CHEMICAL BASIS OF LIFE

#1 Describe an atom and how its structure affects interactions between atoms.

Introduction: Chemistry is essential for understanding physiology because body functions result from chemical changes within cells.

A. Structure of Matter

1. Matter: _____

2. Elements: _____

   a. Living organisms require about _____ (See Table 2.1 p. 31)
   _____, _____, _____, _____ make up more than 95% (by weight) of the human body.

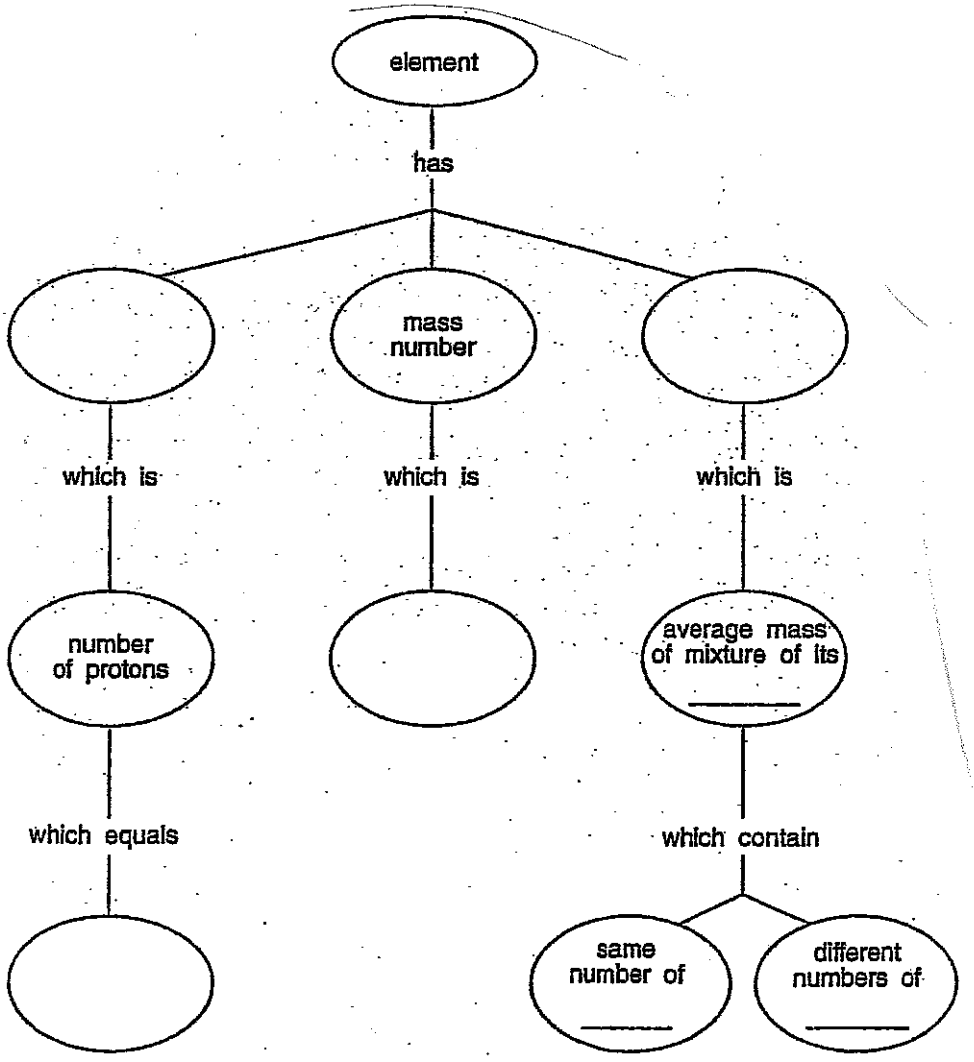
   b. are composed of _____: _____
   _____

   c. Insert the chemical symbol in the answer blanks for each of the following:

