

Microbiology: A Clinical Approach, Second Edition
Chapter 2 Fundamental Chemistry for Microbiology
Question Bank

Multiple Choice

1. Which of the following indicates the correct order of the items from simple to complex?
- A. molecules > atoms > cells > tissues
 - B. Tissues > cells > molecules > atoms
 - C. Cells > molecules > atoms > tissues
 - D. Atoms > molecules > cells > tissues
 - E. Atoms > molecules > tissues > cells

Answer: D

Feedback: Tissues are composed of cells which are composed of molecules which are composed of atoms.

Difficulty: 4

2. Atomic structure gives an atom
- A. Its mass
 - B. Its reactivity
 - C. Its valence in molecules
 - D. All of the above

Answer: D

Feedback: The structure of an atom gives its mass, which is the sum of its protons and neutrons, and its reactivity and valence, which depend on its outer shell of electrons.

Difficulty: 1

3. Which of the following statements is **not true**?
- A. Oxygen has 2 unpaired electrons in the second shell.
 - B. Nitrogen has 7 electrons which occupy the first and second shells.
 - C. Hydrogen has an atomic number of 1 and an atomic weight of 2.
 - D. Carbon has an atomic number of 6 and an atomic weight of 12.
 - E. The third shell must contain 18 electrons to be stable.

Answer: C

Feedback: The atomic weight of hydrogen is 1 as it does not have any neutrons.

Difficulty: 1

4. The quaternary structure of a protein refers to
- A. Its amino acid sequence
 - B. The way the protein folds
 - C. The links that stabilize the protein
 - D. The way protein subunits interact with each other
 - E. All of the above

Answer: D

Feedback: Quaternary structure occurs in very large proteins in which multiple polypeptides (protein subunits) are joined together. This joining together of individual polypeptide chains also occurs through the formation of bonds and between amino acids in the individual polypeptide chains.

Difficulty: 1

5. Cations are different from anions because cations
- A. Have a positive charge
 - B. Are formed by the loss of an electron
 - C. Are attracted to negatively charged ions
 - D. Include Na^+ , Li^+ , Mg^{2+} , Al^{3+}
 - E. All of the choices

Answer: E

Feedback:

Cations have a positive charge, are formed by the loss of an electron, and are attracted to negatively charged ions. Na^+ , Li^+ , Mg^{2+} , and Al^{3+} are all examples of cations. In contrast, anions have a negative charge, are formed by the gain of an electron, and are attracted to positively charged ions.

Difficulty: 2

6. When a molecule only contains sets of 2 shared electrons, it must contain which bonds?
- A. Hydrogen
 - B. Inorganic
 - C. Ionic
 - D. Covalent

Answer: D

Feedback: A covalent bond is the chemical bond that involves the sharing of pairs of electrons between atoms.

Difficulty: 1

7. Chemical bonding between two different atoms always occurs between their
- A. Unfilled outer orbital
 - B. Nuclei
 - C. First shells
 - D. Cores
 - E. Third shells

Answer: A

Feedback: A bond is particularly likely to form if the atoms contain unshared electrons in their outer orbitals.

Difficulty: 1

8. Which is **not true** of covalent bonds?
- A. They can be polar
 - B. They can be nonpolar
 - C. They can be composed of cations and anions
 - D. They occur when electrons are shared between atoms
 - E. Most molecules synthesized in cells are covalently bonded

Answer: C

Feedback: An ionic bond is formed between a positively charged cation which has donated an electron, and the negatively charged anion which received the donated electron. Covalent bonds can be nonpolar, where the shared electron pair is equidistant from the nuclei in the bond, or polar, if the electron pair is closer to one nucleus than the other. Most of the molecules synthesized in the cell contain carbon in covalent linkage to itself or other atoms.

Difficulty: 1

9. An atom that has donated an electron to form an ionic bond is classified as _____ and is positively charged.
- A. A cation
 - B. Polar
 - C. Nonpolar
 - D. A solvent
 - E. An anion

Answer: A

Feedback: A cation is a positively charged atom that has donated an electron to form an ionic bond.

Difficulty: 1

Instructor Note: students will need to access the periodic table.

- 10.** Investigate the periodic table. What is the common theme of the elements in Column 2?
- A. They can all become readily accept electrons
 - B. The ions they form will be negative
 - C. The ions they form will have a single charge
 - D. The ions they form will have a double charge

Answer: D

Feedback: The elements in Column 2 of the periodic table, such as Beryllium, Magnesium, and Calcium, all have 2 electrons in their outer shell which they can readily lose to form doubly charged cations.

