# *Life The Science of Biology 11th edition Sadava Test Bank*

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# Test Bank

to accompany

*Life: The Science of Biology,* Eleventh Edition

Sadava • Hillis • Heller • Hacker

## Chapter 2: Small Molecules and the Chemistry of Life

## TEST BANK QUESTIONS

### Multiple Choice

1. An atom with _____ has an atomic mass of 14.
a. 14 neutrons
b. 14 electrons
c. 7 neutrons and 7 electrons
d. 7 protons and 7 electrons
e. 6 protons and 8 neutrons
Answer: e
Learning Outcome: 2.1.1.a Describe the structure of an atom.
Bloom's Level: 3. Applying

2. Which statement about an atom is true?
a. Only protons contribute significantly to the atom's mass.
b. Only neutrons contribute significantly to the atom's mass.
c. Only electrons contribute significantly to the atom's mass.
d. Both protons and neutrons together contribute significantly to the atom's mass.
e. Both protons and electrons together contribute significantly to the atom's mass.
Answer: d
Learning Outcome: 2.1.1.a Describe the structure of an atom.
Bloom's Level: 1. Remembering

3. What is the difference between an atom and an element?
a. An atom is made of protons, electrons, and (most of the time) neutrons; an element is composed of only one kind of atom.
b. An element is made of protons, electrons, and (most of the time) neutrons; an atom is composed of only one kind of element.
c. An atom does not contain electrons, whereas an element does.
d. An atom contains protons and electrons, whereas an element contains protons, electrons, and neutrons.
e. All atoms are the same, whereas elements differ in structure and properties.
Answer: a
Learning Outcome: 2.1.1.a Describe the structure of an atom.
Bloom's Level: 2. Understanding

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4. In the history of the discovery of the parts of an atom, the neutron was discovered after the proton and electron. What property of a neutron made it more difficult than the proton or electron to discover?
a. Diameter
b. Location in the nucleus
c. Mass
d. Lack of charge
e. Presence in isotopes
Answer: d
Learning Outcome: 2.1.2.a Compare and contrast the properties of protons, neutrons, and electrons.
Bloom's Level: 3. Applying

5. The number of protons in a neutral atom equals the number of
a. electrons.
b. neutrons.
c. electrons plus neutrons.
d. neutrons minus electrons.
e. isotopes.
Answer: a
Learning Outcome: 2.1.3.a Explain why atoms typically have no overall electrical charge.
Bloom's Level: 1. Remembering

6. Which of the following statements about the atom is true?
a. There are usually more protons than electrons in an atom because the negative charge of an electron is larger than the positive charge of a proton.
b. The negative charge of an electron adds mass to an atom without influencing other properties.
c. In an atom with a neutral charge, the number of electrons is equal to the number of protons.
d. The number of electrons determines whether an atom of an element is radioactive.
e. The energy level of electrons is higher in shells close to the nucleus of the atom.
Answer: c
Learning Outcome: 2.1.3.a Explain why atoms typically have no overall electrical charge.
Bloom's Level: 2. Understanding

7. A lithium atom contains three protons. For this atom to remain inert in an electric field, it must also contain
a. three neutrons.
b. three electrons.
c. two neutrons and two electrons.
d. no electrons.
e. no neutrons.
Answer: b
Learning Outcome: 2.1.3.a Explain why atoms typically have no overall electrical charge.

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Bloom's Level: 3. Applying

8. Refer to the table below.

| Sample | State | Elemental composition |
|---|---|---|
| A | Solid | Mg, Fe, O, Zn, Ni, Mn |
| B | Gas | C, H |
| C | Solid | N, C, P, S, O, H |
| D | Liquid | O, H |

Four samples taken from an underground geologic site were analyzed in a chemistry lab. The table summarizes the elements found in greatest abundance in each sample. Which sample(s) could have originated from living sources?
a. C only
b. A and B
c. B and C
d. A and C
e. B, C, and D
Answer: c
Learning Outcome: 2.1.4.a Compare the elements found in living tissue with elements found in nonliving matter.
Bloom's Level: 4. Analyzing

9. The six elements most common in organisms are
a. calcium, iron, hydrogen, phosphorus, potassium, and oxygen.
b. water, carbon, hydrogen, nitrogen, sodium, and oxygen.
c. carbon, oxygen, hydrogen, phosphorus, sulfur, and nitrogen.
d. nitrogen, carbon, iron, sulfur, calcium, and hydrogen.
e. phosphorus, helium, carbon, potassium, hydrogen, and oxygen.
Answer: c
Learning Outcome: 2.1.4.a Compare the elements found in living tissue with elements found in nonliving matter.
Bloom's Level: 1. Remembering

10. The number of different natural elements found in the universe is closest to
a. 18.
b. 54.
c. 86.
d. 94.
e. 146.
Answer: d

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Learning Outcome: 2.1.4.a Compare the elements found in living tissue with elements found in nonliving matter.
Bloom's Level: 1. Remembering

11. The best reference source for the atomic number and mass number of an element is
a. a good chemistry text.
b. a dictionary.
c. the periodic table.
d. a general physics book.
e. a good biology text.
Answer: c
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 1. Remembering

12. Which element has a higher atomic mass than phosphorus?
a. Hydrogen
b. Oxygen
c. Sodium
d. Magnesium
e. Calcium
Answer: e
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 4. Analyzing

13. According to the periodic table, which element has the same number of outer shell (valence) electrons as oxygen?
a. Calcium
b. Nitrogen
c. Fluorine
d. Sodium
e. Sulfur
Answer: e
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 3. Applying

14. According to the periodic table, the compound that sulfur forms with hydrogen is most like
a. $NH_4^+$.
b. $NH_3$.
c. $H_2O$.
d. HF.
e. HCl.
Answer: c

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Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 4. Analyzing

15. Carbon and silicon have the same number of
a. protons.
b. valence (outer shell) electrons.
c. neutrons.
d. electrons.
e. protons and neutrons.
Answer: b
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 3. Applying

16. Which pair has similar chemical properties?
a. $^{12}C$ and $^{14}C$
b. $^{12}C$ and $^{40}Ca$
c. $^{16}O$ and $^{16}N$
d. $^{1}H$ and $^{22}Na$
e. $^{18}O$ and $^{45}Ca$
Answer: a
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 2. Understanding

17. The atomic number of an element is the same as the number of _____ in each atom.
a. neutrons
b. neutrons plus electrons
c. neutrons plus protons
d. protons
e. protons plus electrons
Answer: d
Learning Outcome: 2.1.6.a Analyze the number of protons and neutrons present in an atom from its atomic number and mass number.
Bloom's Level: 1. Remembering

18. The mass number of an atom is determined primarily by the _____ it contains.
a. number of electrons
b. number of protons
c. sum of the number of protons and the number of electrons
d. sum of the number of protons and the number of neutrons
e. number of charges
Answer: d

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Learning Outcome: 2.1.6.a Analyze the number of protons and neutrons present in an atom from its atomic number and mass number.
Bloom's Level: 1. Remembering

19. A stable isotope of phosphorus has an atomic number of 15 and an atomic mass of 31. How many neutrons does this isotope of phosphorus have?
a. 14
b. 16
c. 30
d. 31
e. 46
Answer: b
Learning Outcome: 2.1.6.a Analyze the number of protons and neutrons present in an atom from its atomic number and mass number.
Bloom's Level: 3. Applying

20. Carbon-12 is the most abundant isotope of carbon on Earth. Carbon-13 makes up about 1 percent of Earth's carbon atoms and is useful for radio imaging. Which of the following is true?
a. Carbon-13 has more protons than carbon-12.
b. Carbon-13 has more neutrons than carbon-12.
c. Carbon-13 has more electrons than carbon-12.
d. Carbon-13 has an electronic configuration that is different from that of carbon-12.
e. Carbon-13 has an equal number of protons and neutrons.
Answer: b
Learning Outcome: 2.1.6.a Analyze the number of protons and neutrons present in an atom from its atomic number and mass number.
Bloom's Level: 3. Applying

21. Nitrogen-14 and nitrogen-15 are isotopes. Nitrogen-15 is used to determine protein structure. Which of the following is true?
a. Nitrogen-15 has more neutrons than nitrogen-14.
b. Nitrogen-15 has more protons than nitrogen-14.
c. Nitrogen-15 has more electrons than nitrogen-14.
d. Nitrogen-15 has an electronic configuration that is different from that of nitrogen-14.
e. Nitrogen-15 has an equal number of protons and neutrons.
Answer: a
Learning Outcome: 2.1.6.a Analyze the number of protons and neutrons present in an atom from its atomic number and mass number.
Bloom's Level: 3. Applying

22. Drawings of hydrogen, deuterium, and tritium would contain different numbers of
a. protons.
b. neutrons.
c. electrons.
d. nuclei.

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e. electron shells.
Answer: b
Learning Outcome: 2.1.7.a Draw the atomic structures of three isotopes of hydrogen.
Bloom's Level: 3. Applying

23. $^{31}_{15}P$ and $^{32}_{15}P$ have virtually identical chemical and biological properties because they have the same
a. half-life.
b. number of neutrons.
c. atomic weight.
d. mass number.
e. number of electrons.
Answer: e
Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 3. Applying

24. What part of the atom determines how the atom reacts chemically?
a. Proton
b. Neutron
c. Electron
d. Innermost shell
e. Nucleus
Answer: c
Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 1. Remembering

25. The ability of an atom to combine with other atoms is determined by the atom's
a. atomic weight.
b. ability to form isomers.
c. number and distribution of electrons.
d. nuclear configuration.
e. mass number.
Answer: c
Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 2. Understanding

26. An atom is most stable when
a. it can have one unpaired valence electron, allowing it to follow the octet rule.
b. it can share electrons with other atoms to form an uneven number of pairs of electrons.
c. it has eight electrons.
d. it can fill its outermost shell by sharing electrons or by gaining or losing one or more electrons until it is filled.
e. its outermost electron shell follows the quartet rule.

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Answer: d
Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 2. Understanding

27. Which element is the most chemically reactive?
a. Carbon
b. Helium
c. Neon
d. Argon
e. Krypton
Answer: a
Learning Outcome: 2.1.9.b Explain how elements can be grouped according to their chemical properties in a periodic fashion.
Bloom's Level: 2. Understanding

28. All of the elements listed below follow the octet rule *except*
a. hydrogen.
b. chlorine.
c. carbon.
d. sodium.
e. nitrogen.
Answer: a
Learning Outcome: 2.1.9.b Explain how elements can be grouped according to their chemical properties in a periodic fashion.
Bloom's Level: 2. Understanding

29. Which of the elements listed below requires two additional electrons to fill the outermost electron shell?
a. Lithium
b. Carbon
c. Nitrogen
d. Oxygen
e. Fluorine
Answer: d
Learning Outcome: 2.1.9.b Explain how elements can be grouped according to their chemical properties in a periodic fashion.
Bloom's Level: 3. Applying

30. Which correctly shows the relative strengths of chemical bonds in decreasing order?
a. Covalent, ionic, hydrogen, van der Waals forces
b. Ionic, covalent, hydrogen, van der Waals forces
c. van der Waals forces, covalent, ionic, hydrogen
d. Hydrogen, covalent, van der Waals forces, ionic
e. Ionic, covalent, van der Waals forces, hydrogen
Answer: a

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Learning Outcome: 2.2.1.a Identify examples of chemical bonds.
Bloom's Level: 2. Understanding

31. Which atom usually has the greatest number of covalent bonds with other atoms?
a. Carbon
b. Oxygen
c. Sulfur
d. Hydrogen
e. Nitrogen
Answer: a
Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.
Bloom's Level: 1. Remembering

32. In a hydrogen molecule, the two atoms are held together by
a. hydrogen bonds.
b. a shared pair of electrons.
c. van der Waals forces.
d. ionic attractions.
e. differences in electronegativity.
Answer: b
Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.
Bloom's Level: 2. Understanding

33. Which statement is true?
a. Carbon makes the same number of covalent bonds as phosphorus does.
b. Oxygen makes more covalent bonds than sulfur does.
c. Sulfur makes more covalent bonds than carbon does.
d. Hydrogen makes more covalent bonds than carbon does.
e. Oxygen makes fewer covalent bonds than nitrogen does.
Answer: e
Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.
Bloom's Level: 3. Applying

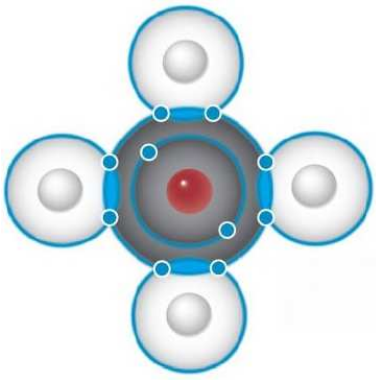
34. Oxygen forms _____ covalent bond(s), carbon forms _____, and hydrogen forms _____.
a. one; four; one
b. four; four; four
c. two; four; none
d. two; four; one
e. two; two; two
Answer: d
Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.