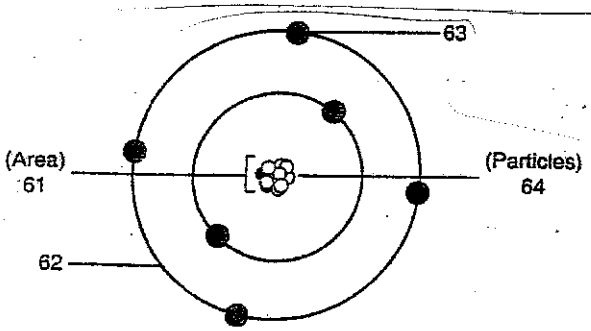
_____ oxygen	_____ iodine	_____ calcium	_____ magnesium	_____ iron
_____ hydrogen	_____ sodium	_____ chloride	_____ potassium	_____ zinc
_____ nitrogen	_____ phosphorus	_____ sulfur	_____ carbon	_____

B. Atomic Structure

1. Complete the *Glencoe* concept map. Use basic vocabulary for atomic structure.



2. Identify each numbered structure by labeling the following figure: Figure 2.1 Diagram of Atom



61 _____

62 _____

63 _____

64 _____

***If you are unsure of your chemistry knowledge, complete WKST A "Atomic Structure." Use the key to check your answers.

3. Complete WKST A *Atomic Structure. [It may help you to visualize the structure by coloring.]*

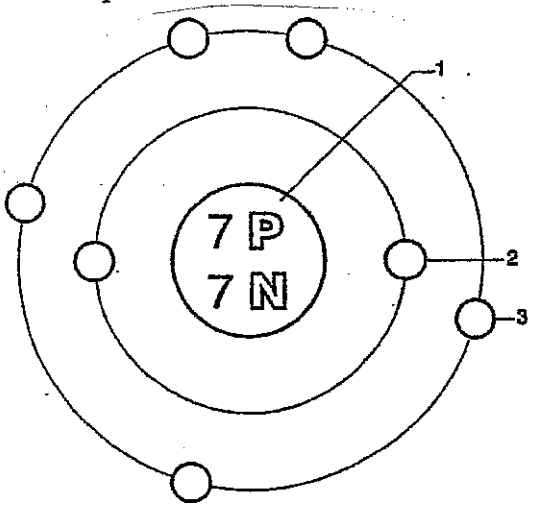


Figure 2.1. Atomic structure of nitrogen.

A. Atomic Structure

_____ **label:**

- O P (protons)
- O N (neutrons)

1. O nucleus
2. O electrons in first shell
3. O electrons in second shell

Exercise 2.1:

_____ 1. The nucleus contains _____ and _____ .

_____ a. Nitrogen's atomic number (number of protons) is _____ .

_____ b. Nitrogen's atomic mass (number of protons + number of neutrons) is _____ .

_____ 2. How many electrons does nitrogen have in the first shell? second shell? total?

_____ 3. Since protons are positive and electrons are negative, an *atom* (as it is shown here) has _____ (a positive charge, negative charge, no charge).

_____ 4. The first shell can hold a maximum of 2 electrons, the second a maximum of 8. Does nitrogen have a complete first shell? complete second shell?

_____ 5. The number of electrons in the outermost shell determines the chemical properties of an atom. Therefore, nitrogen would behave most like _____ (carbon with 6 electrons, oxygen with 8 electrons, phosphorus with 15 electrons).