Difficulty: 4

- 11.** Carbon atoms can form how many bonds with other atoms?
- A. 6
 - B. 12
 - C. 4
 - D. 2
 - E. 8

Answer: C

Feedback: We learn from the periodic table the following: name, carbon; symbol, C; atomic number, 6; atomic weight, 12.0107. Carbon has six electrons, two filling the first shell and four in its outer shell. These four spin in the unfilled outer shell allowing for four covalent bonds to be formed.

Difficulty: 4

- 12.** Chlorine has at atomic number of 17. Therefore, which of the following is **not correct** regarding chlorine?
- A. Chlorine has a mass number of 34
 - B. Chlorine has 2 electrons in the first shell, 8 electrons in the second shell, and 7 electrons in the third shell
 - C. If chlorine accepts an electron, it becomes a chloride cation
 - D. Chlorine needs only one electron to fill its outer shell
 - E. Atomic chlorine has 17 electrons

Answer: A

Feedback: Chlorine has an atomic mass of 35 not 34. Although in some cases the mass is twice the atomic number, the atomic number does not necessarily give information about the mass.

Difficulty: 3

13. Carbon dioxide (CO₂) forms as a result of
- A. Ionic bonds forming between carbon and oxygen
 - B. Two pairs of electrons from the carbon forming double covalent bonds with each oxygen
 - C. Single covalent bonds between carbon and oxygen
 - D. Hydrogen bonding between carbon and oxygen

Answer: B

Feedback: The structure of carbon dioxide is O=C=O.

Difficulty: 1

14. _____ bonds form when electrons are transferred between atoms, whereas _____ bonds involve the sharing of electrons.
- A. Covalent; hydrogen
 - B. Hydrogen; covalent
 - C. Ionic; hydrogen
 - D. Covalent; ionic
 - E. Ionic; covalent

Answer: E

Feedback: Answers can be found in the glossary.

Difficulty: 1

15. Water surrounds cations and anions and keeps them dissociated in solution by forming
- A. Nonpolar covalent bonds
 - B. Tertiary structure
 - C. Peptide bonds
 - D. Active sites
 - E. Spheres of hydration

Answer: E

Feedback: A sphere of hydration is a set of water molecules that surround an ion. The oxygen atoms in the water molecule are attracted electrostatically to the positive charge on the metal ion.

Difficulty: 1

16. The components of ATP include
- A. Adenine, ribose sugar, and three phosphates
 - B. Amino acid and three phosphates
 - C. Adenine, triglycerols, and one phosphate
 - D. Adenine, deoxyribose sugar, and three phosphates

Answer: A

Feedback: ATP is the abbreviation for adenosine triphosphate. Adenosine is the adduct of adenine and ribose.

Difficulty: 4

17. Which of the following statements is correct?
- A. A base is a H^+ ion donor
 - B. Pure water is completely neutral and has a pH of 0
 - C. On a pH scale, gastric fluids are classified as alkaline
 - D. H^+ ion concentration is inversely related to pH
 - E. If the hydroxyl ions outnumber the H^+ ions, the pH will be less than 7.0

Answer: D

Feedback: High H^+ concentration results in a low pH. Therefore pH is inversely related to the hydrogen ion concentration.

Difficulty: 3

18. Which of the following is *not* synthesized by cells?
- A. Carbohydrates
 - B. Nucleic acids
 - C. Proteins
 - D. Lipids
 - E. Nalco

Answer: E

Feedback: Carbohydrates, nucleic acids, proteins, and lipids are all synthesized by living organisms.

Difficulty: 4

19. The part of a biological molecule that participates in chemical reactions is referred to as
- A. ATP
 - B. A covalent bond
 - C. Primary structure
 - D. An active site

E. A functional group

Answer: E

Feedback: Functional groups are specific groups of atoms or bonds within molecules that are responsible for the characteristic chemical reactions of those molecules.

Difficulty: 1

20. Animals store carbohydrates in the form of

- A. Monosaccharide's
- B. Glycogen
- C. Starch
- D. Disaccharides
- E. Cellulose

Answer: B

Feedback: Glycogen is a polymer and is stored in the liver, muscle, and fat cells. After carbohydrate ingestion, more glycogen is produced, and is then released as blood glucose levels fall.