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Bloom's Level: 1. Remembering

35. Refer to the Bohr model of methane shown below.



Methane ($CH_4$)

Which statement about this structure is true?
a. All bonds are ionic bonds.
b. All bonds are hydrogen bonds.
c. All bonds contain paired electrons from carbon.
d. All bonds contain paired electrons from hydrogen.
e. All bonds contain paired electrons shared between carbon and hydrogen.
Answer: e
Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.
Bloom's Level: 3. Applying

36. A double covalent chemical bond represents the sharing of _____ electron(s).
a. one
b. two
c. three
d. four
e. six
Answer: d
Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.
Bloom's Level: 1. Remembering

37. Two carbon atoms held together in a double covalent bond share _____ electron(s).
a. one
b. two
c. four
d. six
e. eight
Answer: c

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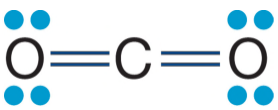
Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.
Bloom's Level: 2. Understanding

38. Differences in the electronegativity of atoms that share electrons in a bond are involved in
a. a polar covalent bond.
b. an ionic bond.
c. a hydrogen bond.
d. van der Waals forces.
e. hydrophobic interactions.
Answer: a
Learning Outcome: 2.2.4.a Identify examples of polar covalent and nonpolar covalent bonds.
Bloom's Level: 2. Understanding

39. The two covalent bonds in a water molecule are polar because
a. oxygen is more electronegative than hydrogen.
b. oxygen and hydrogen have similar electronegativities.
c. oxygen is less electronegative than hydrogen.
d. water is a small molecule.
e. water is hydrophilic.
Answer: a
Learning Outcome: 2.2.4.a Identify examples of polar covalent and nonpolar covalent bonds.
Bloom's Level: 2. Understanding

40. Which statement about ionic and covalent bonds is true?
a. An ionic bond is stronger than a covalent bond.
b. Compared with an ionic bond, a nonpolar covalent bond has more equal electron sharing.
c. An ionic bond is almost identical to a nonpolar covalent bond.
d. Ionic bonds vary in length, but covalent bonds are all the same length.
e. An ionic bond can have multiple bonds, but a covalent bond cannot.
Answer: b
Learning Outcome: 2.2.4.a Identify examples of polar covalent and nonpolar covalent bonds; 2.2.6.a Give an example of an ionic attraction and show how electrons are involved in its formation.
Bloom's Level: 2. Understanding

41. Refer to the figure below.




The figure shows the molecular structure of carbon dioxide. Carbon dioxide is nonpolar,

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whereas water is polar. Which of the true statements below explains these differences?
a. Carbon dioxide does not contain any polar covalent bonds, whereas water does.
b. Carbon dioxide contains only double bonds, whereas water contains only single bonds.
c. Carbon dioxide is a linear molecule, whereas water has a bent shape.
d. Carbon dioxide contains carbon atoms, whereas water does not.
e. Carbon and oxygen do not differ greatly in electronegativity, whereas hydrogen and oxygen do.
Answer: c
Learning Outcome: 2.2.5.a Explain why water is a polar molecule.
Bloom's Level: 5. Evaluating

42. The ball-and-stick structure of methane ($CH_4$) shows that
a. the molecule is flat.
b. the molecule is not polar.
c. all bonds are hydrogen bonds.
d. all bond angles are different.
e. all bond lengths are different.
Answer: b
Learning Outcome: 2.2.5.a Explain why water is a polar molecule.
Bloom's Level: 4. Analyzing

43. All of the following are nonpolar *except*
a. $O_2$.
b. $N_2$.
c. $CH_4$.
d. NaCl.
e. $H_2$.
Answer: d
Learning Outcome: 2.2.5.a Explain why water is a polar molecule.
Bloom's Level: 3. Applying

44. When magnesium (Mg) bonds with another element, it
a. gains two electrons from the other element.
b. shares four electrons with the other element.
c. loses two electrons to the other element.
d. forms a hydrogen bond.
e. gains six electrons from the other element.
Answer: c
Learning Outcome: 2.2.6.a Give an example of an ionic attraction and show how electrons are involved in its formation.
Bloom's Level: 3. Applying

45. A covalent bond is formed by the sharing of _____ between atoms, whereas an ionic bond is formed by the _____.
a. neutrons; sharing of electrons
b. electrons; electric attraction between two neutral atoms

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c. protons; electric attraction between two neutral atoms
d. protons; sharing of electrons
e. electrons; transfer of electrons from one atom to another
Answer: e
Learning Outcome: 2.2.6.a Give an example of an ionic attraction and show how electrons are involved in its formation.
Bloom's Level: 2. Understanding

46. Particles that have a net negative charge are called
a. electronegative.
b. cations.
c. anions.
d. acids.
e. bases.
Answer: c
Learning Outcome: 2.2.6.a Give an example of an ionic attraction and show how electrons are involved in its formation.
Bloom's Level: 1. Remembering

47. Which compound is held together by ionic bonds?
a. Water
b. Sugar
c. Sodium chloride
d. Methane
e. Ammonia
Answer: c
Learning Outcome: 2.2.6.a Give an example of an ionic attraction and show how electrons are involved in its formation.
Bloom's Level: 1. Remembering

48. Hydrogen bonds
a. form between two hydrogen atoms.
b. form only between hydrogen and oxygen atoms within a molecule.
c. form only between a weak electronegative atom and hydrogen.
d. involve a transfer of electrons.
e. form weak interactions but can provide structural stability when many are found in a single molecule.
Answer: e
Learning Outcome: 2.2.7.a Draw an example of a hydrogen bond and explain how it forms.
Bloom's Level: 2. Understanding

49. Hydrogen bonds are attractions
a. between oppositely charged ions.
b. between atoms, resulting in electron sharing.
c. between cations.

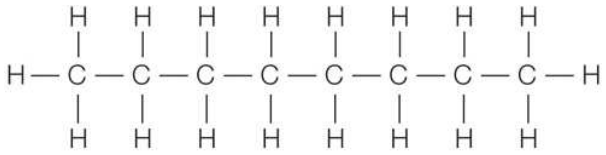
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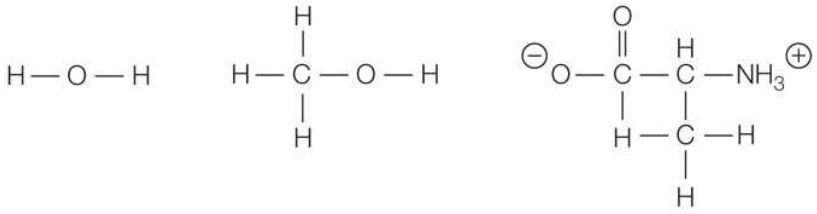
d. between atoms, each with partial electrical charges.
e. that rely on hydrophobic interactions.
Answer: d
Learning Outcome: 2.2.7.a Draw an example of a hydrogen bond and explain how it forms.
Bloom's Level: 1. Remembering

50. Cholesterol is a lipid most often found in cell membranes. It is composed primarily of carbon and hydrogen atoms and has the following chemical formula: $C_{27}H_{46}O$. Based on this information, one would expect cholesterol to be
a. insoluble in water.
b. a highly polar molecule.
c. a cation.
d. an anion.
e. insoluble in hexane.
Answer: a
Learning Outcome: 2.2.8.a Distinguish between hydrophilic and hydrophobic interactions using examples.
Bloom's Level: 3. Applying

51. Refer to the figure below showing the chemical structures of several molecules.



Octane



Water Methanol Amino acid

Which pair of molecules is most likely to be miscible (each soluble in the other)?
a. Octane and water
b. Water and methanol
c. Amino acid and octane
d. Methanol and octane
e. Amino acid and methanol
Answer: b

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Learning Outcome: 2.2.8.a Distinguish between hydrophilic and hydrophobic interactions using examples.
Bloom's Level: 4. Analyzing

52. A van der Waals interaction is an attraction between
a. the electrons and the nucleus of one molecule.
b. two nonpolar molecules, due to the exclusion of water.
c. the electrons of one molecule and the protons of a nearby molecule.
d. two adjacent nonpolar molecules, due to variations in their electron distribution.
e. two polar molecules, because they are surrounded by water molecules.
Answer: d
Learning Outcome: 2.2.9.a Identify instances in which van der Waals forces are important.
Bloom's Level: 2. Understanding

53. Carbon-14 is a radioactive isotope of carbon. When an organism is alive, the total amount of carbon-14 in the organism's body remains constant. As soon as the organism dies, the amount of carbon-14 begins to decrease in a predictable way. This provides evidence for which statement about living organisms?
a. Different organisms have different life-spans.
b. Living organisms are dynamic and constantly exchanging matter with the environment.
c. There is a huge diversity of life-forms represented among the organisms living today.
d. All living organisms are composed of cells.
e. Living organisms pass on biological information to their offspring.
Answer: b
Learning Outcome: 2.3.1.a Justify the claim that living organisms are dynamic.
Bloom's Level: 5. Evaluating

54. A biologist is conducting experiments on human muscle and collects a variety of data, listed below. Which type of data would provide evidence for the claim that living organisms are chemically dynamic?
a. Amount of force generated by a muscle fiber
b. Length of a muscle fiber
c. Elemental composition of a muscle fiber
d. Rate of metabolism of glucose by a muscle fiber
e. Duration of contraction of a muscle fiber
Answer: d
Learning Outcome: 2.3.1.a Justify the claim that living organisms are dynamic.
Bloom's Level: 3. Applying

55. A chemist measures the masses of two substances separately, then combines them in a reaction flask and heats the mixture. After several minutes, the chemist cools the flask and measures the mass of the contents. The final mass of the contents is less than the sum of the masses of the two substances placed in the flask before heating. Which statement provides a possible explanation for this observation?

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a. Physical changes in the two starting substances resulted in products with less combined mass than the starting substances.
b. Heating caused the substances to melt, which resulted in a change in overall volume and mass.
c. The two starting substances absorbed energy from the heat, which destroyed some of the atoms making up the substances.
d. Only one product was formed from the combination of two reactants, resulting in less overall mass at the end.
e. The two starting substances underwent chemical change to produce two products, one of which was a gas.
Answer: e
Learning Outcome: 2.3.2.a Describe changes taking place during a chemical reaction.
Bloom's Level: 5. Evaluating

56. Refer to the oxidation-reduction reaction below.

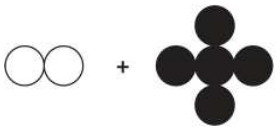
$Fe + Cu^{2+} \rightarrow Cu + Fe^{2+}$

This reaction occurs spontaneously when a strip of iron metal is placed into a solution of copper sulfate dissolved in water. During the reaction, iron metal is oxidized to form a cation, and copper ion is reduced to form copper metal. Which statement describes the change taking place?
a. The change is not a chemical change because no covalent bonds were broken and new ones formed.
b. The change is not a chemical change because there were too few elements involved.
c. The change is a chemical change because the products differ chemically from the reactants.
d. The change is a chemical change because it occurred spontaneously.
e. The change is a chemical change because there was no overall change in mass.
Answer: c
Learning Outcome: 2.3.2.a Describe changes taking place during a chemical reaction.
Bloom's Level: 5. Evaluating

57. Refer to the figure showing reactants before chemical change occurs.



Which diagram could represent the products of this change?
a.



b.

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c.



d.

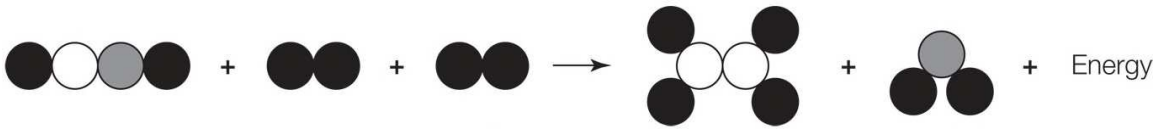


e.



Answer: e
Learning Outcome: 2.3.3.a Compare the products and reactants of a chemical reaction.
Bloom's Level: 4. Analyzing

58. Refer to the figure below.




Which statement about the figure is true?
a. It shows a chemical change because the products differ from the reactants.
b. It shows a chemical change because the three molecules were transformed into two molecules.
c. It shows a chemical change because energy was released as a result of the change.
d. It does not accurately show a chemical change because the numbers of atoms on the two sides of the arrow differ.
e. It does not accurately show a chemical change because energy is shown on the wrong side of the arrow.
Answer: d
Learning Outcome: 2.3.3.a Compare the products and reactants of a chemical reaction.
Bloom's Level: 4. Analyzing

59. Some reactions, such as the decomposition of nitroglycerin in dynamite, release large amounts of energy in the form of heat. Others, such as those taking place inside cells, release much smaller amounts of heat. Which statement is true about these reactions?
a. The total amount of energy involved in the cellular reactions is conserved, but new energy is created during the explosive reaction involving nitroglycerin.
b. Though a larger overall change in energy occurs in the nitroglycerin reaction, the total amount of energy present before and after each reaction does not change.
c. Cells use up energy, causing an overall decrease in the total amount of energy present before cellular reactions, while nonliving things, such as dynamite, do not.