6. Atoms are not stable unless their shells are filled with electrons.

_____ a. Would you expect nitrogen to be stable in the form that it is shown here?

_____ b. How many electrons would be needed to complete nitrogen's second shell?

_____ c. If we add electrons to complete nitrogen's second shell, would its charge change?

_____ 7. Groups of atoms with the same number of protons are called _____ (elements, compounds).

4. Isotopes
   a. Definition: _____
   b. are distinguished by _____: _____
   c. All isotopes of a particular element have the same number of e- and react _____ _____. Therefore, any of the isotopes of O can play the same role in an organism's metabolic reactions.
   d. Unstable isotopes *aka*: _____atomic fragments / energy
      aka: _____
      _____
   e. The three forms of atomic radiations are _____.
   f. The most penetrating form of atomic radiation is _____.
   g. Half-life: _____
   h. Half-life of I _____ P _____ Co _____ Ra _____
   i. Why are radioactive substances useful in medicine? _____
      _____
   j. List a use for each substance: I-131 _____; Tl-201 _____;
      Ga-67 _____; Co-60 _____
5. Atomic Weight
   a. Definition: _____
   b. Find the atomic weights for each of the four elements that are found in largest % in the body.

_____

Hint: Use the symbols to save space and the Appendix -1 for the answers!

6. Electron Shells
   a. The charge on atoms is _____.
   b. Chemical behavior of an atom results from _____.
   c. An atom with a full outer shell of e- is considered _____.
   d. An atom with an incomplete outer shell tends to _____.
      _____.

#2 Compare the ways in which atoms combine to form molecules and compounds.

C. Bonding of Atoms

1. Chemical bond: _____
   a. produces _____: chemical structures that contain more than one atom bonded together by shared e-
   b. or _____: any chemical substance made up of atoms of 2+ elements regardless of the type of bond joining them
   c. electrically charged atoms and molecules are: _____
   d. cation: _____ anion: _____
   e. List the 8 most common ions in body fluids: _____

_____

2. Types of bonds
   a. IONIC
      1) definition: _____
      2) the process is called _____
      3) Complete WKST D *Ionic Bonds on the following page.*
   b. COVALENT
      1) definition: _____
      2) Complete WKST C *Covalent Bonds on the following page.*
   c. HYDROGEN
      1) definition: _____
      2) These don't create molecules but alter molecular shapes or pull molecules together.

D. Ionic Bonds

Label each atom and color its electrons:

1. O sodium
2. O chlorine
3. O calcium

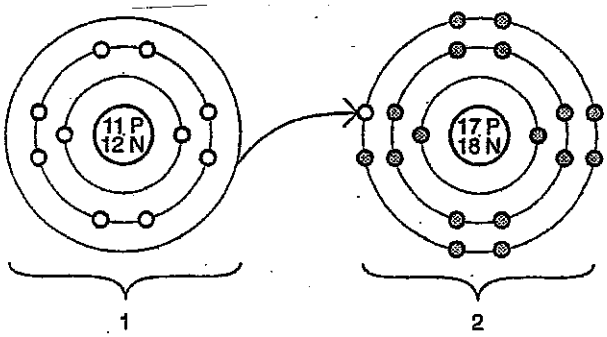


Figure 2.4a. Sodium chloride (NaCl).

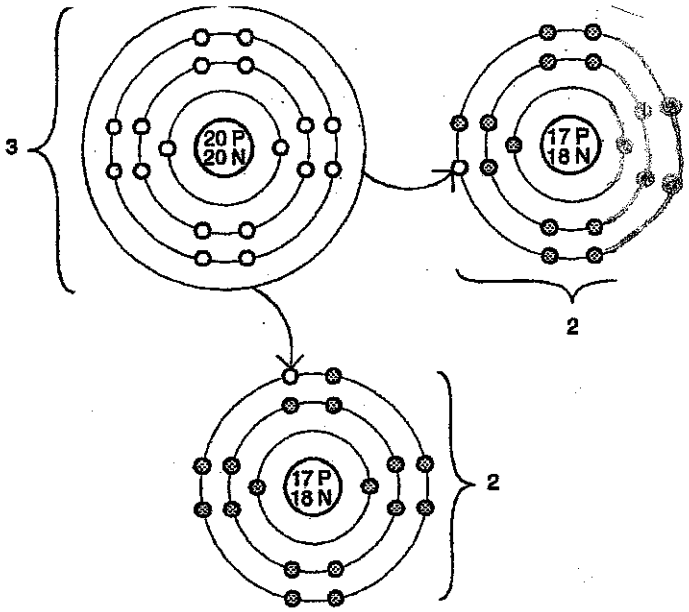


Figure 2.4b. Calcium chloride ($CaCl_2$).

