-14

$E_{A_{rev}} = 59 - 0 = 59$ kJ

net time of reaction.

1. a no change
   b the rate is increased
   c no change
2. a the third step
   b +55 kJ/mol
   c +39 kJ/mol
   d -20 kJ/mol