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d. Both living cells and nonliving things, such as dynamite, cause an overall loss of energy when they release heat during reactions.
e. Only living things conserve energy from their reactions in the form of chemical bond energy, while nonliving things, such as dynamite, lose energy when they react.
Answer: b
Learning Outcome: 2.3.4.a Explain how the law of conservation of energy applies to chemical reactions.
Bloom's Level: 3. Applying

60. Which statement about biochemical reactions is *false*?
a. They obey the rules of chemistry and physics.
b. They must always balance the number of atoms in the reactants and the products.
c. They can create new energy during the reaction.
d. They can store energy in the form of a covalent bond.
e. They can change the form of energy found in the cell.
Answer: c
Learning Outcome: 2.3.4.a Explain how the law of conservation of energy applies to chemical reactions.
Bloom's Level: 2. Understanding

61. Refer to the reaction shown.

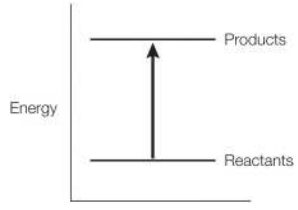
$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$ + energy

Which statement about the reaction is true?
a. $O_2$ is a product.
b. Chemical bonds are conserved during the reaction.
c. The same atoms are present before and after the reaction.
d. A net input of energy is needed for this reaction.
e. The products are similar to the reactants.
Answer: c
Learning Outcome: 2.3.4.b Demonstrate an example to show that chemical reactions obey the law of conservation of matter.
Bloom's Level: 3. Applying

62. Refer to the balanced chemical equation below.

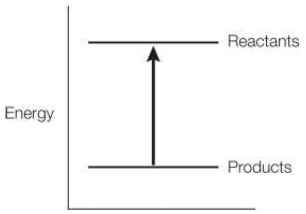
$CH_4 + 2\ O_2 \rightarrow\ CO_2 + 2\ H_2O + 890$ kJ

Which graph represents the energy changes accompanying this reaction?
a.

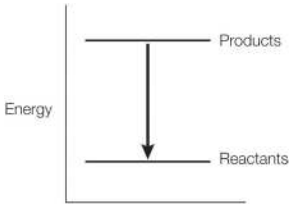



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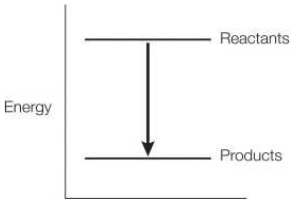
b.



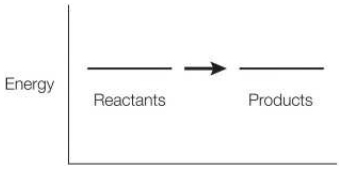

c.




d.




e.




Answer: d
Learning Outcome: 2.3.5.a Explain how energy is involved in a chemical reaction.
Bloom's Level: 3. Applying

63. Which observation makes a strong case that the study of water and its properties is relevant to the study of structural biology?
a. Corals are marine animals that live in close association with photosynthetic algae that supply the corals with a source of food.
b. Some Arctic fish produce antifreeze proteins to prevent ice crystals from forming in their cells.
c. Animals that live in caves their entire lives rely on nutrients brought into their habitats by running water or by other organisms.
d. Ice loses mass as water molecules go from the solid state directly to the gas state.
e. Lake ecosystems can be destroyed by chemical fertilizers carried from farmland into lakes in rain runoff.
Answer: b

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Learning Outcome: 2.4.1.a Explain why the study of water and its properties is relevant to the study of living organisms.
Bloom's Level: 3. Applying

64. Which statement explains why ice floats in liquid water?
a. As water molecules go from the liquid to the solid state, their rate of motion decreases.
b. Water molecules maintain the same bent shape in liquid and solid states.
c. The ordered lattice structure of water molecules in ice is maintained by hydrogen bonds.
d. The arrangement of water molecules in ice results in fewer molecules per unit volume than in liquid water.
e. Water molecules maintain the same mass as they transition from the liquid to the solid state.
Answer: d
Learning Outcome: 2.4.2.a Justify the difference in densities of ice and liquid water.
Bloom's Level: 3. Applying

65. Ice floats because the ice crystals
a. contain fewer water molecules per volume than the liquid water.
b. are more dense than liquid water.
c. form heat, which makes water expand.
d. can move quickly and therefore can float.
e. have a high surface tension.
Answer: a
Learning Outcome: 2.4.2.a Justify the difference in densities of ice and liquid water.
Bloom's Level: 2. Understanding

66. Which characteristic of water contributes most to the relatively constant temperatures of the oceans?
a. Water has the ability to ionize slightly.
b. Water has a high specific heat.
c. Salt water has low surface tension.
d. Salt water is denser than freshwater.
e. Water requires a small amount of heat energy to raise its temperature.
Answer: b
Learning Outcome: 2.4.3.a Explain how the structure of water can be used to understand why water temperature changes slowly under the same conditions that causes the temperatures of other substances to change rapidly.
Bloom's Level: 2. Understanding

67. In the summer, ice is used to cool beverages primarily because it
a. floats.
b. is inexpensive.
c. does not affect taste.
d. is composed only of water.
e. absorbs a lot of heat as it melts.

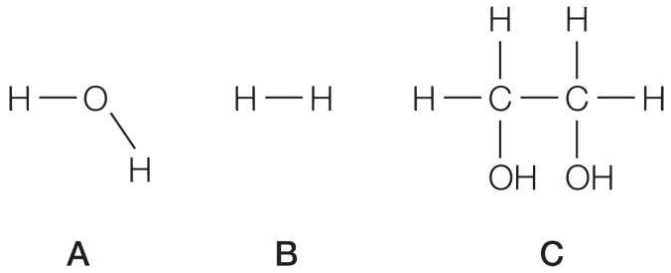
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Answer: e
Learning Outcome: 2.4.3.a Explain how the structure of water can be used to understand why water temperature changes slowly under the same conditions that causes the temperatures of other substances to change rapidly.
Bloom's Level: 3. Applying

68. A car sitting in the sun on a hot summer day becomes very hot to the touch. Water in a bucket sitting next to the car under the same conditions for the same length of time feels cool to the touch. Which statement explains this difference?
a. Radiant energy goes into breaking the forces of attraction between water molecules before increasing their rate of motion.
b. Radiant energy is reflected off the surface of water rather than being absorbed by the water molecules.
c. Radiant energy cannot easily penetrate water because of its density and is therefore not absorbed readily.
d. Radiant energy is absorbed poorly by liquids, compared with solids.
e. Radiant energy is absorbed by certain elements more readily than by other elements.
Answer: a
Learning Outcome: 2.4.3.a Explain how the structure of water can be used to understand why water temperature changes slowly under the same conditions that cause the temperatures of other substances to change rapidly.
Bloom's Level: 3. Applying

69. Refer to the figures below.

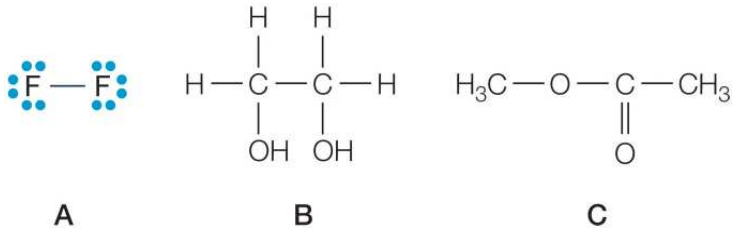



The correct ranking of these compounds in order of lowest to highest heat capacity per mole of compound is B < A < C. Which property would most likely be responsible for this trend?
a. Molecular weight
b. Number of bonds
c. Hydrogen bonding capacity
d. Molecular shape
e. Ability to dissolve in water
Answer: c
Learning Outcome: 2.4.3.b Analyze the chemical structures of various compounds including water and predict their relative heat capacities.
Bloom's Level: 4. Analyzing

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70. Refer to the figures below.




A B C

Which compound would have a higher heat of vaporization than water, and why?
a. Compound A because it is smaller in size than water.
b. Compound A because unlike water, it is not capable of hydrogen bonding.
c. Compound B because it can form more hydrogen bonds per molecule than water.
d. Compound B because it contains more covalent bonds per molecule than water.
e. Compound C because it contains more oxygen atoms per molecule than water.
Answer: c
Learning Outcome: 2.4.4.a Compare water's heat of vaporization to the heats of vaporization of other substances and explain reasons for differences.
Bloom's Level: 4. Analyzing

71. What features of the water molecule are responsible for its high heat of vaporization, and what other compound shares these features?
a. Water's small size and low molecular weight; carbon dioxide ($CO_2$)
b. Water's polarity and its ability to form intermolecular hydrogen bonds; ammonia ($NH_3$)
c. Water's single bonds and tetrahedral bond orientations; methane ($CH_4$)
d. Water's bent shape and lone pairs of electrons; sulfur dioxide ($SO_2$)
e. Water's covalent bonds involving hydrogen and oxygen atoms; hydrogen peroxide (HOOH)
Answer: b
Learning Outcome: 2.4.4.a Compare water's heat of vaporization to the heats of vaporization of other substances and explain reasons for differences.
Bloom's Level: 3. Applying

72. Some frog species lay their eggs in shallow waters. After fertilization, the embryos develop into tadpoles that require an aquatic environment until they develop into adults. This can be challenging in shallow waters, especially in regions where the daytime temperatures can reach the upper 90s in Fahrenheit degrees. Which two properties of water are most responsible for improving the odds of tadpole survival in these shallow waters on hot days?
a. High surface tension and strong adhesive forces
b. Strong cohesive and adhesive forces
c. High heat capacity and high surface tension
d. High heat of vaporization and strong adhesive forces
e. High heat capacity and high heat of vaporization

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Answer: e
Learning Outcome: 2.4.4.b Describe how water's heat of vaporization affects living organisms.
Bloom's Level: 3. Applying

73. When exposed to extreme heat, the human body relies on _____ to absorb excess calories of heat and maintain normal body temperature.
a. evaporation
b. condensation
c. respiration
d. transpiration
e. degradation
Answer: a
Learning Outcome: 2.4.4.b Describe how water's heat of vaporization affects living organisms.
Bloom's Level: 3. Applying

74. Surface tension and cohesion occur in pure water because water
a. is nonpolar.
b. contains covalent bonds.
c. forms intermolecular hydrogen bonds.
d. resists changes in temperature.
e. requires high energy input to vaporize.
Answer: c
Learning Outcome: 2.4.5.a Draw a diagram representing molecular structures to explain water's cohesive and adhesive properties.
Bloom's Level: 2. Understanding

75. Vertebrate animals rely on movement of sodium ions in and out of nerve cells to transmit nerve impulses. Which property of water is relevant to this function, and why?
a. Water's strong adhesive properties, because this property explains the attraction between water and other substances
b. Water's changing density with temperature, because this property allows water to move as it heats up
c. Water's polarity, because this property makes it an effective solvent for charged particles
d. Water's high surface tension, because this property allows water to act as a surface that cannot be penetrated easily
e. Water's strong cohesive properties, because this property explains the attraction between water and itself
Answer: c
Learning Outcome: 2.4.6.a Explain why water's solvent properties are important in understanding events taking place inside cells.
Bloom's Level: 3. Applying

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76. Phosphate ion has the structure $PO_4^{3-}$. This ion is reversibly added to and removed from many different protein molecules in the cell as a means of regulating the proteins' functions. Water's solvent properties are important in understanding the modification of proteins by phosphate ion because
a. biochemists use water as the solvent in laboratory experiments aimed at mimicking the internal workings of a cell.
b. when proteins are removed from cells and placed in solvents from the lab, their functions change.
c. the external cell environment is composed of water, and many signaling molecules move through aqueous environments to bind to receptors on cell surfaces.
d. the internal cell environment is composed of water, and all cellular reactions occur within this aqueous solvent.
e. the phosphate ion has different solubilities in different solvents.
Answer: d
Learning Outcome: 2.4.6.a Explain why water's solvent properties are important in understanding events taking place inside cells.
Bloom's Level: 3. Applying

77. To determine the number of molecules in a teaspoon of sugar, you have to know
a. the mass of the sugar.
b. the mass and density of the sugar.
c. the molecular weight of the sugar.
d. Avogadro's number.
e. the mass and molecular weight of the sugar, and Avogadro's number.
Answer: e
Learning Outcome: 2.4.7.a Perform quantitative analyses of biochemical compounds using the mole concept.
Bloom's Level: 2. Understanding

78. A mole of hydrogen and a mole of carbon have
a. different numbers of molecules.
b. fewer hydrogen atoms than carbon atoms.
c. the same number of molecules.
d. the capacity to form one mole of carbohydrate.
e. a different number of molecules than a mole of oxygen.
Answer: c
Learning Outcome: 2.4.7.a Perform quantitative analyses of biochemical compounds using the mole concept.
Bloom's Level: 2. Understanding

79. Which compound containing $^{1}H$, $^{12}C$, and/or $^{16}O$ has the greatest number of molecules in a sample with a mass of 2 g?
a. Water ($H_2O$)
b. Carbon dioxide ($CO_2$)
c. Acetic acid ($CH_3OOH$)
d. Carbonic acid ($H_2CO_3$)

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e. Table sugar ($C_{12}H_{22}O_{11}$)
Answer: a
Learning Outcome: 2.4.7.a Perform quantitative analyses of biochemical compounds using the mole concept.
Bloom's Level: 3. Applying