_____ 1. Ionic bonding involves the transfer of electrons from one atom to another, fo ions. Which molecules show ionic bonding?

_____ a. For NaCl, _____ loses electrons nd _____ gains electrons.

_____ b. For NaCl, what are the charges on the newly formed *ions?*

_____ 2. Ionic bonding is the attraction of positive and negative ions. Which ions are a to each other in NaCl?

_____ 3. For $CaCl_2$, _____ loses electrons and _____ gain electrons.

_____ a. What is the charge on the calcium ion? chloride ion?

_____ b. Why is only one chlorine needed to accept sodium's electrons, while two chlorines are needed to accept calcium's electrons?

_____ 4. Does the sodium chloride molecule have a positive charge, negative charge, c charge? calcium chloride molecule?

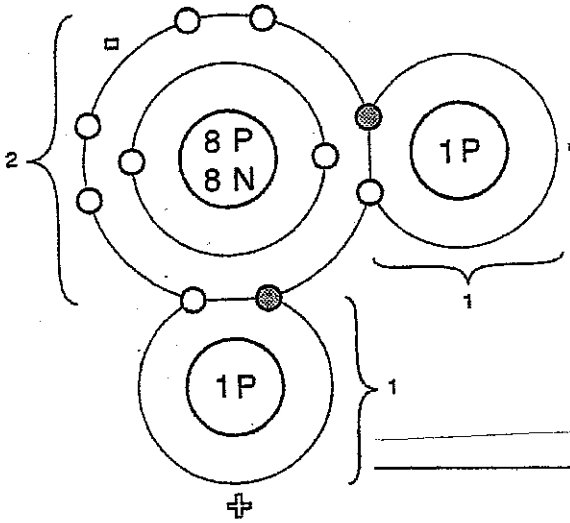


Figure 2.3a. Water (H_2O).

C. Covalent Bonds

Color and label:

O + electropositive

O –electronegative

Label each atom and color its electrons:

1. O hydrogen
2. O oxygen

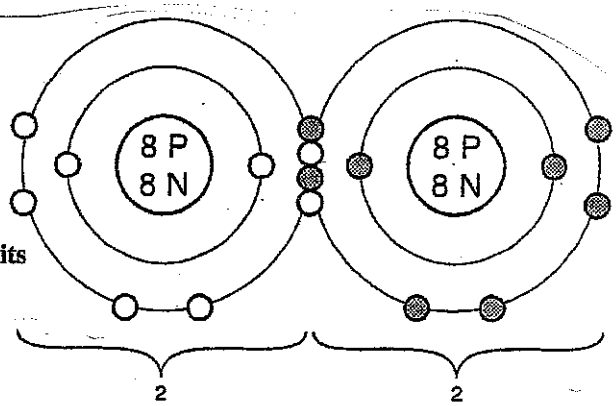


Figure 2.3b. Molecular oxygen (O_2).

_____ 1. Covalent bonding involves the sharing of electrons. Which molecules show covalent bonds?

_____ a. Single covalent bonds (sharing of two electrons) occur in _____ (H_2O, O_2).

_____ b. Double bonds (sharing of four electrons) occur in _____ (H_2O, O_2).

_____ 2. In the figures shown, the outer shell of oxygen has _____ (number) electrons and hydrogen has _____ (number) electrons.

_____ 3. Does covalent bonding create complete outer shells?

OBJECTIVE: #3 Use chemical notation to symbolize chemical reactions, and distinguish among three major types of chemical reactions that are important for studying physiology.

