

Becker's World of the Cell, 8e (Hardin/Bertoni/Kleinsmith)

Chapter 2 The Chemistry of the Cell

Multiple-Choice Questions

1) What branch of chemistry deals specifically with living systems?

- A) organic chemistry
- B) inorganic chemistry
- C) biochemistry
- D) biological chemistry
- E) both choices C and D

Answer: E

2) Ribose has five carbon atoms, of which three are asymmetric. What is the maximum number of stereoisomers that may exist for ribose?

- A) 2
- B) 4
- C) 6
- D) 8
- E) 10

Answer: D

3) Which of the following is *not* a fundamental property of carbon?

- A) Carbon-containing molecules are diverse.
- B) Carbon-containing molecules form stereoisomers.
- C) Carbon-containing molecules are stable.
- D) Carbon has a valence of 4.
- E) Carbon atoms are most likely to form ionic bonds with one another.

Answer: E

4) Which of the following is *true* of an asymmetric carbon atom?

- A) Only amino acids have asymmetric carbon atoms.
- B) A carbon with hydrogens attached at two locations is usually asymmetric.
- C) Methane has an asymmetric carbon.
- D) Asymmetric carbon atoms create stereoisomers.
- E) Molecules may have only one asymmetric carbon atom.

Answer: D

5) Carbon can form _____ covalent bonds.

- A) single
- B) double
- C) triple
- D) single and double
- E) single, double, and triple

Answer: E

6) Which of the following is a unit of energy?

- A) calorie
- B) joule
- C) watt
- D) mole
- E) both choices A and B

Answer: E

7) Biologically, which of the following is the *least* important characteristic of water?

- A) Water molecules are polar.
- B) Water molecules have numerous hydrogen bonds.
- C) Water is a good solvent.
- D) Water typically contains isotopes of hydrogen.
- E) Water has a temperature-stabilizing capacity.

Answer: D

8) While fishing, a biology student makes the following observations:

- 1) Water spiders appear to be able walk on the surface of the water.
- 2) Flat rocks may be made to skip across the water.

Which of the following properties of water can explain these observations?

- A) Water is an excellent solvent.
- B) Water molecules create spheres of hydration around solute molecules.
- C) Water molecules are cohesive.
- D) Water molecules are often associated via hydrogen bonds.
- E) both choices C and D

Answer: E

9) The moon lacks life and varies dramatically in temperature. If we could keep a layer of water spread on the surface of the moon, what effect would it have?

- A) Physical conditions would remain the same.
- B) Because water has a high heat of vaporization, the temperatures would rise to the upper extremes.
- C) The temperatures would drop to the lower extremes.
- D) Water would absorb and hold heat and moderate the temperature extremes.
- E) Life would be possible, but it would have to withstand these extremes in temperature.

Answer: D

10) Why do polar substances such as NaCl dissolve so readily in water?

- A) NaCl is a very dry powder, and the water is able to soak into the salt.
- B) The sodium ions repel the negative end of the water molecule.
- C) Spheres of hydration form between the water and the ions.
- D) The charged ends of the water molecules are able to surround the oppositely charged salt ion.
- E) both choices C and D

Answer: E

11) In the lab, you choose to design a simple experiment to distinguish between hydrophilic and hydrophobic substances. You start by adding equal amounts of vinegar and oil to a container. After shaking, the vinegar and oil levels separate, based upon polarity and density. To this you add glucose and sodium citrate and shake again. Where do you expect to find the glucose and sodium citrate in greatest quantities?

- A) Both will concentrate in the oil layer.
- B) The glucose will concentrate in the vinegar, sodium citrate in the oil.
- C) Both will concentrate in the vinegar layer.
- D) Sodium citrate will concentrate in the vinegar, glucose in the oil.
- E) Both will be uniform throughout both layers.

Answer: C

12) Which of the following is *false* regarding water's specific heat?