80. How would you make 100 mL of an aqueous solution with a 0.25 M concentration of a compound that has a molecular weight of 200 Da?
a. Add 25 g of the compound to 100 mL of water.
b. Add 20 g of the compound to 100 mL of water.
c. Measure 2.5 g of the compound and add water until the volume equals 100 mL.
d. Measure 2 g of the compound and add water until the volume equals 100 mL.
e. Measure 5 g of the compound and add water until the volume equals 100 mL.
Answer: e
Learning Outcome: 2.4.7.a Perform quantitative analyses of biochemical compounds using the mole concept.
Bloom's Level: 3. Applying

81. $H_2SO_4$ can ionize completely to yield two $H^+$ ions and one $SO_4^{2-}$ ion. $H_2SO_4$ is therefore a
a. weak base.
b. strong base.
c. buffer.
d. weak acid.
e. strong acid.
Answer: e
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 3. Applying

82. When 0.1 mole of sodium hydroxide (NaOH) is added to 1 liter of water, it ionizes, releasing $OH^-$ and $Na^+$ ions. The resulting solution is
a. acidic.
b. basic.
c. neutral.
d. molar.
e. a buffer.
Answer: b
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 3. Applying

83. The difference between an acid and a base is that an acid _____, whereas a base _____.
a. undergoes a reversible reaction; does not
b. releases $OH^-$ ions in solution; accepts $OH^-$ ions

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c. releases $H^+$ ions in solution; accepts $H^-$ ions
d. releases $OH^-$ ions in solution; releases $H^+$ ions
e. releases $H^+$ ions in solution; accepts $H^+$ ions
Answer: e
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 2. Understanding

84. Which has the greatest concentration of hydrogen ions?
a. Household ammonia at pH 11
b. Baking soda at pH 9
c. Human blood at pH 7
d. Black coffee at pH 5
e. Cola at pH 3
Answer: e
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 3. Applying

85. The optimum soil pH for growing strawberries is 6.5, whereas the optimum soil pH for growing blueberries is 4.5. Therefore, the number of hydrogen ions needed to grow blueberries is _____ times the number needed to grow strawberries.
a. 2
b. 10
c. 100
d. 1,000
e. 1,000,000
Answer: c
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 4. Analyzing

86. Which statement comparing a solution of lemon juice (pH ~2) to a solution of tomato juice (pH ~4) is true?
a. The lemon juice has more hydroxyl ions per liter.
b. The lemon juice has more hydrogen acceptors per liter.
c. The lemon juice has more $H^+$ ions per liter.
d. The lemon juice has a higher pH.
e. The lemon juice has a more basic pH.
Answer: c
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 3. Applying

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87. Carbonic acid and sodium bicarbonate act as buffers in the blood. When a small amount of acid is added to this buffer, the $H^+$ ions are used up as they combine with the bicarbonate ions. When this happens, the pH of the blood
a. becomes basic.
b. becomes acidic.
c. does not change.
d. is reversible.
e. ionizes.
Answer: c
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 4. Analyzing

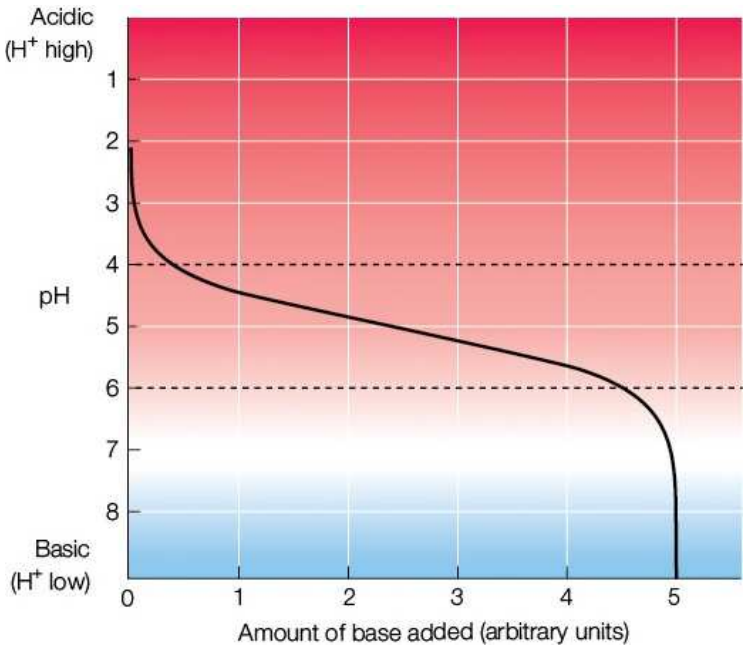
88. A solution with pH 9 contains
a. more $H^+$ ions than $OH^-$ ions.
b. more $OH^-$ ions than $H^+$ ions.
c. the same number of $OH^-$ ions and $H^+$ ions.
d. no $OH^-$ ions.
e. only $H^-$ ions.
Answer: b
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 2. Understanding

89. A 1.0 M solution of HCl has a pH of
a. 1.0.
b. 3.5.
c. 7.0.
d. 11.2.
e. 14.0.
Answer: a
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 3. Applying

90. Refer to the figure below.

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Which part of the diagram has the largest $H^+$ change per unit of base added?
a. The area between the dotted lines
b. The area between pH 2 and pH 4
c. The area between pH 4 and pH 6
d. The area between pH 6 and pH 8
e. The areas between pH 2 and pH 4 and between pH 6 and pH 8
Answer: e
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 4. Analyzing

**Fill in the Blank**

91. The mass of a proton serves as the standard unit of measure for 1 Da. A _____ also has a mass of about 1 Da.
Answer: neutron
Learning Outcome: 2.1.2.a Compare and contrast the properties of protons, neutrons, and electrons.
Bloom's Level: 1. Remembering

92. An atom has 36 protons and 44 neutrons. This atom has atomic number 36, and its atomic symbol is _____.
Answer: Kr
Learning Outcome: 2.1.5.a Given an atomic number of an atom, identify the element represented by the atom.
Bloom's Level: 3. Applying

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93. Oxygen and carbon are defined as different elements because they have atoms with different numbers of _____ in the nucleus.
Answer: protons
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 2. Understanding

94. Every atom *except* _____ has one or more neutrons in its nucleus.
Answer: hydrogen
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 1. Remembering

95. An atom with 20 protons and 25 neutrons has an atomic number 20 and a mass number _____.
Answer: 45
Learning Outcome: 2.1.6.a Analyze the number of protons and neutrons present in an atom from its atomic number and mass number.
Bloom's Level: 3. Applying

96. The chemical properties of an element are determined by the number of _____ in the atom's valence shell.
Answer: electrons
Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 2. Understanding

97. The tendency of atoms in stable molecules to have eight electrons in their outermost shells is known as the _____.
Answer: octet rule
Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 1. Remembering

98. A _____ links two or more atoms through attractive forces to create a molecule.
Answer: chemical bond
Learning Outcome: 2.2.1.a Identify examples of chemical bonds.
Bloom's Level: 1. Remembering

99. Of the different types of chemical bonds, the strongest bond in biological systems is the _____ bond.
Answer: covalent
Learning Outcome: 2.2.3.a Explain why covalent bonds are so strong.
Bloom's Level: 1. Remembering

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100. Refer to the table below.

| Bond | Bond Type | Bond Length (pm) | Bond Energy (kJ/mol) |
|---|---|---|---|
| C – C | Single | 154 | 347 |
| C = C | Double | 134 | 614 |
| C ≡ C | Triple | 120 | 839 |

The data support the claim that the strength of a covalent bond increases with the number of _____ that are shared between two atoms.
Answer: electrons
Learning Outcome: 2.2.3.a Explain why covalent bonds are so strong.
Bloom's Level: 4. Analyzing

101. An atom's electronegativity depends on how many _____ charges it has and on the distance between the _____ and the valence electrons.
Answer: positive; nucleus
Learning Outcome: 2.2.4.a Identify examples of polar covalent and nonpolar covalent bonds.
Bloom's Level: 2. Understanding

102. Oxygen, which has an electronegativity of 3.5, will have a stronger attraction for _____ compared with carbon, which has an electronegativity of 2.5.
Answer: electrons
Learning Outcome: 2.2.4.a Identify examples of polar covalent and nonpolar covalent bonds.
Bloom's Level: 2. Understanding

103. The electric charge in _____ covalent bonds is unequally distributed because one nucleus has a stronger attraction for the electrons than the other has.
Answer: polar
Learning Outcome: 2.2.4.a Identify examples of polar covalent and nonpolar covalent bonds.
Bloom's Level: 1. Remembering

104. A _____ bond forms when there is an attraction between a partial positive charge on a hydrogen atom involved in a polar covalent bond and a partial negative charge on a nearby electronegative atom.
Answer: hydrogen

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Learning Outcome: 2.2.7.a Draw an example of a hydrogen bond and explain how it forms.
Bloom's Level: 1. Remembering

105. When two nonpolar molecules are in close proximity, their interactions are enhanced by _____.
Answer: van der Waals forces
Learning Outcome: 2.2.9.a Identify instances in which van der Waals forces are important.
Bloom's Level: 1. Remembering

106. Refer to the chemical equation below.

$C_6H_{12}O_6 \rightarrow 6\ CO_2 + 6\ H_2O$

In this equation, $C_6H_{12}O_6$ functions as the _____.
Answer: reactant
Learning Outcome: 2.3.2.a Describe changes taking place during a chemical reaction.
Bloom's Level: 2. Understanding

107. Refer to the chemical equation below.

$2\ H_2O + 572\ kJ \rightarrow\ 2\ H_2 + O_2$

According to the law of _____, the sum of the bond energies in 2 moles of water plus 572 kJ equals the sum of the bond energies in 2 moles of hydrogen gas and 1 mole of oxygen gas.
Answer: conservation of energy
Learning Outcome: 2.3.4.a Explain how the law of conservation of energy applies to chemical reactions.
Bloom's Level: 3. Applying

108. Refer to the balanced chemical equation below.

$2\ H_2O + 572\ kJ \rightarrow\ 2\ H_2 + O_2$

According to the information given, the energy supplied for this reaction is stored in the chemical _____ of the products.
Answer: bonds
Learning Outcome: 2.3.5.a Explain how energy is involved in a chemical reaction.
Bloom's Level: 3. Applying

109. Refer to the balanced chemical equation below.

$N_2 + 2\ O_2 + 180\ kJ \rightarrow\ 2\ NO_2$

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This reaction involves a net _____ of energy.
Answer: input
Learning Outcome: 2.3.5.a Explain how energy is involved in a chemical reaction.
Bloom's Level: 4. Analyzing

110. Because it is the most abundant compound present in the bodies of living organisms, _____ is an important compound whose properties are essential to the study of biology.
Answer: water
Learning Outcome: 2.4.1.a Explain why the study of water and its properties is relevant to the study of living organisms.
Bloom's Level: 3. Applying

111. The water strider can skate along the surface of water because of a property of liquids called _____.
Answer: surface tension
Learning Outcome: 2.4.5.a Draw a diagram representing molecular structures to explain water's cohesive and adhesive properties.
Bloom's Level: 2. Understanding

112. One mole of a substance contains $6.02 \times 10^{23}$ molecules. This number is known as _____.
Answer: Avogadro's number
Learning Outcome: 2.4.7.a Perform quantitative analyses of biochemical compounds using the mole concept.
Bloom's Level: 1. Remembering

113. Prolactin is a peptide hormone produced by the pituitary gland that stimulates breast and milk development in pregnant women. The normal prolactin concentration in a pregnant woman's blood is 10–209 ng/mL. Because prolactin's molecular weight is 22,000 g/mole, a concentration of 110 ng/mL is equivalent to a concentration of 5 nM (nanomolar). Compared with the concentration of most molecules in the blood, the concentration of prolactin is significantly _____.
Answer: lower
Learning Outcome: 2.4.7.a Perform quantitative analyses of biochemical compounds using the mole concept.
Bloom's Level: 4. Analyzing

114. If the pH of an acid rain sample is 2.5 pH units more acidic than water, the acid rain sample has a pH of _____.
Answer: 4.5
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 3. Applying

115. Blood contains bicarbonate ions and carbonic acid and prevents significant changes in pH in the body because they act as _____.