D. Chemical Reactions

1. Definition: _____
2. CIRCLE the option making the statement true. Reactants (go into / are produced) during a chemical reaction. Products (go into / are produced) during a chemical reaction.
3. are described using chemical shorthand or chemical notation for example: water _____ ; glucose _____; table salt _____; oxygen _____
4. Complete WKST H *Chemical Reactions. [It may help you to visualize the processes by coloring.]*

H. Chemical Reactions

Color:

- ○ reactants (chemicals going into reaction)
- ○ products (end result of reaction)

Label:

a. synthesis reaction
b. decomposition reaction
c. exchange reaction

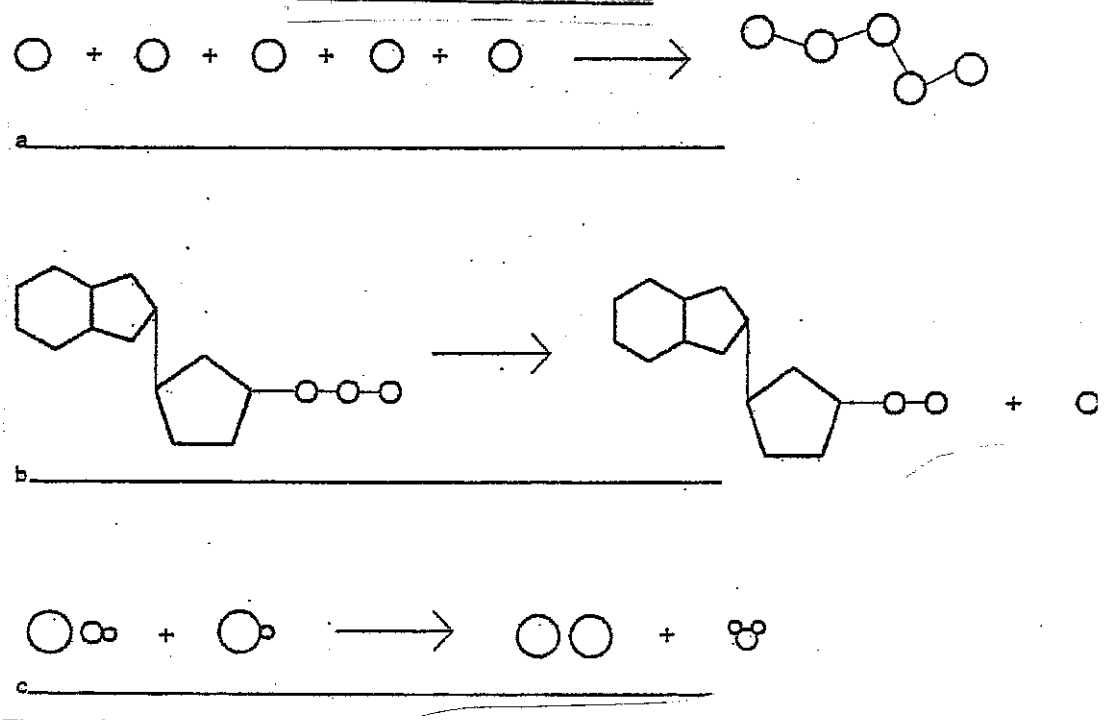


Figure 2.8 Types of chemical reactions.

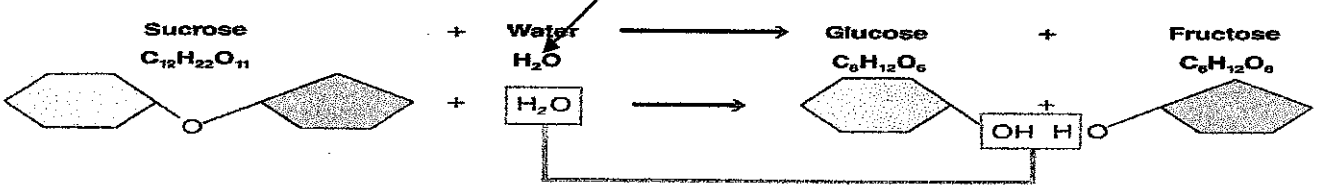
_____ 1. Bond formations that produce larger molecules are anabolic reactions. An example of an anabolic reaction is _____.