Difficulty: 4

21. What is the chemical formula of glucose?

- A. $C_6H_{12}O_6$
- B. $C_5H_{10}O_5$
- C. $C_4H_8O_5$
- D. $C_6H_6O_{12}$
- E. $C_{12}H_6O_6$

Answer: A

Feedback: Glucose is a hexose containing six carbon atoms. Glucose has a -CHO group, four other carbons contain H-C-OH, and the sixth carbon is of the form H- CH- OH.

Difficulty: 1

22. When two monosaccharides are joined together, _____ is formed through _____ synthesis.

- A. A disaccharide; dehydration
- B. A polysaccharide; hydrolysis
- C. Glycogen; dehydration
- D. A disaccharide; hydrolysis
- E. Starch; dehydration

Answer: A

Feedback: Two monosaccharides combine to form a disaccharide and release H₂O (H-O-H) through dehydration.

Difficulty: 2

23. Which of the following molecules is **not** a lipid?

- A. Cholesterol
- B. Glycolipid
- C. Steroid
- D. Glycogen
- E. Phospholipid

Answer: D

Feedback: Glycogen is a carbohydrate. All the carbons of glycogen contain hydrophilic substitutions and it is soluble in water.

Difficulty: 4

24. What is common to all monoglycerides, diglycerides, and triacylglycerol (fats)?

- A. Three fatty acids
- B. Glycerol
- C. An amino acid
- D. A monosaccharide
- E. A nitrogenous base

Answer: B

Feedback: All glycerides contain glycerol.

Difficulty: 4

25. Fatty acids are removed from triacylglycerols by the chemical process of

- A. Dehydration
- B. Hydration
- C. Solvation
- D. Polarity
- E. Hydrolysis

Answer: E

Feedback: The link between the fatty acid and glycerol is replaced by the addition of water.

Difficulty: 1

26. Which of the following is part of a glycolipid?
- A. Adenine
 - B. Amino acid
 - C. Carbohydrate
 - D. Phosphate
 - E. ATP

Answer: C

Feedback: Glycolipids are lipids with carbohydrates attached.

Difficulty: 4

27. A triglyceride contains fatty acids that are _____ and therefore do not dissolve with water.
- A. Hydrophilic
 - B. Carbohydrates
 - C. No lipid groups
 - D. Ribose sugars
 - E. Hydrophobic

Answer: E

Feedback: The carboxyl end of the molecule is hydrophilic but the majority of molecule is hydrophobic and cannot interface with water.

Difficulty: 1

28. Which of the following is a steroid found in animal cell membranes?
- A. Glycolipid
 - B. Cholesterol
 - C. Nucleic acid
 - D. Amino acid
 - E. Protein

Answer: B

Feedback: Cholesterol is a steroid which is a component of plasma membranes in many eukaryotic cells.

Difficulty: 4

29. The building blocks of _____ are _____.
- A. Polysaccharides; fatty acids
 - B. DNA; ribose

- C. Steroids; glucose
- D. Proteins; amino acids
- E. Glycogen; starch

Answer: D

Feedback: Amino acids are the building blocks of proteins. Polysaccharides are composed of monosaccharides, nucleic acids of nucleotides, and glycogen of glucose. Steroids are derived from fatty acids.

Difficulty: 4

- 30.** All 20 amino acids have three common chemical components attached to a central carbon. Which of the following **is not attached**?
- A. Hydrogen
 - B. Carboxyl group
 - C. Glucose
 - D. Amino group

Answer: C

Feedback: The three common components attached to the central carbon of an amino acid are a carboxyl, an amino group, and a hydrogen. The fourth link can be any of 20 different chemical groups, none of which are glucose.

Difficulty: 4

- 31.** Some proteins form _____ which stabilizes their folding.
- A. Spheres of hydration
 - B. Double bonds
 - C. Disulfide bridges
 - D. Magnetic resonance
 - E. Energy of activation

Answer: C

Feedback: Disulfide bridges contribute to the three dimensional shape of polypeptides.

Difficulty: 4

- 32.** Helices and pleated sheets that contribute to protein structure are considered to be which level of protein structure?
- A. Primary
 - B. Secondary
 - C. Tertiary
 - D. Quaternary

Answer: B

Feedback: Secondary structures involve the coiling or folding of the polypeptide brought about by the sequence of amino acids and hydrogen bonds between amino acids. Secondary structures include alpha helices, beta pleated sheets, or random coils.