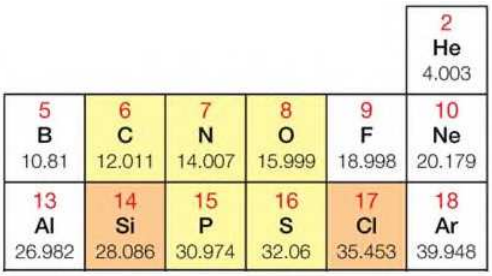
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Answer: buffers
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 2. Understanding

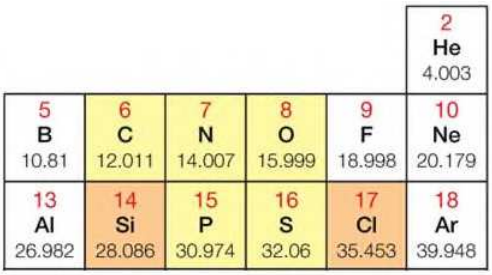
**Short Answer/Essay**

116. Refer to the figure below showing part of the periodic table.




What is the name of the element that has an atomic number of 15?
Answer: Phosphorus
Textbook Reference: 2.1 Atomic Structure Explains the Properties of Matter
Learning Outcome: 2.1.5.a Given an atomic number of an atom, identify the element represented by the atom.
Bloom's Level: 1. Remembering

117. Refer to the figure below showing part of the periodic table.




What is the name of the element that has the same number of valence electrons as silicon (Si)?
Answer: Carbon
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 3. Applying

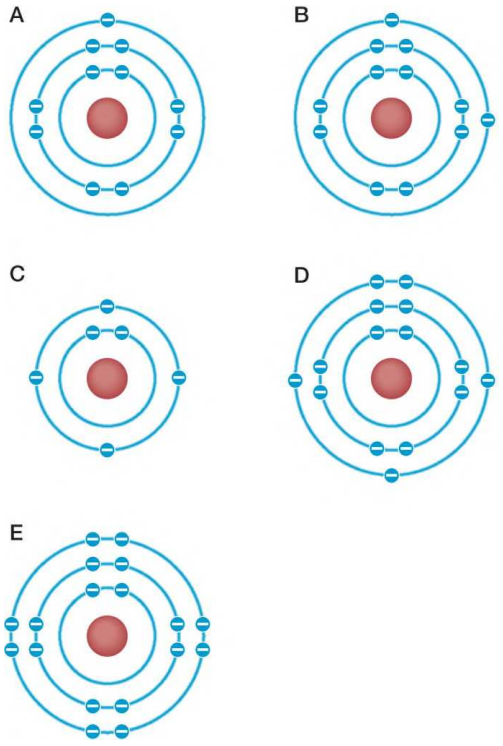
118. Refer to the figure below showing part of the periodic table.

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| | | | | | |
|---|---|---|---|---|---|
| | | | | | 2<br>He<br>4.003 |
| 5<br>B<br>10.81 | 6<br>C<br>12.011 | 7<br>N<br>14.007 | 8<br>O<br>15.999 | 9<br>F<br>18.998 | 10<br>Ne<br>20.179 |
| 13<br>Al<br>26.982 | 14<br>Si<br>28.086 | 15<br>P<br>30.974 | 16<br>S<br>32.06 | 17<br>Cl<br>35.453 | 18<br>Ar<br>39.948 |

What are the names of the elements that have complete outer shells?
Answer: Helium, neon, and argon
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 3. Applying

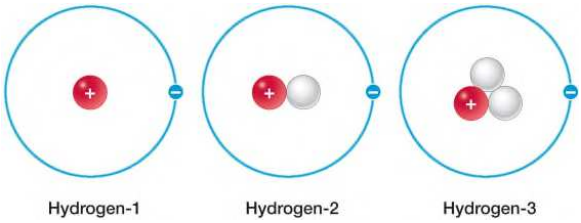
119. Refer to the figure below.




Which diagram represents magnesium (Mg; atomic number 12)?
Answer: B
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 3. Applying

120. Sketch Bohr models to show the three isotopes of hydrogen, then explain how the three structures are similar and how they differ.
Answer:

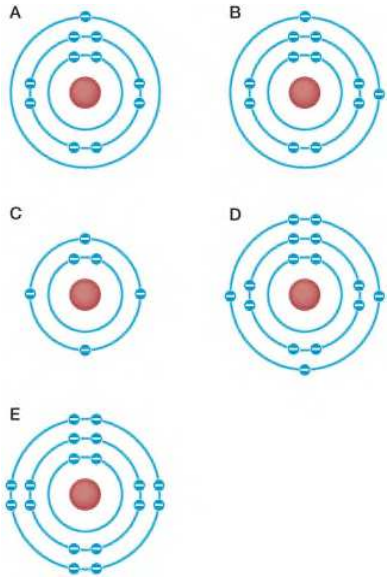
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Each isotope of hydrogen has one proton in the nucleus and one electron moving in the space around the nucleus. The isotopes differ in the numbers of neutrons. Hydrogen-1 has no neutrons, hydrogen-2 has one neutron, and hydrogen-3 has two neutrons.
Learning Outcome: 2.1.7.a Draw the atomic structures of three isotopes of hydrogen.
Bloom's Level: 3. Applying

121. Pharmaceutical chemists use radioisotopic labeling to study how long a drug stays in a test animal and how the drug is metabolized. Explain why radioactive isotopes are useful for these types of studies.
Answer: Radioisotopes have unstable nuclei that decay over time. As they decay, these nuclei emit radiation. This radiation can be detected using special lab equipment. Since these isotopes can be detected by their radiation emissions, and since they behave chemically in the same way that their nonradioactive counterparts behave, these isotopes can be used as tags to follow the fate of specific molecules that are synthesized to contain them.
Learning Outcome: 2.1.8.a Justify the use of radioisotopes as a tool in biological research and as a treatment in medicine.
Bloom's Level: 3. Applying

122. Refer to the figure below.

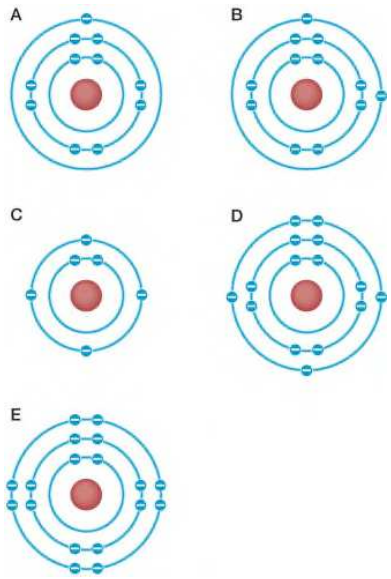



Which diagram represents a stable atom, and what element is it?

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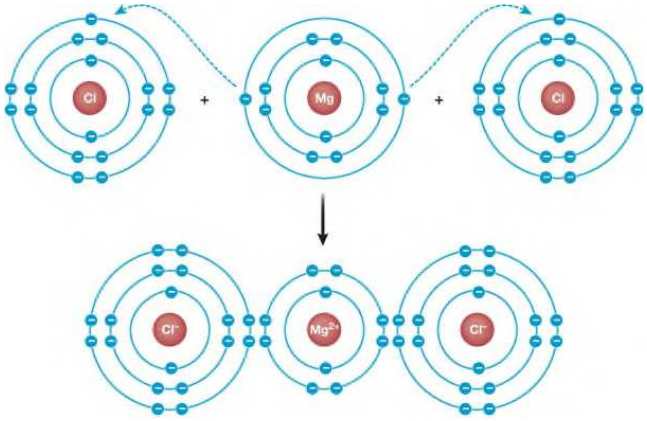
Answer: E; argon (or Ar)
Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 2. Understanding

123. Refer to the figure below.




Which diagrams show atoms that will lose electrons to form a stable ion? List all that apply.
Answer: Both A and B
Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 3. Applying

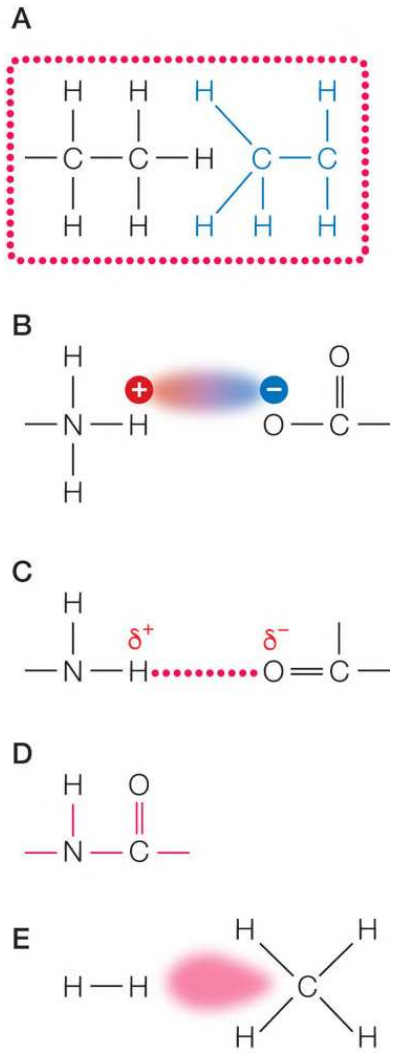
124. An ionic compound has the formula $XCl_2$, where X is a cation bonded through ionic attractions to two $Cl^-$ anions. Sketch Bohr models to show how the ions interact to form such a compound.
Answer:




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Learning Outcome: 2.2.6.a Give an example of an ionic attraction and show how electrons are involved in its formation.
Bloom's Level: 6. Creating

125. Refer to the figure below showing various chemical bonds and interactions.



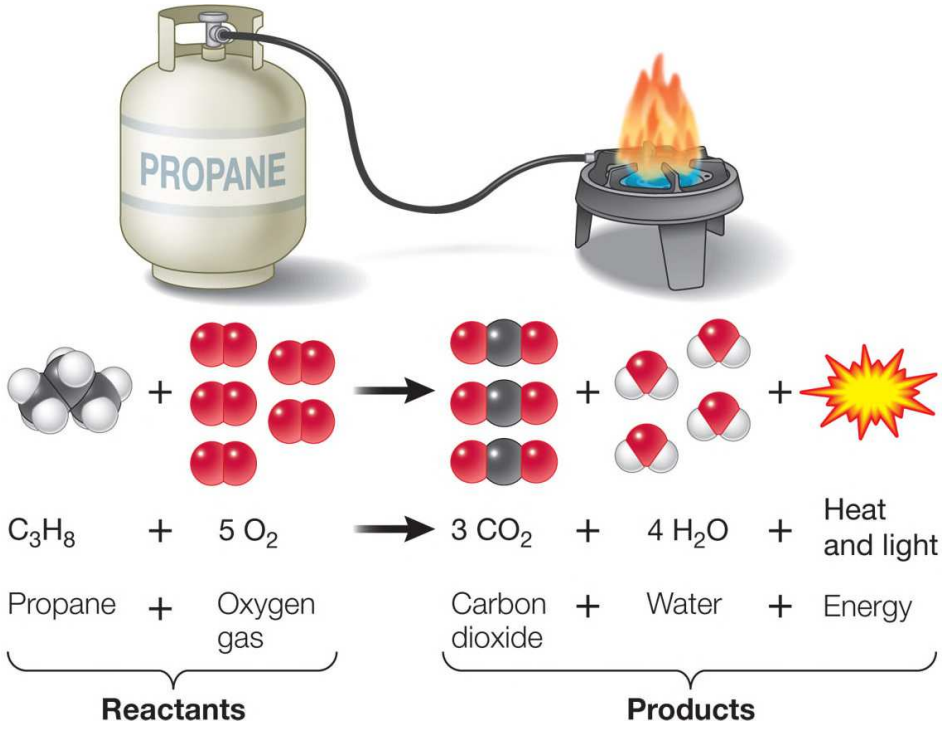

Nonpolar molecules would likely exhibit which type(s) of bonds or interactions?
Answer: A or E
Learning Outcome: 2.2.8.a Distinguish between hydrophilic and hydrophobic interactions using examples.
Bloom's Level: 2. Understanding

126. Geckos are lizards that are amazing climbers. A gecko can climb up a glass surface and stick to it with a single toe. Professor Kellar Autumn, along with his students and collaborators, have shown that each toe of a gecko has millions of micrometer-sized hairs and that each hair splits into hundreds of 200 nm tips that provide intimate contact

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with a surface. Careful measurements show that a million of these tips could easily support the animal, but it has far more. The toes stick well on hydrophilic and hydrophobic surfaces. Bending the hairs allows the gecko to detach. What kind of noncovalent force is involved in gecko sticking?
Answer: This is an example of van der Waals forces, which act over a short distance and do not involve polarity.
Learning Outcome: 2.2.9.a Identify instances in which van der Waals forces are important.
Bloom's Level: 3. Applying

127. Refer to the figure below.

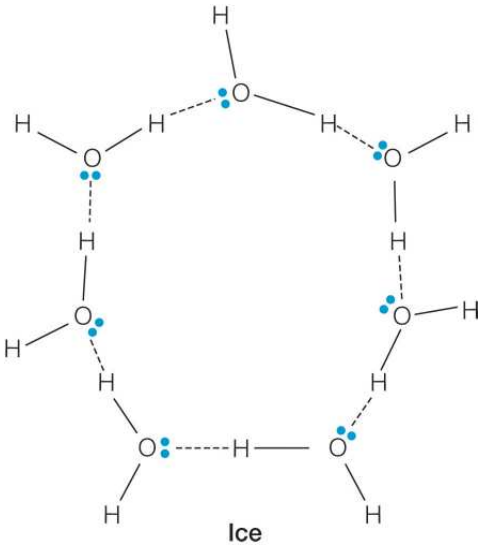



Explain how this reaction obeys the law of conservation of matter.
Answer: The equation is balanced with an equal number of atoms in the reactants and products, showing that matter is neither created nor destroyed. The total number of carbon atoms (black), oxygen atoms (red), and hydrogen atoms (white/gray) on the left side of the equation is equal to the total number of C, N, and H atoms on the right side.
Learning Outcome: 2.3.4.b Demonstrate an example to show that chemical reactions obey the law of conservation of matter.
Bloom's Level: 3. Applying

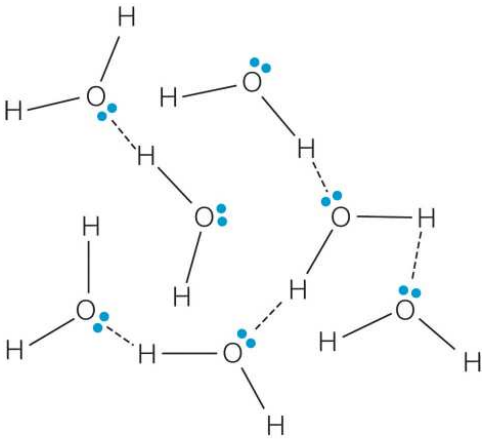
128. How do the densities of ice and liquid water differ? Justify your answer with a sketch.
Answer: Ice is less dense than liquid water. This is due to differences in packing of water molecules in the two phases, even though hydrogen bonding occurs in both states. The sketch below shows seven water molecules in each state. In ice, these molecules are more

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spread out than they are in the liquid state since they occupy points in a lattice. The liquid state is characterized by more tight packing of the molecules since they do not form a regular lattice structure.