_____ 2. Breakage of bonds that results in the formation of smaller molecules are catabolic reactions. An example of a catabolic reaction is _____.

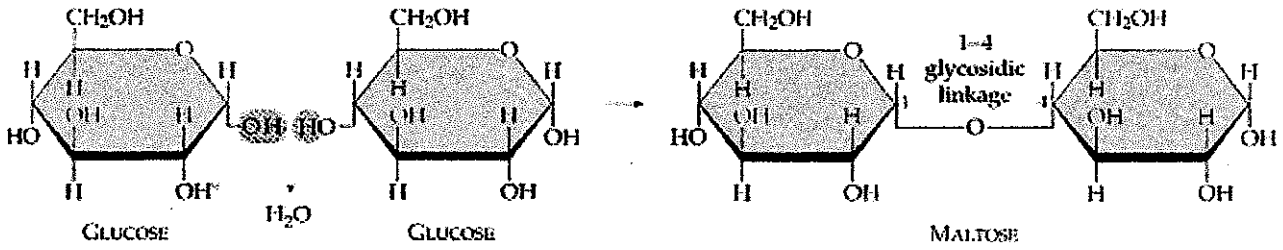
_____ 3. Endergonic reactions require an outside source of energy, which is then stored as chemical bond energy. Which are endergonic—anabolic or catabolic reactions?

_____ 4. Breakage of chemical bonds releases energy during exergonic reactions. Which are exergonic—anabolic or catabolic reactions?

5. a. A decomposition reaction involving the addition of a H_2O molecule: _____
   b. Cells can harness energy to power essential functions from the decomposition of complex molecules. This process is called _____



6. a. A reaction that is opposite of hydrolysis: _____
   also known as: _____
   b. Catabolism supports this process of building : _____



(a) Condensation synthesis of maltose

7. _____ are examples of exchange reactions in the body.
8. a. _____: 2 reactions occurring at the same time
   b. if balanced : _____

OBJECTIVE: #4 Describe the crucial role of enzymes in metabolism.

E. Enzymes *[also use pages 48-49 on Enzyme Function and Figure 2-18]*

9. Energy must be provided to activate reactants in chemical reactions. Activation energy is _____
10. Enzyme: aka: catalyst _____
11. Cells make enzyme molecules to promote specific reaction. Enzymes function to _____ _____ which in turn _____ chemical reactions.
12. a. If energy released is greater than activation energy: _____reaction.
    b. If more energy is required to begin the reaction: _____reaction.
13. Enzymatic binding depends on _____ of molecules.
14. a. Color and label figure 2.19 below.
    b. The presence of an enzyme (increases, decreases) the energy of activation. (Circle one.)
    c. How does the enzyme do this?
15. Complete WKST R *Enzymes.* (diagram below/questions on next page) *[It may help you to visualize the processes by coloring.]*

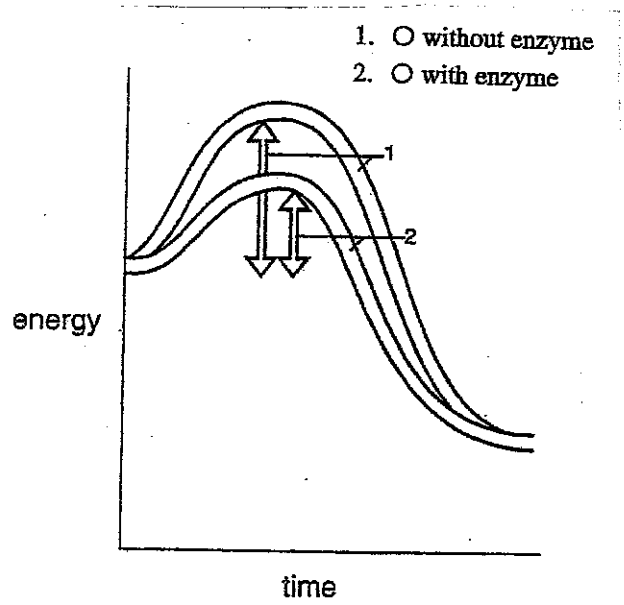


Figure 2.19. Effect of enzyme on energy of activation.

