CHAPTER 3
ENERGY, CATALYSIS, AND BIOSYNTHESIS

Catalysis and the Use of Energy by Cells

3-1 Chemical reactions carried out by living systems depend on the ability of some organisms to capture and use atoms from nonliving sources in the environment. The specific subset of these reactions that breakdown nutrients in food can be described as _____.

(a) metabolic
(b) catabolic
(c) anabolic
(d) biosynthetic

3-2 The second law of thermodynamics states that the disorder in any system is always increasing. In simple terms, you can think about dropping NaCl crystals into a glass of water. The solvation and diffusion of ions is favored because there is an increase in _____.

(a) pH
(b) entropy
(c) ionic structure
(d) stored energy

3-3 The energy used by the cell to generate specific biological molecules and highly ordered structures is stored in the form of _____.

(a) Brownian motion
(b) heat
(c) light waves
(d) chemical bonds

3-4 At first glance, it may seem that living systems are able to defy the second law of thermodynamics. However, on closer examination it becomes clear that although cells create organization from raw materials in the environment, they also contribute to disorder in the environment by releasing _____.

(a) water
(b) radiation
(c) heat
(d) proteins

3-5 If you weigh yourself on a scale one morning then eat four pounds of food during the day, will you weigh four pounds more the next morning? Why or why not? Hint: What happens to the atoms contained in the food as useful energy is derived from metabolizing the food molecules?

3-6 Which of the following statements are true or false? If a statement is false, explain why it is false.

A. The second law of thermodynamics states that the total amount of energy in the Universe does not change.
B. The ultimate source of energy for living systems is chlorophyll.
C. CO_2 gas is fixed in a series of reactions that are light-dependent.
D. H_2 is the most stable and abundant form of hydrogen in the environment.

3-7 Two college roommates do not agree on the best way to handle the clutter piled up in your dorm room. Roommate 1 explains that chaos is inevitable, so why fight it? Roommate 2 counters that maintaining an organized environment makes life easier in many ways, and that chaos is not inevitable. What law of thermodynamics drives the thinking of roommate 1? What thermodynamic argument can be used to support roommate 2?

3-8 Assume that the average human adult requires 2000 kilocalories per day to sustain all normal processes and maintain a constant weight. If manufactured solar panels could somehow provide power directly to the human body, what size solar panel would be required (in cm^2)? Assume there are 10 hours of sunlight per day, and that the usable energy output for a typical solar panel is 850 kJ/ft^2 per hour.

Note: 1 kcal = 4.184 kJ
1 ft^2 = 929.03 cm^2

3-9 Fill in the blanks, selecting from the choices below.

Light + _____ + _____ → _____ + heat + sugars

CO, CO_2, O_2, H_2, H_2O, N_2, NO

3-10 During respiration, energy is retrieved from the high-energy bonds found in certain organic molecules. Which of the following, in addition to energy, are the ultimate products of respiration?

(a) CO_2, H_2O
(b) CH_3, H_2O
(c) CH_2OH, O_2
(d) CO_2, O_2

3-13 For each of the pairs A–D in Figure Q3-13, pick the more reduced member of the pair.

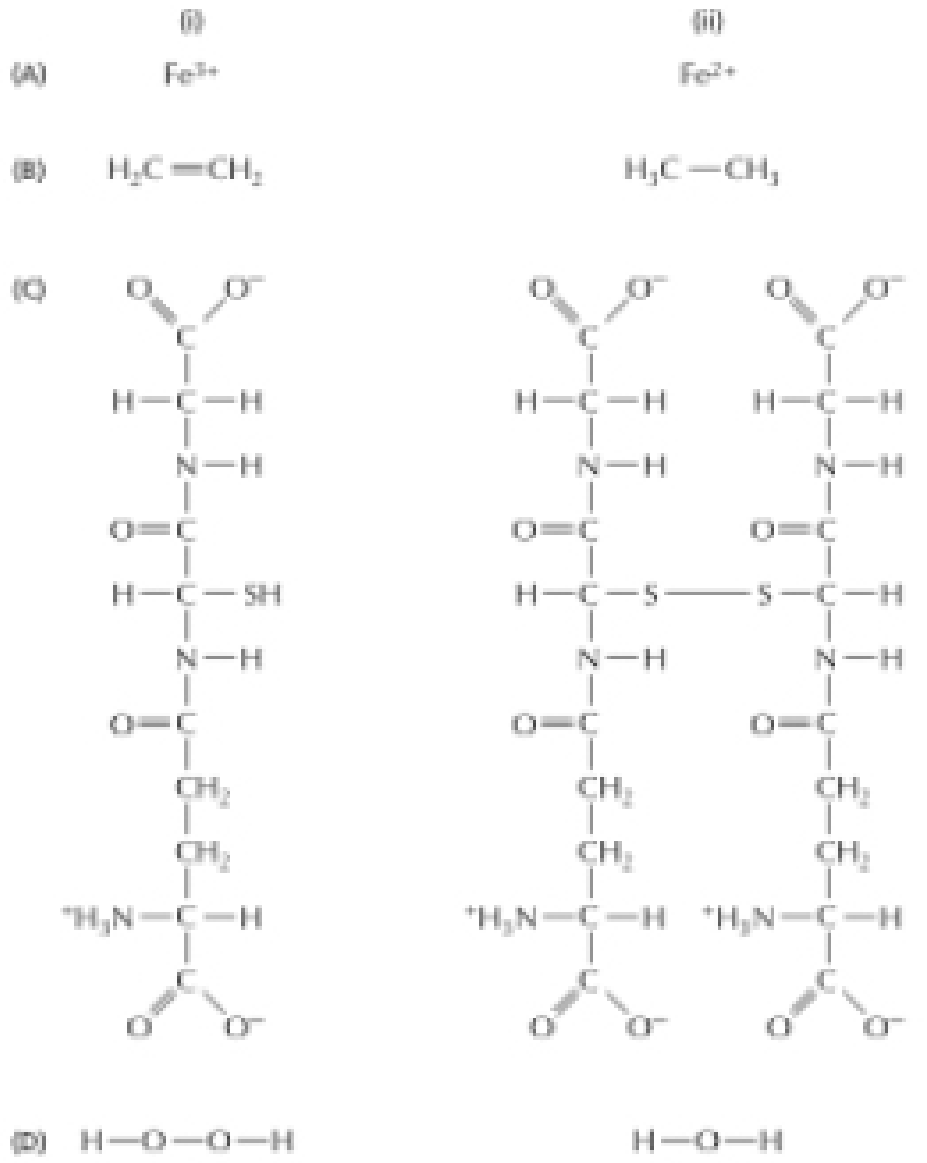

Figure Q3-13

3-14 Oxidation is the process by which oxygen atoms are added to a target molecule. Generally, the atom that is oxidized will experience which of the following with respect to the electrons in its outer shell?

(a) a net gain
(b) a net loss
(c) no change
(d) an equal sharing

3-15 When elemental sodium is added to water, the sodium atoms ionize spontaneously. Uncharged Na becomes Na^+. This means that the Na atoms have been _____.

(a) protonated
(b) oxidized
(c) hydrogenated
(d) reduced

3-16 Arrange the following molecules in order with respect to their relative levels of oxidation (assign 5 to the most oxidized and 1 to the most reduced).

_____ CH_2O (formaldehyde)

_____ CH_4 (methane)