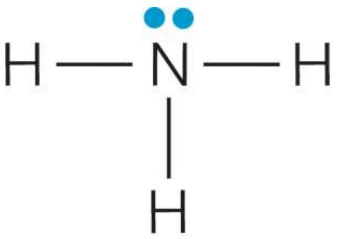
Ice



Liquid water

Learning Outcome: 2.4.2.a Justify the difference in densities of ice and in liquid water using a model illustrating the packing arrangement of water molecules.
Bloom's Level: 6. Creating

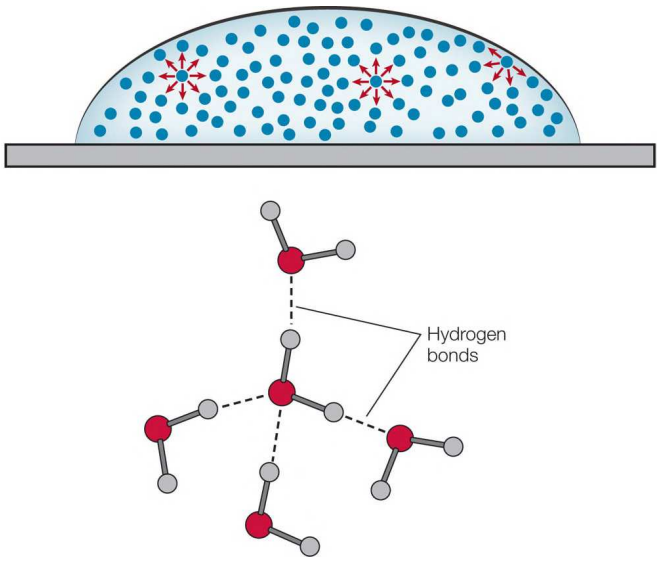
129. Refer to the figure below.



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The figure shows the molecular structure of ammonia. Would you expect liquid ammonia to have a heat capacity similar to that of water or very different from that of water? Explain your reasoning.
Answer: Liquid ammonia should have a heat capacity similar to that of water. Both compounds are polar molecules, and both are capable of forming intermolecular hydrogen bonds in the liquid state. Because of these two properties, the molecules in both liquids are strongly attracted to one another. It takes a lot of energy to disrupt these attractive forces. This will be observed as high heat capacities for both compounds.
Learning Outcome: 2.4.3.b Analyze the chemical structures of various compounds including water and predict their relative heat capacities.
Bloom's Level: 3. Applying

130. Water is a polar molecule. This property contributes to cohesion and surface tension. Sketch five water molecules, and indicate how hydrogen bonding between molecules contributes to cohesion and surface tension. Be sure to include appropriate covalent bonds in each molecule.
Answer:




Learning Outcome: 2.4.5.a Draw a diagram representing molecular structures to explain water's cohesive and adhesive properties.
Bloom's Level: 6. Creating

## LEARNING CURVE QUESTIONS

### Multiple Choice

1. A helium atom contains
a. a very large nucleus by volume.

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b. electrons that have a mass similar to that of protons.
c. two hydrogen molecules.
d. two positively charged neutrons.
e. two negatively charged electrons.
Answer: e
Hint: Remember that an atom contains negatively charged electrons that move about a very small nucleus composed of positively charged protons and uncharged neutrons.
Learning Outcome: 2.1.1.a Describe the structure of an atom.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

2. How many electrons occupy the orbital in the first energy level of an oxygen atom?
a. One
b. Two
c. Four
d. Six
e. Eight
Answer: b
Hint: Consider that an oxygen atom has eight electrons and that electrons fill the lowest energy levels first.
Learning Outcome: 2.1.1.a Describe the structure of an atom.
Bloom's Level: 2. Understanding
Difficulty Level: Easy

3. A neutral atom lost one or more particles. Before this loss, the atom had a mass of 15.99491 Da, and it was not influenced by an electric field. After this loss, the atom had a mass of 15.99440 Da, and its movement was diverted by an electric field. What particle(s) did the atom lose?
a. One neutron
b. One proton
c. One electron
d. One proton and one electron
e. One neutron and one electron
Answer: c
Hint: Remember that an electron has a mass much smaller than either a proton or a neutron, each of which has a mass of about 1 Da.
Learning Outcome: 2.1.2.a Compare and contrast the properties of protons, neutrons, and electrons.
Bloom's Level: 4. Analyzing
Difficulty Level: Easy

4. Which statement could be used to explain why an atom is electrically neutral?
a. The atom has a nucleus consisting of protons and neutrons.
b. Electrons move in the space surrounding the atomic nucleus.
c. The atom contains an equal number of protons and electrons.
d. Two atoms of the same element can have differing numbers of neutrons.

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e. All atoms contain positively charged protons and negatively charged electrons.
Answer: c
Hint: Remember that a particle can be neutral if all of the negative charges cancel all of the positive charges.
Learning Outcome: 2.1.3.a Explain why atoms typically have no overall electrical charge.
Bloom's Level: 5. Evaluating
Difficulty Level: Moderate

5. Refer to the table below.

| Atomic particle | Protons | Neutrons | Behavior in an electrical field |
|---|---|---|---|
| 1 | 31 | 28 | Moved toward positive electrode |
| 2 | 8 | 8 | Movement not affected |
| 3 | 23 | 21 | Moved toward negative electrode |

The table shows a summary of information about atomic particles under study in a physics lab. What could explain why two of the particles were affected by the electrical field while one particle remained unaffected?
a. An imbalance in protons and electrons causes the effect.
b. Only particle 2 has an equal number of protons and neutrons.
c. Small particles are less influenced by electrical fields than large particles.
d. Having an odd number of protons causes a particle to be influenced by an electrical field.
e. Particle 2 has the fewest charged particles in its nucleus.
Answer: a
Hint: Remember that the net charge on a particle is the sum of the charges of its electrons and protons.
Learning Outcome: 2.1.3.a Explain why atoms typically have no overall electrical charge.
Bloom's Level: 4. Analyzing
Difficulty Level: Difficult

6. What is true about an atom that has no charge?
a. Its nucleus contains neutrons, which are neutral particles.
b. Its protons are balanced by an equivalent number of neutrons.
c. Its mass depends on the numbers of protons and electrons in its structure.
d. It has an even number of electrons.
e. It has equal numbers of electrons and protons.
Answer: e
Hint: Remember that in an atom, the number of negative charges is canceled by the number of positive charges.
Learning Outcome: 2.1.3.a Explain why atoms typically have no overall electrical charge.
Bloom's Level: 1. Remembering

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Difficulty Level: Moderate

7. Refer to the table below, which shows the percentage abundance of elements by mass in five different samples.

| Sample | Al | Si | C | N | Fe | Mg | H | O |
|---|---|---|---|---|---|---|---|---|
| 1 | trace | trace | trace | 75% | trace | trace | trace | 22% |
| 2 | 12% | 25% | trace | trace | 10% | trace | trace | 51% |
| 3 | 36% | trace | 10% | trace | 12% | 25% | 15% | trace |
| 4 | trace | 52% | trace | trace | trace | trace | trace | 45% |
| 5 | trace | trace | 18% | 3% | trace | trace | 10% | 65% |

Which sample was taken from a living organism?
a. 1
b. 2
c. 3
d. 4
e. 5
Answer: e
Hint: Remember that two of the most abundant elements in living things are carbon and oxygen.
Learning Outcome: 2.1.4.a Compare the elements found in living tissue with elements found in nonliving matter.
Bloom's Level: 4. Analyzing
Difficulty Level: Difficult

8. Which six elements provide most of the mass of biological organisms?
a. C, O, N, H, P, S
b. K, O, N, H, P, C
c. C, O, Na, H, P, S
d. C, O, N, H, F, Mg
e. C, O, N, H, P, Mg
Answer: a
Hint: With one exception, these elements are all located on the right side of the periodic table.
Learning Outcome: 2.1.4.a Compare the elements found in living tissue with elements found in nonliving matter.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

9. Which symbol represents an atom with atomic number 28?
a. $^{56}_{28}Ba$

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b. $^{28}_{57}La$

c. $^{28}_{56}Ba$

d. $^{57}_{28}Ni$

e. $^{28}_{56}Ni$

Answer: d
Hint: Remember to consult the periodic table to identify an element based on the number of protons in its nucleus.
Learning Outcome: 2.1.5.a Given an atomic number of an atom, identify the element represented by the atom.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

10. Which atom has the same number of nuclear particles as $^{14}_{6}C$?

a. $^{12}_{6}C$

b. $^{15}_{7}N$

c. $^{11}_{5}B$

d. $^{14}_{7}N$

e. $^{15}_{8}O$

Answer: d
Hint: Remember that protons and neutrons make up an atom's nucleus and that their sum is the mass number of an atom.
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

11. Which pair of atoms would be expected to have similar chemical properties?

a. $^{24}_{12}Mg$ and $^{80}_{38}Sr$

b. $^{70}_{34}Se$ and $^{70}_{35}Br$

c. $^{6}_{3}Li$ and $^{8}_{4}Be$

d. $^{10}_{5}B$ and $^{20}_{10}Ne$

e. $^{235}_{92}U$ and $^{235}_{91}Pa$

Answer: a
Hint: Remember that elements in the same group of the periodic table have the same number of valence electrons.
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

12. Which symbol represents an atom with the greatest number of neutrons?

a. $^{35}_{15}P$

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b. $^{34}_{16}S$

c. $^{30}_{14}Si$

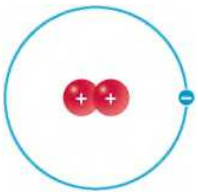
d. $^{38}_{18}Ar$

e. $^{34}_{13}Al$

Answer: e
Hint: Remember that the mass number is the sum of the protons and neutrons in an atom's nucleus.
Learning Outcome: 2.1.6.a Analyze the number of protons and neutrons present in an atom from its atomic number and mass number.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

13. Oxygen (O) has an atomic number of 8. What is the approximate atomic mass of an oxygen atom in daltons?
a. 8
b. 12
c. 16
d. 20
e. 24
Answer: c
Hint: Remember that the mass of an atom is mainly due to the sum of its protons and neutrons.
Learning Outcome: 2.1.6.a Analyze the number of protons and neutrons present in an atom from its atomic number and mass number.
Bloom's Level: 2. Understanding
Difficulty Level: Moderate

14. Which structure represents an isotope of hydrogen?
a.

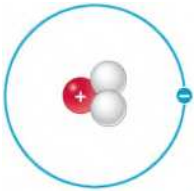


b.

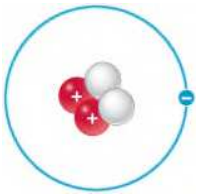


c.

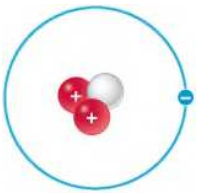
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d.

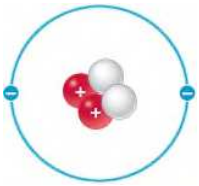


e.



Answer: c
Hint: Remember that the atomic number of hydrogen is 1.
Learning Outcome: 2.1.7.a Draw the atomic structures of three isotopes of hydrogen.
Bloom's Level: 4. Analyzing
Difficulty Level: Difficult

15. Refer to the figure below.



The figure represents a helium atom. What change to this figure would allow it to represent an isotope of hydrogen?
a. Remove one small circle from the outer ring, and remove two unlabeled circles from the center.
b. Remove one small circle from the outer ring, and remove one circle labeled with "+" and two unlabeled circles from the center.
c. Remove one small circle from the outer ring, and change one circle labeled with "+" to an unlabeled circle in the center.
d. Remove one small circle from the outer ring, and change one unlabeled circle to a circle labeled with "+" in the center.
e. Remove one small circle from the outer ring, and add one unlabeled circle to the center.
Answer: b
Hint: Remember that the atomic number of hydrogen is 1.
Learning Outcome: 2.1.7.a Draw the atomic structures of three isotopes of hydrogen.

