Biochem

COOPERATIVITY

Cooperativity is another type of *allosteric activation.* The binding of one substrate molecule to one active site of one subunit of the enzyme causes a change in the entire molecule and locks all subunits in an active position. This mechanism amplifies the response of an enzyme to its substrates.

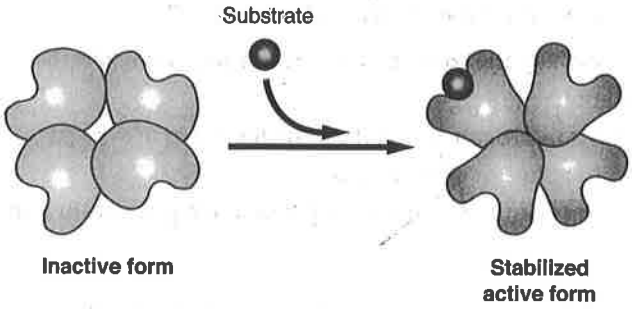


Figure 2.22 Cooperativity

MULTIPLE-CHOICE QUESTIONS

1. Which of the following is correct about isotopes of carbon?
   (A) They are all radioactive.
   (B) They contain the same number of neutrons but a different number of protons.
   (C) They contain the same number of electrons but are chemically different because the number of neutrons is different.
   (D) They are chemically identical because they have the same number of electrons.

2. All of the following are characteristics of water EXCEPT
   (A) water has a relatively high boiling point
   (B) water molecules have little attraction for each other
   (C) water is a universal solvent
   (D) ice is less dense than water

3. The pH of blood
   (A) is normally close to 7.4
   (B) is strongly acidic
   (C) varies with the needs of the cells
   (D) is about 6.9

4. Chaperonins are involved with
   (A) holding the two strands of DNA together
   (B) maintaining the normal pH level of blood
   (C) proper folding of proteins
   (D) enantiomers

5. Which of the following is stored in the human liver for energy?

(A) glucose
(B) glycogen
(C) glycerol
(D) glucagon

6. Which of the following is an example of a hydrogen bond?

(A) the attraction between the oxygen of one water molecule and the hydrogen of an adjacent molecule
(B) the bond between hydrogen and carbon in glucose or any sugar
(C) the peptide bond between amino acids
(D) the intramolecular bond between hydrogen and oxygen within a molecule of water

7. All of the following statements are correct about enzymes EXCEPT

(A) they raise the energy of activation of all reactions
(B) they enable reactions to occur at a relatively low temperature
(C) they remain unchanged during a reaction
(D) they are often located within the plasma membrane of the cell

8. Which statement is correct about pH?

(A) There are no hydrogen ions in a strong basic solution.
(B) Pure water has a neutral pH of 7 because the concentration of hydrogen ions equals the concentration of hydroxyl ions.
(C) The concentration of a solution with a pH of 5 is 5 times more acidic than a solution with pH 1.
(D) The concentration of hydrogen ions in a solution with a pH of 2 is 2,000 times more acidic than a solution with pH of 4.

9. Which of the following can be used to determine the rate of an enzyme-catalyzed reaction?

(A) the rate of substrate formed
(B) the decrease in temperature in the system
(C) the rate of enzyme used up
(D) the rate of substrate used up

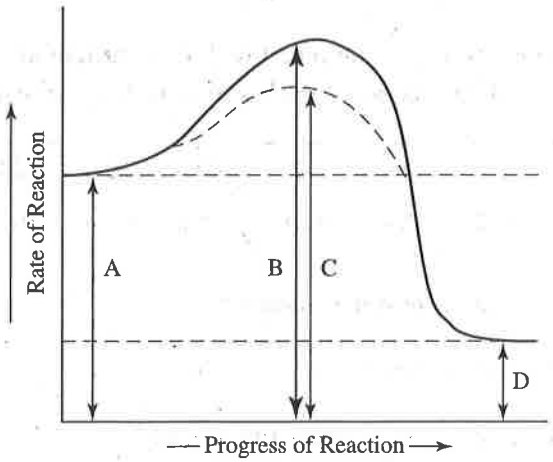
10. Which of the following best describes the reaction shown below?

$A + B \rightarrow AB + \text{energy}$

(A) hydrolysis
(B) an exergonic reaction
(C) an endergonic reaction
(D) catabolism

Questions 11–12

The graph below demonstrates two chemical reactions. One is catalyzed by an enzyme, one is not.



11. Which letter shows the energy of activation for the enzyme-catalyzed reaction?

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

12. Which letter shows the potential energy of the product?

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

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13. Which level of protein structure is most related to specificity?