- A) The specific heat of water is 1.0 calorie per gram.
- B) Heat applied to water must initially break a number of hydrogen bonds.
- C) Water's high specific heat has a temperature-buffering effect.
- D) Water gains and loses heat more slowly than most other solvents do.
- E) The specific heat of water is similar to most liquids.

Answer: E

13) Why is a selectively permeable membrane so important to living things?

- A) It allows cells to attach to adjacent tissues.
- B) It provides a good barrier between the inside and outside of the cell.
- C) Proteins will avoid a selectively permeable membrane.
- D) The membrane may absorb several times its weight in cholesterol.
- E) all of the above

Answer: B

14) The term *amphipathic* refers to those molecules that are

- A) hydrophilic.
- B) hydrophobic.
- C) charged at both ends but with opposite charges.
- D) nonpolar at both ends.
- E) charged at one end and nonpolar at the other.

Answer: E

15) The cell membrane can be described most accurately as

- A) permeable to most small molecules but impermeable to larger ones.
- B) permeable to only larger molecules.
- C) permeable to all molecules.
- D) permeable to some molecules and impermeable to others.
- E) impermeable to all polar molecules.

Answer: D

16) Because membranes usually are not permeable to polysaccharides, nucleic acids, and proteins, how are cells able to incorporate these molecules?

- A) These macromolecules are only incorporated into structures outside the membrane.
- B) Macromolecules are broken down extracellularly, and their subunits diffuse through the membrane.
- C) Macromolecules are digested extracellularly, and their subunits move through transport proteins.
- D) Macromolecules are transported via endocytosis and are digested within the cell.
- E) both choices C and D

Answer: E

17) The cell membrane can be described most accurately as

- A) permeable to all small molecules and ions but impermeable to larger ones.
- B) permeable to only larger molecules.
- C) permeable to some molecules and impermeable to others.
- D) impermeable to all polar molecules.
- E) permeable to all molecules.

Answer: C

18) Detergents are best able to dissolve oil from fabric or dishes during washing because

- A) the positively charged end is associated with a sphere of hydration, while the negatively charged end interacts with the oil droplet.
- B) the negatively charged end is associated with a sphere of hydration, while the positively charged end interacts with the oil droplet.
- C) the nonpolar end is associated with a sphere of hydration, while the charged end interacts with the oil droplet.
- D) the charged end is associated with a sphere of hydration, while the nonpolar end interacts with the oil droplet.
- E) because detergents are nonpolar, they increase the size of the oil droplet, allowing the water to be more effective at removing the oil.

Answer: D

19) While synthesizing a new blue pigment, a chemist notices that the new compound congregates between an aqueous (water) environment and a hydrophobic environment. When added to a mixture of oil and water, the pigment creates a blue ring around the droplets of oil. Which of the following statements best describes this new pigment?

- A) The pigment is a polar molecule and is forming hydrogen bonds with both the water and oil molecules.
- B) The pigment is hydrophilic and will not form hydrophobic bonds with the oil.
- C) The pigment is amphipathic, having polar and nonpolar regions.
- D) The pigment is neither polar nor nonpolar; it is apolar.
- E) The pigment is probably hydrophobic and is attempting to bond with the oil.

Answer: C

20) Which of the following is *not* true of hydrocarbons?

- A) Octane is a hydrocarbon.
- B) Hydrocarbons are insoluble in water.
- C) Many hydrocarbons are used in living systems.
- D) Only hydrogen atoms are used to complete the valence requirements of carbon.
- E) Phospholipids have hydrocarbon tails.

Answer: C

21) Which of the following is *not* a possible noncovalent interaction?

- A) hydrogen bonding
- B) ionic bonding
- C) van der Waals interactions
- D) hydrophobic interactions
- E) polar covalent bonding

Answer: E

22) Which one of the following biological polymers is mismatched with its monomer?

- A) DNA - nucleotide
- B) enzyme - amino acid
- C) chitin - monosaccharide
- D) protein - amino acid
- E) cellulose - amino acid

Answer: E

23) Which of the following is *not* an activated monomer?