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Bloom's Level: 5. Evaluating
Difficulty Level: Difficult

16. The five statements below describe properties of radioisotopes. Which statement is best used to justify the use of a radioisotope as a treatment for destroying cancer cells in human patients?
a. Each radioisotope gives off energy in the form of radiation.
b. A radioisotope undergoes nuclear decay to form a different element.
c. A radioisotope differs from other isotopes of the same element in its number of neutrons.
d. Radioisotopes can be detected using devices such as Geiger counters that detect radiation.
e. Most elements have at least one radioisotope.
Answer: a
Hint: What property of a radioisotope can kill cancer cells?
Learning Outcome: 2.1.8.a Justify the use of radioisotopes as a tool in biological research and as a treatment in medicine.
Bloom's Level: 5. Evaluating
Difficulty Level: Moderate

17. Scientists have used glucose labeled with carbon-14 in place of carbon-12 to trace the metabolic fate of glucose fed to mice. Relative to carbon-12, which property of carbon-14 is essential in these types of experiments?
a. Carbon-14 has to be heavier than carbon-12.
b. Carbon-14 has to have more neutrons than carbon-12.
c. Carbon-14 has to be safer than carbon-12 for use in animal studies.
d. Carbon-14 has to have the same chemical reactivity as carbon-12.
e. Carbon-14 has to release a certain kind of radiation.
Answer: d
Hint: Consider that the tracer glucose differs from normal glucose in having carbon-14 substituted for carbon-12. The tracer compound should behave the same way as the normal compound in order for a valid conclusion to be drawn from the results.
Learning Outcome: 2.1.8.a Justify the use of radioisotopes as a tool in biological research and as a treatment in medicine.
Bloom's Level: 5. Evaluating
Difficulty Level: Moderate

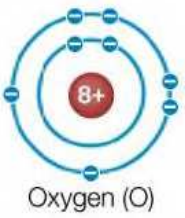
18. A neon atom has a total of ten electrons and is very unreactive. What accounts for this lack of reactivity?
a. Its outermost electron shell is full.
b. Ten is an even number of electrons.
c. The number of electrons is equal to the number of protons in a neon atom.
d. All electrons are paired in a neon atom.
e. Neon is a gas.
Answer: a

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Hint: Remember that atoms tend to gain, lose, or share electrons to achieve a full outer shell.
Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 3. Applying
Difficulty Level: Easy

19. Refer to the figure below.




An oxygen atom by itself is very reactive, whereas an oxygen atom that has combined with two hydrogen atoms to form a water molecule is very stable. What explains this observation?
a. Oxygen starts out with a total of eight electrons and becomes more stable when it adds more electrons.
b. The eight protons in the oxygen nucleus need additional electrons from hydrogen atoms to help neutralize their charge.
c. The two electrons in the innermost shell of an oxygen atom need two additional electrons to balance out.
d. The mass provided by the two hydrogen atoms adds to the mass of the oxygen atom, which increases the stability of the entire structure.
e. An oxygen atom only has six electrons in its valence shell and needs two electrons from hydrogen to fill this shell.
Answer: e
Hint: Remember that atoms tend to gain, lose, or share electrons so that their outer shell achieves a total of eight electrons for greatest stability.
Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

20. Which particles determine how an atom interacts with other atoms?
a. Protons
b. Neutrons
c. Electrons
d. Nuclei
e. Bosons
Answer: c
Hint: Which particles are located in the outermost regions of an atom where they can interact with other atoms?

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Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

21. In which column/group of the periodic table would you expect to find elements with five valence electrons?
a. The group that starts with Be
b. The group that starts with B
c. The group that starts with N
d. The group that starts with F
e. None of the above
Answer: c
Hint: Remember that the number of valence electrons increases as you go from left to right across the periodic table.
Learning Outcome: 2.1.9.b Explain how elements can be grouped according to their chemical properties in a periodic fashion.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

22. In the periodic table, when elements are in the same vertical column, they share a similar
a. atomic mass.
b. number of neutrons.
c. number of valence electrons.
d. number of unstable isotopes.
e. number of protons.
Answer: c
Hint: Remember what structural feature of an atom determines its chemical reactivity, which is used to group elements in the periodic table.
Learning Outcome: 2.1.9.b Explain how elements can be grouped according to their chemical properties in a periodic fashion.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

23. In the periodic table, why are hydrogen, lithium, and sodium in the same column?
a. They have different numbers of protons.
b. They have the same number of unpaired electrons.
c. They have the same number of electrons.
d. The periodic table is in alphabetical order.
e. They have fully filled electron shells.
Answer: b
Hint: Remember what structural feature of an atom determines its chemical reactivity, which is used to group elements in the periodic table.
Learning Outcome: 2.1.9.b Explain how elements can be grouped according to their chemical properties in a periodic fashion.

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Bloom's Level: 2. Understanding
Difficulty Level: Moderate

24. What type of chemical bond connects the carbon and oxygen atoms in the molecule shown below?

$H_3C—OH$

a. Nonpolar covalent bond
b. Asymmetric bond
c. Polar covalent bond
d. Hydrogen bond
e. Hydrophobic interaction
Answer: c
Hint: How does the bonding of two atoms of differing elements affect the polarity of a bond?
Learning Outcome: 2.2.1.a Identify examples of chemical bonds.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

25. Which is *not* an example of a force between two atoms?
a. Ionic attraction
b. van der Waals interaction
c. Electronegativity
d. Covalent bond
e. Hydrogen bond
Answer: c
Hint: Consider that chemical bonds and attractive interactions are forces that hold two atoms together.
Learning Outcome: 2.2.1.a Identify examples of chemical bonds.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

26. Covalent bonds
a. include polar but not nonpolar types.
b. may be single, double, or triple bonds and can vary in orientation.
c. involve electrons donated by only one of the bonding atoms.
d. involve attractions between ions.
e. occur only between atoms of two different elements.
Answer: b
Hint: Remember that covalent bonds form when atoms share electrons.
Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.
Bloom's Level: 2. Understanding
Difficulty Level: Easy

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27. A single carbon atom can bond a total of _____ hydrogen atoms, and the outer shell of each hydrogen atom then contains _____ electrons.
a. two; two
b. two; four
c. four; four
d. four; two
e. eight; two
Answer: d
Hint: How many valence electrons does carbon have? Remember that each valence electron from carbon will pair with a valence electron from hydrogen.
Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

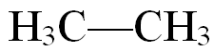
28. Which statement is true?
a. A single covalent bond involves 1 electron.
b. A double covalent bond involves 4 electrons.
c. A double covalent bond involves 8 electrons.
d. A triple covalent bond is formed among 3 atoms.
e. A triple covalent bond involves 12 electrons.
Answer: b
Hint: Remember that a pair of electrons is needed to form one covalent bond.
Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.
Bloom's Level: 2. Understanding
Difficulty Level: Difficult

29. Which correctly ranks the relative strengths of bonds and interactions?
a. Covalent bond > ionic attraction > hydrogen bond > hydrophobic interaction > van der Waals.
b. Covalent bond > ionic attraction = hydrogen bond > hydrophobic interaction > van der Waals.
c. Covalent bond < ionic attraction < hydrogen bond < hydrophobic interaction < van der Waals.
d. Covalent bond < ionic attraction = hydrogen bond < hydrophobic interaction < van der Waals.
e. Covalent bond < ionic attraction = van der Waals < hydrophobic interaction < hydrogen bond.
Answer: b
Hint: Check Table 2.1 to compare the ranges of bond energies that characterize the different types of bonds.
Learning Outcome: 2.2.3.a Explain why covalent bonds are so strong.
Bloom's Level: 4. Analyzing
Difficulty Level: Difficult

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30. What type of chemical bond connects the two carbon atoms in the molecule shown below?



a. Nonpolar covalent bond
b. Asymmetric bond
c. Polar covalent bond
d. Hydrogen bond
e. Double covalent bond
Answer: a
Hint: How does the bonding of two atoms of the same element affect the polarity of a bond?
Learning Outcome: 2.2.4.a Identify examples of polar covalent and nonpolar covalent bonds.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

31. The electronegativity of an atom is a relative measure of the
a. number of electrons in an atom.
b. number of electrons in the atom's outermost electron shell.
c. difference between the number of atoms and the number of protons.
d. affinity an atom has for electrons and its ability to capture additional electrons.
e. affinity an atom has for protons and its ability to capture additional protons.
Answer: d
Hint: Remember that the attractive force exerted on electrons by an atom's nucleus varies depending on the number of protons in the nucleus.
Learning Outcome: 2.2.4.a Identify examples of polar covalent and nonpolar covalent bonds.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

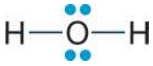
32. Which covalent bond is most polar?
a. Nitrogen–oxygen
b. Carbon–oxygen
c. Hydrogen–oxygen
d. Nitrogen–hydrogen
e. Carbon–hydrogen
Answer: c
Hint: Consider the differences in electronegativities of the atoms.
Learning Outcome: 2.2.4.a Identify examples of polar covalent and nonpolar covalent bonds.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

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33. Five statements describing water are given below. Which could best be used to explain why water is polar?
a. The water molecule is composed of three atoms held together by two covalent bonds.
b. The water molecule contains oxygen and hydrogen.
c. The two O–H bonds in water are oriented such that the molecule has a bent shape.
d. The oxygen atom is the central atom in a water molecule.
e. The two O–H bonds in a water molecule are identical.
Answer: c
Hint: Remember that each O–H bond is polar, but the shape of the molecule determines how this characteristic affects the overall polarity of the molecule.
Learning Outcome: 2.2.5.a Explain why water is a polar molecule.
Bloom's Level: 5. Evaluating
Difficulty Level: Moderate

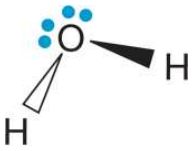
34. The figures below have all been used to represent a water molecule. Which could best be used to explain why water is polar?
a.




b.

$H_2O$

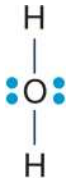
c.




d.




e.



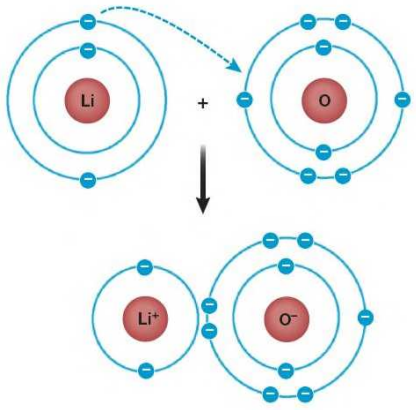

Answer: c
Hint: How are bond angles important in allowing polar bonds to contribute to forming a polar molecule?
Learning Outcome: 2.2.5.a Explain why water is a polar molecule.
Bloom's Level: 5. Evaluating

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Difficulty Level: Moderate

35. How does the ionic compound magnesium chloride form?
a. A magnesium atom loses one electron, a chlorine atom gains one electron, and an ionic bond forms between the chloride ion and the magnesium ion.
b. A magnesium atom loses two electrons, two chlorine atoms each gain one electron, and an ionic bond forms between each chloride ion and the magnesium ion.
c. Two magnesium atoms each lose one electron, two chlorine atoms each gain one electron, and an ionic bond forms between each chloride ion and each magnesium ion.
d. A chlorine atom loses one electron, a magnesium atom gains one electron, and an ionic bond forms between the chloride ion and the magnesium ion.
e. Two chlorine atoms each lose one electron, a magnesium atom gains two electrons, and an ionic bond forms between each chloride ion and the magnesium ion.
Answer: b
Hint: Check the periodic table to decide how each element gains or loses electrons and how many electrons are gained or lost.
Learning Outcome: 2.2.6.a Give an example of an ionic attraction and show how electrons are involved in its formation.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

36. Refer to the figure below.




Does this figure accurately show how the ionic compound lithium oxide forms?
a. Yes, because it shows two atoms forming ions that attract one another.
b. Yes, because it shows how lithium and oxygen share electrons to form a bond.
c. No, because lithium should gain electrons from oxygen, not the other way around, as shown.
d. No, because oxygen has an incomplete outer shell and needs an electron from a second lithium atom.
e. No, because the figure does not show how lithium and oxygen share electrons.
Answer: d
Hint: Remember that when they form ions, atoms gain or lose as many electrons as needed to fill their valence shells.

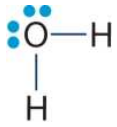
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Learning Outcome: 2.2.6.a Give an example of an ionic attraction and show how electrons are involved in its formation.
Bloom's Level: 5. Evaluating
Difficulty Level: Difficult

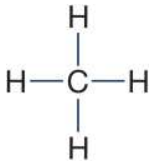
37. A(n) _____ bond is created by a(n) _____ attraction between two _____.
a. ionic; electrical; ions
b. cation; ionic; atoms
c. anion; ionic; molecules
d. ionic; van der Waals; ions
e. anion; cation; atoms
Answer: a
Hint: Remember that particles of opposite charges attract one another in forming one kind of chemical bond.
Learning Outcome: 2.2.6.a Give an example of an ionic attraction and show how electrons are involved in its formation.
Bloom's Level: 2. Understanding
Difficulty Level: Easy

38. A cation has the opposite charge from a(n)
a. hydrophilic interaction.
b. anion.
c. nonpolar bond.
d. ionic interaction.
e. complex ion.
Answer: b
Hint: Remember that a cation is a positively charged ion.
Learning Outcome: 2.2.6.a Give an example of an ionic attraction and show how electrons are involved in its formation.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

39. Which figure shows an example of a hydrogen bond?
a.




b.




c.

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d.