(A) tertiary
(B) primary
(C) secondary
(D) quaternary

LAB QUESTIONS

Questions 14–20

In a lab experiment, one enzyme is combined with its substrate at time 0. The product is measured in micrograms at 20-second intervals and recorded on the data table below.

Time (s)	0	20	40	60	80	100	120
Product (μg)	0.0	0.25	0.50	0.70	0.80	0.85	0.85

14. What is the initial rate of the enzyme reaction?

15. What is the rate after 100 seconds?

16. Why is there no increase in product after 100 seconds?

17. What would happen if you added only more enzyme after 100 seconds?

18. What would happen if you added only more substrate after 100 seconds?

19. What would happen if you boiled the enzyme for 10 minutes before you did the experiment?

20. What would happen if you added strong acid to the enzyme 1 hour before you did the experiment?

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Answers to Multiple-Choice Questions

1. **(D)** Since they have the same number of electrons, isotopes of the same element are chemically identical. Only some of the isotopes of carbon (such as C-14) are radioactive. Isotopes vary only in the number of neutrons.

2. **(B)** Water molecules have strong attraction for each other because they are polar and because of strong hydrogen bonding between molecules.

3. **(A)** The pH of blood remains very close to 7.4 at all times and is maintained by the bicarbonate buffering system. This is an example of how an organism maintains homeostasis or internal stability.

4. **(C)** Molecules called chaperone proteins or chaperonins assist in the proper folding of other proteins.

5. **(B)** Glycogen is a polysaccharide that stores sugars in the liver and skeletal muscle. Glucose is not stored; it is produced and used up constantly. Glycerol and fatty acids make up lipids. Glucagon is a hormone that is responsible for breaking down glycogen into glucose. Glycine is the simplest amino acid.

6. **(A)** Hydrogen bonding is actually an intermolecular attraction between two molecules, not a covalent bond *within* one molecule. Choice B describes a covalent bond within a molecule. The bond between Na^+ and Cl^- is ionic. A peptide bond exists between the amino group of one amino acid and the carboxyl group of an adjacent amino acid.

7. **(A)** Enzymes lower the energy of activation, thus speeding up the reaction.

8. **(B)** The pH of a solution is neutral when the hydrogen ion (H^+) concentration equals the hydroxyl ion (OH^-) concentration. Pure water has a pH of 7 because it consists of equal amounts of H^+ and OH^-. Strong basic solutions contain mostly hydroxyl ions, but there are some hydrogen ions in it. The concentration of a solution of pH 5 is 10,000 times more acidic than a solution with pH 1. The concentration of hydrogen ions in a solution with a pH of 2 is 100 times more acidic than a solution with pH of 4. A solution with a pH of 5 means there are 1×10^{-5} moles of hydrogen ions in solution.

9. **(D)** Substrate is used up as the product is formed. Since enzymes are never used up, they are reused. So enzyme levels cannot be used to monitor the progress of a reaction. Enzymes lower the energy needed to begin the reaction (the E_A), but they do not affect the temperature of the system.

10. **(B)** The reaction is exergonic because it releases energy. Endergonic and endothermic are synonyms for a reaction that requires energy. Catabolism is the breaking down of a substance; this reaction is anabolic, a building-up process.

11. **(C)** Enzymes lower the energy of activation.

12. **(D)** The potential energy (PE) of the product is the same for both reactions.

13. **(A)** Tertiary structure dictates the three-dimensional shape and function of a protein.

Answers to Lab Questions

14. 0.25 µg per 20 seconds or 0.0125 µg/s. Rate is derived by taking the change in amount divided by the time. (0.25 µg – 0.00 µg)/20 s = 0.25 µg/20 s.

15. Zero. This is true because no new product is formed. The calculation is 0.85 – 0.85 = 0.

16. There is no increase in product after 100 seconds because all the enzymes are saturated and are already catalyzing reactions as fast as they can.

17. Assuming there is excess substrate that enzyme is not colliding with, an addition of enzyme after 100 seconds would increase the rate of reaction until the enzyme, once again, became saturated.

18. If you add more substrate after 100 seconds, there would be no change because the enzyme is saturated and reacting with as much substrate as it can. The enzyme cannot handle any more substrate. If you added both substrate and enzyme after 100 seconds, the reaction rate would increase temporarily until the enzyme became saturated once again.

19. If you boiled the enzyme prior to doing the experiment, you would get no product because the enzyme would probably have been denatured by the high heat and would not catalyze the reaction.

20. If you expose the enzyme to strong acid prior to doing the experiment, there would probably be no product because the enzyme would have been denatured by the acid.