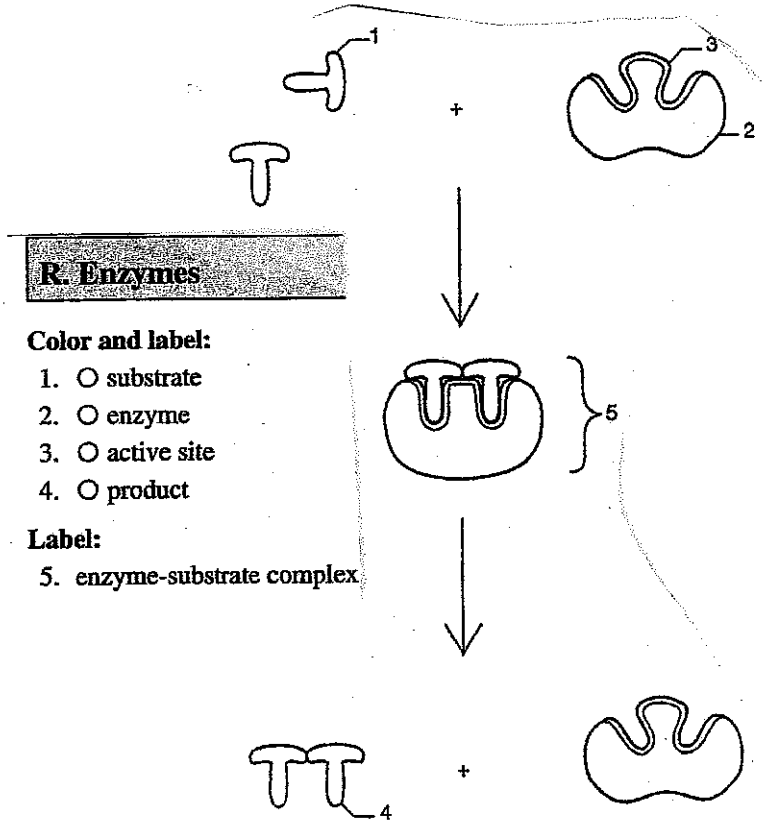


Figure 2.18. Enzyme action.

R. Enzymes

Exercise 2.18:

_____ 1. The molecule the enzyme reacts with is the _____.

_____ a. Do the substrates and active site have similar shapes?

_____ b. Would you expect the substrates and active site to be chemically compatible?

_____ c. Since physical and chemical fit are necessary for enzyme substrate interaction, would you expect enzymes to be specific or nonspecific in their reactions?

_____ 2. Does the shape of the enzyme shown change when it reacts with its substrates?

_____ 3. How does the enzyme help the substrate molecules react?

_____ 4. Is the enzyme used up in the reaction?

_____ 5. Since enzymes are proteins, what would happen to the shape of an enzyme as it is heated?

_____ 6. How will heating the system change the ability of the enzyme to function?

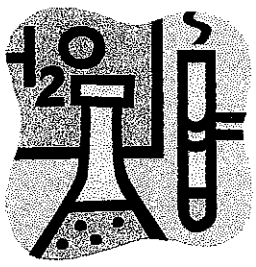
_____ 7. If the system cools, the rate of the reaction _____ (increases, remains the same, decreases).

_____ 8. Can a change in pH alter enzyme activity?

_____ 9. What would you expect the optimum pH to be for enzymes in the body?

OBJECTIVE: #6 Explain how the chemical properties of water make life possible.