Difficulty: 4

33. Which of the following refers to the loss of protein three dimensional structure when temperature or pH is altered?
- A. Denaturation
 - B. Polarity
 - C. Hydration
 - D. Hydrolysis
 - E. Dehydration

Answer: A

Feedback: The loss of the original structure of a protein is called denaturation.

Difficulty: 1

34. The purines of nucleic acids are
- A. Adenine and guanine
 - B. Thymine and guanine
 - C. Adenine and cytosine
 - D. Thymine and cytosine
 - E. Uracil and guanine

Answer: A

Feedback: The two purines are adenine and guanine. The basic purine structure contains 5 carbon and 4 nitrogen atoms in two aromatic rings.

Difficulty: 4

35. DNA differs from RNA in that
- A. DNA uses the sugar deoxyribose, whereas RNA uses the sugar ribose
 - B. Only DNA has 5-prime to 3-prime direction
 - C. DNA uses uracil, whereas RNA uses thymine
 - D. DNA is usually found as a single chain, whereas RNA is usually found as a double helix

Answer: A

Feedback: DNA contains the sugar deoxyribose, uses thymine, and is usually found as a double helix. RNA contains the sugar ribose, uses uracil, and is usually found as a single chain. Both DNA and RNA have 5-prime to 3-prime direction.

Difficulty: 4

- 36.** All of the following are components of a nucleotide **except**
- A. Nitrogenous base
 - B. Phosphate group
 - C. Amino acid
 - D. Pentose sugar

Answer: C.

Feedback: Nucleotides do not contain amino acids. A nucleotide contains a nitrogenous base, phosphate group, and a pentose sugar.

Difficulty: 4

- 37.** The term antiparallel means that DNA
- A. Has two strands that run in opposite directions
 - B. Has secondary structure in both strands
 - C. Has one strand containing deoxyribose sugars and the other containing ribose sugars
 - D. Can bind to RNA by using complementary base pairs
 - E. Contains purines, whereas RNA contains pyrimidines

Answer: A

Feedback: Each DNA strand is composed of a phosphate and sugar backbone linked together in a 5' to 3' direction. Double-stranded DNA has two strands running in opposite directions (antiparallel), one going from 5' to 3' end and the other from 3' to 5' end.

Difficulty: 4

Essay

- 38.** Name and describe the four levels of protein structure and the chemical bonds involved at each level. Why is protein structure important?

Answer: Protein structure has four levels: primary, secondary, tertiary, and quaternary. Primary structure is simply the linear sequence of amino acids held together by peptide bonds. Secondary structure uses hydrogen bonds on the backbone of the polypeptide to form folds (pleated sheets) and coils (helices). Tertiary structure uses hydrogen bonds, disulfide bonds, and other weak

bonds between R groups to provide folding of the chain upon itself, creating major three-dimensional structure. Quaternary structure is used only by proteins that are composed of more than one polypeptide chain and also involves hydrogen bonds and disulfide bonds as seen with tertiary structure. Protein structure is important as determines protein functionality. If a protein does not fold correctly or becomes denatured, the functionality of the protein is lost.

Difficulty: 2

39. In the context of structure and function, explain why lowering the pH of a solution would inhibit an enzyme's activity.

Answer: The vast majority of enzymes are proteins made up of amino acids held together by peptide bonds. The weak bonds that stabilize secondary, tertiary, and quaternary structure that are responsible for the three-dimensional structure of enzymes are destabilized by alterations in pH, causing denaturation. If an enzyme becomes denatured its active site may adopt a different conformation that will no longer be able to bind to reactants. Therefore, changing the structure of an enzyme disrupts its function.

Difficulty: 4

40. In terms of chemical structure discuss the similarities and differences between DNA and RNA.

Answer: DNA and RNA are both nucleic acids composed of polymers of nucleotides held together by covalent phosphodiester bonds found on the sugar phosphate backbone. In both cases, the nucleotides contain a phosphate group, a pentose sugar, and a nitrogenous base, which can be either a purine or a pyrimidine. DNA and RNA both exhibit polarity, with a distinct 5' terminal (the phosphate end) and a 3' terminal (the pentose sugar end). DNA and RNA use the purines adenine and guanine.

DNA and RNA differ in that DNA has a deoxyribose sugar, whereas RNA has a ribose sugar. They use different pyrimidines with DNA using cytosine and thymine, and RNA using cytosine and uracil. DNA is usually a double-stranded antiparallel molecule stabilized by hydrogen bonding between adenine and thymine, and also between guanine and cytosine. In contrast, RNA is most often found as a single-stranded molecule.

Difficulty: 4