- A) adenosine triphosphate
- B) glucose-6-phosphate
- C) aminoacyl tRNA
- D) amino acid
- E) uracil triphosphate

Answer: D

24) Which of the following statements about the polymerization of macromolecules is *false*?

- A) Often the energy needed for polymerization is supplied by ATP.
- B) The polymer chain usually has two different ends.
- C) Water is added to join the monomers of the macromolecules.
- D) A monomer is usually activated by the coupling of the monomer to a carrier.
- E) Macromolecules are synthesized by the stepwise addition of monomers.

Answer: C

25) Which of the following is *not* a structural polysaccharide?

- A) glycogen
- B) peptidoglycan
- C) cellulose
- D) chitin
- E) All of the above are structural polysaccharides.

Answer: A

26) The polymerization of different types of macromolecules is similar in many respects. Which of the following principles below is *least* likely to be common to all methods of polymerization of macromolecules?

- A) To be added to the polymer, the monomer must be activated.
- B) Macromolecules are synthesized by the addition of monomers.
- C) The polymer is directional.
- D) Polymerization is passive, requiring little ATP.
- E) As monomers are added to the polymer, water is removed from the macromolecule.

Answer: D

27) Which of the following is *not* soluble in water?

- A) lipids
- B) sugars
- C) amino acids
- D) disaccharides
- E) nucleic acids

Answer: A

28) The hierarchical nature of cellular structure is accurately illustrated in which of the following lists of substances (from smallest to largest)?

- A) nucleotides, chromosome, DNA, nucleus, cell
- B) cellulose, glucose, cell wall, cell
- C) nucleotides, nucleus, DNA, chromosome, cell
- D) nucleotides, DNA, chromosome, nucleus, cell
- E) protein, membrane, amino acids, chloroplast, cell

Answer: D

29) Which of the following sequences correctly lists the hierarchical nature of cellular structures, from smallest to largest?

- A) organic molecules, supramolecular structures, macromolecules, organelles, cells
- B) organelles, organic molecules, supramolecular structures, macromolecules, cells
- C) organic molecules, macromolecules, organelles, supramolecular structures, cells
- D) organic molecules, macromolecules, supramolecular structures, organelles, cells
- E) macromolecules, organic molecules, supramolecular structures, organelles, cells

Answer: D

30) An enzyme synthesized in the laboratory is found to have little activity when compared to the enzyme extracted from cell culture. Both enzymes were examined and have identical amino acid composition. What is the best explanation for the lack of activity of the synthesized enzyme?

- A) The van der Waals radius was altered during laboratory synthesis.
- B) The synthetic enzyme was not made of amino acids.
- C) The ATP required for self-assembly was present in the cell extract but not in the laboratory synthesis.
- D) Denaturation of the synthesized enzyme was not complete.
- E) The synthesized enzyme was not folded correctly because molecular chaperones were not present.

Answer: E

31) A hypothetical automobile has 100 parts that are to be assembled by four workers. During the car's assembly, each worker constructs 25 parts individually, and then the four resulting components are assembled together. The manner in which the car was assembled is much like which cellular strategy?

- A) hierarchical assembly
- B) renaturation
- C) electrostatic assembly
- D) self-assembly
- E) assisted self-assembly

Answer: A

32) Heat shock proteins are

- A) only actively synthesized during conditions of intense heat.
- B) only observed in prokaryotic cells.
- C) molecular chaperones synthesized during times of cellular stress.
- D) unique to every organism.
- E) present only in certain organelles.

Answer: C

33) Which of the following molecules is involved with assisted assembly?

- A) water molecules
- B) helper proteins
- C) molecular chaperones
- D) tobacco mosaic viruses
- E) none of the above

Answer: C

34) Which of the following was *not* considered part of the "alphabet of biochemistry" by George Wald?