F. Water and Physiological Systems



1. a. Characteristics
   1) single most important _____ of the body
   2) accounts for nearly _____ of body weight
   b. Properties
   1) _____ reactant for chemical reactions
   2) High _____: _____
   3) Excellent _____ → creates solutions for the reactions w/i living cells

OBJECTIVE: #7 Describe the pH scale and the role of buffers in body fluids.
OBJECTIVE: #8 Acids, bases, and salts are inorganic compounds with important physiological roles.

G. Acids, Bases, and pH

1. Acid: _____
   a. H^+ ions are referred to as protons; acids are referred to as proton donors
   b. example: _____
2. Base: _____
   a. OH^- ions react quickly w/ H^+ ions to form _____
   b. example _____
3. Salts: _____
   a. are examples of : electrolytes
   b. alterations in concentration can disturb _____

4. pH :
   a. definition: the negative logarithm of the H^+ concentration used to indicate the acidic or alkaline condition of a solution ; _____
   (Figure 2.9 p 40)
   b. What is the difference in concentration per whole number on the pH scale? _____
   c. In other words, a solution with a pH of 6 has _____ the hydrogen ion concentration of a solution with a pH of 7.
   d. Fill in the blanks on FIGURE 1.1 with the appropriate terms.

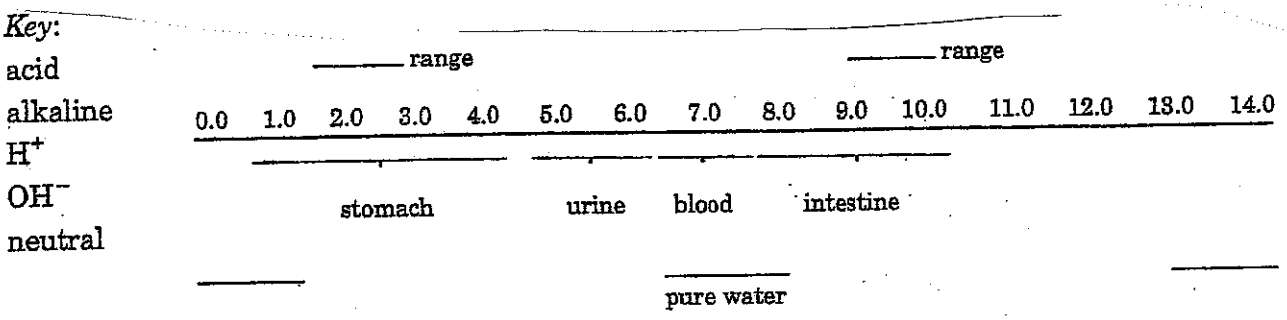


Figure 1.1 The pH scale.

5. pH of human blood: _____ (range _____) ; condition of blood pH drops below 7.35 _____; condition of blood pH above 7.45 _____

6. Fill in the blanks within the paragraph with the appropriate terms from the list:
acid acid-base acidity acidosis alkaline alkalosis higher lower H+ OH- neutral pH

It is essential to understand that a number on the ____ scale is actually the result of dividing the numeral 1 by a mathematical value called a logarithm. The result is that the _____ the concentration of _____ and consequently the greater the _____, the _____ the pH value. Thus pH 4.0 indicates a _____ concentration of H+ and a higher _____, than does pH 5.0 . Most cells are extremely sensitive to changes in the pH of their fluid. The pH of human blood plasma is usually maintained at a value between 7.34 and 7.44 – that is, blood plasma is slightly _____. The normal burning of food by the cells releases carbon dioxide (CO_2), which forms carbonic acid when combined with water. The foods we commonly eat contain Na, K, and Ca, and these substances form _____compounds within the body. When the normal limits of the blood plasma pH are greatly exceeded in either direction along the scale, _____ (pH below 6.8) or _____ (pH above 7.8) can lead to serious illness and even death, unless a proper _____ balance is restored.

7. a. _____ are compounds that stabilize pH by either removing or replacing H^+
   b. List 3 examples of these: _____, _____, _____