- A) the 20 amino acids
- B) the 5 nucleotide bases
- C) two sugars
- D) three lipids
- E) seven proteins

Answer: E

35) Self-assembly is limited by

- A) the size of the molecule.
- B) the presence of water in the cytosol.
- C) information of preexisting structures.
- D) the time associated with forming solely noncovalent interactions.
- E) all of the above

Answer: C

36) All of the following are common functional groups found in biological molecules *except*

- A) phosphate groups.
- B) carbonyl groups.
- C) amino groups.
- D) sulfhydryl groups.
- E) butyl groups.

Answer: E

37) Which of the following is an informational macromolecule?

- A) DNA
- B) ATP
- C) starch
- D) glycogen
- E) polypeptide

Answer: A

38) Monomers are removed from polymers by _____ reactions.

- A) condensation
- B) hydrolysis
- C) neutralization
- D) substitution
- E) redox

Answer: B

39) Self-assembly has been utilized or potentially may be used for all of the following applications *except*

- A) nanotechnology.
- B) electrical conductivity.
- C) biosensors.
- D) drug delivery systems.
- E) All of the above are examples.

Answer: E

40) Which of the following structures will self-assemble?

- A) ribosomes
- B) nucleosomes
- C) translocons
- D) huntingtin
- E) all of the above

Answer: A

Matching Questions

Choose the item in column 2 that best matches each item in column 1.

- A) assists in lipid assembly
- B) nucleic acid
- C) hydroxyl group
- D) methyl group
- E) spheres of hydration
- F) lipid bilayer
- G) ATP
- H) assists in protein assembly
- I) glycogen

- 1) molecular chaperone
- 2) important in hydrogen bonding
- 3) structural polysaccharide
- 4) informational macromolecule
- 5) membrane structure
- J) cellulose

Answers: 1) H 2) C 3) J 4) B 5) F

Match the choice on the left with the choice on the right.

- A) TATA box
- B) disulfide bonds
- C) ribosome
- D) subassembly
- E) ethylene and carbon dioxide
- F) lipase
- G) nitrogen gas
- H) addition of monomer
- I) ionic bond
- J) TMV self-assembly
- K) disassembly

- 6) important in renaturation
- 7) Heinz Fraenkel-Conrat
- 8) condensation reaction
- 9) examples of double bond
- 10) electrostatic interactions
- 11) requirement of hierarchical assembly

Answers: 6) B 7) J 8) H 9) E 10) I 11) D

Match the interaction or bond on the left with the phrase that best describes it on the right.

- A) sharing of electrons
- B) noncovalent attraction among water molecules
- C) association of nonpolar groups
- D) electrostatic interactions
- E) transient interactions at very close range

- 12) hydrogen bond
- 13) ionic bond
- 14) van der Waals interactions
- 15) hydrophobic interaction
- 16) covalent bonding

Answers: 12) B 13) D 14) E 15) C 16) A

Short Answer Questions

1) TMV, or _____, is a rodlike particle with a genome of _____ and a _____ consisting of 2130 copies of a single polypeptide.

Answer: tobacco mosaic virus; RNA; protein coat (capsid)

2) The purpose of reducing and oxidizing agents in denaturation and renaturation is the breaking and reforming of the _____ bond.

Answer: disulfide

3) _____ and _____ groups are negatively charged functional groups of carbon, whereas the _____ group is a positively charged functional group.

Answer: Carboxyl; phosphoryl; amino

4) As a protein is being synthesized, the correct folding of the protein is aided by the movement of nonpolar amino acids toward the inner areas of the protein. How can this phenomenon be explained?

Answer: The exclusion of hydrophobic groups from the aqueous surface is called the hydrophobic effect.

5) The cell membrane is composed of a _____ bilayer. This molecule has regions that are polar and nonpolar and is therefore _____.

Answer: phospholipid; amphipathic

6) The _____ of water is caused by the unequal sharing of electrons between oxygen and hydrogen atoms.

Answer: polarity

7) A selectively _____ membrane is one that allows some molecules to pass through but not others.

Answer: permeable

8) Due to the directionality of polymer synthesis, proteins have distinct _____ and _____ ends.

Answer: amino (-NH₂); carboxyl (-COOH)

9) In order to facilitate polymerization, monomers must be _____.

Answer: activated

10) _____ aid in the assembly of some biomolecules.

Answer: Molecular chaperones

11) _____ carbon atoms allow for the formation of _____, which are mirror images of each other.

Answer: Asymmetric; stereoisomers

12) Macromolecules can be assembled into _____ that are components of organelles and other subcellular organelles.

Answer: supramolecular structures

13) Polymers are synthesized by _____ reactions and broken down into their constituent monomers by _____ reactions.

Answer: condensation; hydrolysis

14) Because carbon is able to form up to four covalent bonds, it can take on a variety of orientations, including linear, _____, and _____ structures.

Answer: branched; ring-containing

Inquiry

1) Water has many unique properties. Can you identify the property of water that is responsible for each of the following observations?

- a. Many insects, such as the water strider, are able to move across the surface of water.
- b. Most people get chilled immediately after taking a shower.
- c. A dime can be made to "float" on the surface of a glass of water.
- d. The dime will sink if salt is added to the water.
- e. On cold days, the water temperature is often warmer than the surrounding air.
- f. Ice forms on the surface of lakes and rivers.
- g. Many salts dissolve in water.
- h. Many oils will not dissolve in water.
- i. The coastal areas of the world have a climate that is more moderate than inland areas.
- j. Some springs contain high amounts of arsenic.
- k. The Great Salt Lake contains high quantities of mineral solutes.

Answer:

- a. Water is cohesive.
- b. Water has a high heat of vaporization.
- c. Water is cohesive.
- d. Water is a good solvent, but a solute reduces its cohesiveness.
- e. Water has a high specific heat.
- f. Water forms a less dense crystalline structure when solid.
- g. Water is a good solvent.
- h. Water is polar.
- i. Water has a temperature-stabilizing capacity.
- j. Water is a good solvent.
- k. Water is a good solvent.

2) Macromolecules are synthesized by a series of steps. Monomers are systematically added to the growing polymer. From what you have learned about the synthesis of macromolecules, can you suggest why people who are trying to lose weight are asked to drink plenty of water?

Answer: Since water is released in the synthesis of polymers like fats (condensation reaction), water will be needed for the breakdown of fat molecules (hydrolysis).

3) For each of the three basic macromolecules (proteins, polysaccharides, and nucleic acids), identify the monomer, its activated/carrier form, and the directionality of the molecule.

Answer: Proteins: amino acids; charged amino acyl tRNAs; $\text{NH}_2 \rightarrow \text{COOH}$.

Polysaccharides: monosaccharides; monosaccharide phosphates; based upon their linkage but typically carbon 1 (or carbon 2) of one monosaccharide to the carbon 2, carbon 3, carbon 4, carbon 5, or carbon 6 of another monosaccharide.

Nucleic acids: nucleotides; nucleotide triphosphates (NTPs); $5' \rightarrow 3'$.

4) Describe how the amphipathic nature of phospholipids leads to the formation of the phospholipid bilayer organization observed in membrane structure. Based upon this information, how would you design a drug delivery system to cross the cell membrane?

Answer: Basically, student answers should include the orientation of phospholipids such that the phosphate ends are surrounded by a hydrating sphere and the hydrophobic tails sequestered within each other (giving the bilayer organization). The drugs could be placed inside phospholipid micelles that would be able to deliver the drugs by fusing with the cell membrane and releasing their contents into the cytoplasm.

5) Describe the ways in which cell membranes are semipermeable.

Answer: Descriptions should include: hydrophilic substances requiring a transporter protein (unless they are less than 600 daltons in size); hydrophobic substances may pass through the membrane; ions require ion channels.