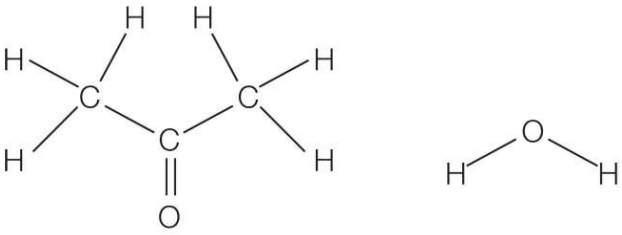


e.



Answer: c
Hint: Remember that hydrogen bonds are not covalent bonds.
Learning Outcome: 2.2.7.a Draw an example of a hydrogen bond and explain how it forms.
Bloom's Level: 3. Applying
Difficulty Level: Easy

40. Refer to the figure below.

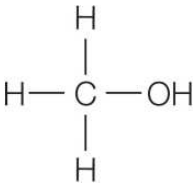


Acetone Water

Two molecules are shown. Where is it most likely that a hydrogen bond would form?
a. Between one of the hydrogen atoms in acetone and the oxygen atom in water
b. Between one of the hydrogen atoms in acetone and one of the hydrogen atoms in water
c. Between the oxygen atom in acetone and the oxygen atom in water
d. Between the oxygen atom in acetone and one of the hydrogen atoms in water
e. Between the carbon atom in acetone and one of the hydrogen atoms in water
Answer: d
Hint: Remember that hydrogen bonds form whenever a highly polar bond containing a hydrogen atom exists. This situation creates a hydrogen atom that has a strong partial positive charge.
Learning Outcome: 2.2.7.a Draw an example of a hydrogen bond and explain how it forms.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

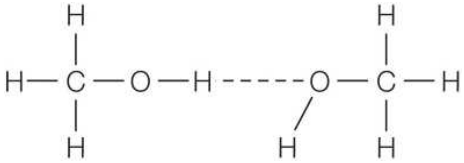
41. Refer to the figure below.

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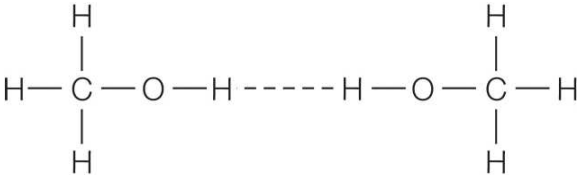


The figure shows the molecular structure of methanol. One type of hydrogen bond has been observed to form between molecules of methanol. Which diagram shows the most likely set of atoms involved in these hydrogen bonds?

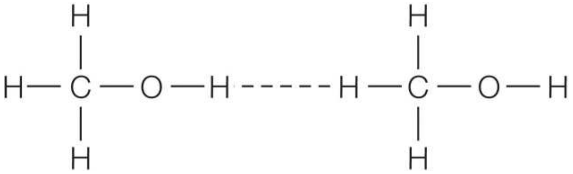
a.



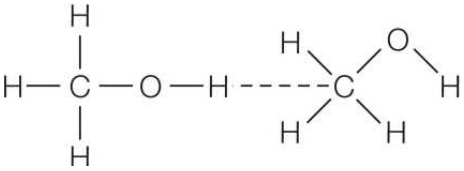
b.



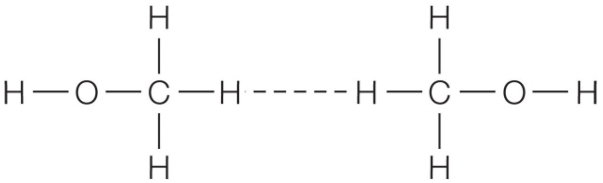
c.



d.



e.



Answer: a

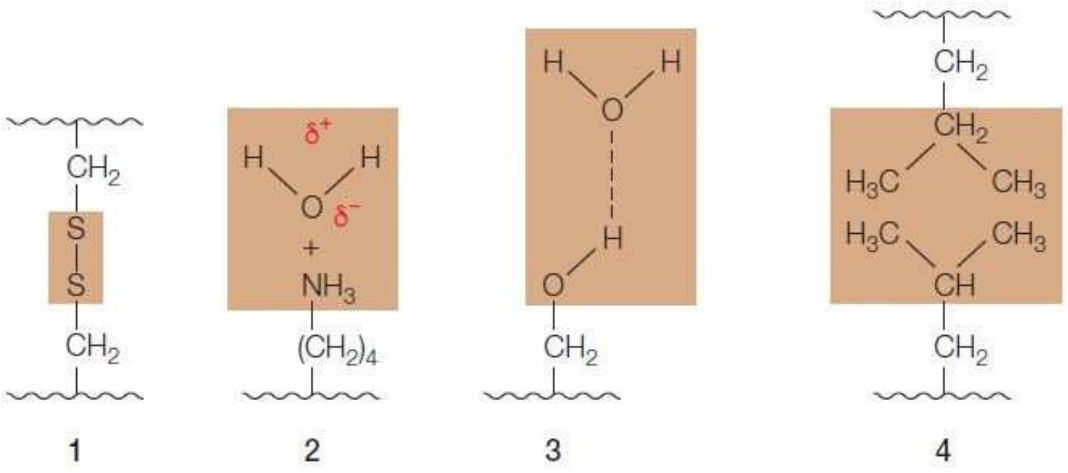
Hint: Remember that hydrogen bonds form whenever a highly polar bond containing a hydrogen atom exists. This situation creates a hydrogen atom that has a strong partial positive charge.

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Learning Outcome: 2.2.7.a Draw an example of a hydrogen bond and explain how it forms.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

42. Vegetable oil is composed of long-chain hydrocarbon molecules. Vegetable oil and water do not mix but form separate layers. Which statement describes the interactions between molecules in this case?
a. The water molecules and the hydrocarbon molecules interact with their own kind through hydrogen bonding, but they do not interact with each other.
b. The water molecules and the hydrocarbon molecules interact with their own kind through hydrophilic interactions, but they do not interact with each other.
c. The water molecules and the hydrocarbon molecules interact with their own kind through hydrophobic interactions, but they do not interact with each other.
d. The water molecules interact through hydrophobic interactions, and the hydrocarbon molecules interact through hydrophilic interactions.
e. The water molecules interact through hydrophilic interactions, and the hydrocarbon molecules interact through hydrophobic interactions.
Answer: e
Hint: What type of intermolecular interactions would you expect to observe between nonpolar long-chain hydrocarbon molecules?
Learning Outcome: 2.2.8.a Distinguish between hydrophilic and hydrophobic interactions using examples.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

43. Refer to the figure below.

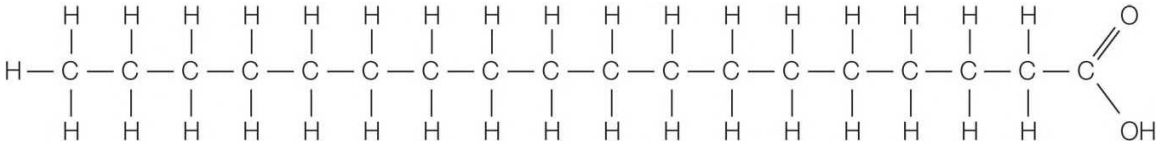



The figure shows four examples of molecular interactions in biological samples. Can any of these be used as examples of hydrophilic or hydrophobic interactions?
a. 1, 2, and 3 hydrophilic; 4 hydrophobic
b. 2 and 3 hydrophilic; 4 hydrophobic

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c. 2 hydrophilic; 4 hydrophobic
d. 3 hydrophilic; 1 and 4 hydrophobic
e. 2 and 3 hydrophilic; 1 and 4 hydrophobic
Answer: b
Hint: Remember that hydrophilic interactions are those that involve polar bonds.
Learning Outcome: 2.2.8.a Distinguish between hydrophilic and hydrophobic interactions using examples.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

44. Refer to the figure below.



The figure shows a molecule found in biological samples. What interactions will occur if 1 part of this compound is mixed with 20 parts of water, and why?
a. Hydrophobic interactions will cause these molecules to disperse evenly between the water molecules.
b. Hydrophilic interactions will cause these molecules to disperse evenly between the water molecules.
c. Hydrophobic interactions between these molecules and water will cause all of the molecules to form a separate layer.
d. Both hydrophobic and hydrophilic interactions between these molecules and water will cause groups of the molecules to form small spherical bunches dispersed in the water.
e. Both hydrophobic and hydrophilic interactions between these molecules and water will cause single molecules to disperse evenly between the water molecules.
Answer: d
Hint: How will the different parts of this molecule interact with water molecules and with other molecules of its kind?
Learning Outcome: 2.2.8.a Distinguish between hydrophilic and hydrophobic interactions using examples.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

45. The opposite of hydrophobic is
a. hydrophilic.
b. hygroscopic.
c. hydrochloric.
d. anisotropic.
e. acidophilic.
Answer: a
Hint: Consider that the root words "hydro" and "phobic" mean "water" and "hating." What set of root words mean "water" and "loving"?

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Learning Outcome: 2.2.8.a Distinguish between hydrophilic and hydrophobic interactions using examples.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

46. Which statement is *false*?
a. Covalent bonds can be polar or nonpolar depending on whether the atoms in the bond share electrons equally or unequally.
b. Hydrogen bonds form between or within molecules.
c. Ionic attractions and hydrogen bonds are noncovalent interactions involving differences in charge.
d. van der Waals forces are so weak that they have no significant importance in molecular interactions.
e. Hydrophobic molecules tend to aggregate together.
Answer: d
Hint: Remember which types of bonds are fleeting but occur in both polar and nonpolar molecules and can add up to a substantial attractive force.
Learning Outcome: 2.2.9.a Identify instances in which van der Waals forces are important.
Bloom's Level: 2. Understanding
Difficulty Level: Difficult

47. Which is an instance of van der Waals forces operating in nature?
a. Plants germinating from seeds
b. Salt dissolving in water
c. Oil separating from water
d. Mammalian hearts pumping blood
e. Houseflies walking on walls and ceilings
Answer: e
Hint: Each case represents some action. Which action results from many van der Waals forces operating at once?
Learning Outcome: 2.2.9.a Identify instances in which van der Waals forces are important.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

48. Which statement about spiders illustrates the importance of van der Waals forces in biology?
a. Some spider species live as solitary animals, while others form communal webs.
b. On a per-weight basis, spider silk is more resistant to breakage than steel.
c. Some spiders paralyze their prey by injecting venom into their bodies.
d. Some spider silks are extremely sticky and can adhere to smooth surfaces, such as glass.
e. Some spiders secrete digestive juices onto their prey to begin digestion before swallowing it.
Answer: d

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Hint: Think about the properties that a substance would have if it were able to apply a large number of van der Waals forces.
Learning Outcome: 2.2.9.a Identify instances in which van der Waals forces are important.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

49. Which experimental procedure could be used to provide evidence that living organisms are dynamic systems?
a. Analyze the elemental composition of a living plant.
b. Follow radioactive carbon atoms in glucose molecules consumed by a mouse.
c. Measure water in a fungus by weighing before and after drying the fungus in an oven.
d. Compare DNA sequences in bacteria with DNA sequences in yeast.
e. Burn plant material in the presence of oxygen and determine the products of combustion.
Answer: b
Hint: Think about the properties of living things that reveal their constantly changing nature.
Learning Outcome: 2.3.1.a Justify the claim that living organisms are dynamic.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

50. Which statement provides evidence that living organisms undergo constant change?
a. Living organisms contain molecules that can be combusted to form carbon dioxide and water.
b. Living organisms contain a large variety of molecules of many different sizes and types.
c. Living organisms are composed of cells that function using chemical reactions.
d. Living organisms follow the same laws of chemistry and physics that nonliving things follow.
e. Living organisms are composed mainly of the elements carbon, hydrogen, oxygen, and nitrogen.
Answer: c
Hint: What property listed is associated with constant change?
Learning Outcome: 2.3.1.a Justify the claim that living organisms are dynamic.
Bloom's Level: 5. Evaluating
Difficulty Level: Difficult

51. Consider two scenarios: (1) a living cell metabolizes glucose to carbon dioxide and water, and (2) a pan of water boils on a stove. Which statement correctly compares these scenarios?
a. Changes in energy occur as the cell metabolizes glucose, but not as the water boils.
b. Atoms are rearranged as the cell metabolizes glucose, but not as the water boils.
c. Matter is conserved as the cell metabolizes glucose, but not as the water boils.
d. Interactions between molecules change as the cell metabolizes glucose, but not as the water boils.

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e. Energy is conserved as the cell metabolizes glucose, but not as the water boils.
Answer: b
Hint: Consider that chemical change is taking place in a cell as it divides, but physical change is taking place in water as it boils.
Learning Outcome: 2.3.2.a Describe changes taking place during a chemical reaction.
Bloom's Level: 4. Analyzing
Difficulty Level: Moderate

52. Which general chemical principles can be applied to all chemical reactions?
a. The number of atoms in the reactants can differ from the number of atoms in the products.
b. Matter can neither be created nor destroyed during a chemical reaction.
c. Energy cannot change its form during a chemical reaction.
d. Some chemical reactions occur without being accompanied by a change in energy.
e. Chemical bonds remain unchanged during a chemical reaction.
Answer: b
Hint: Remember that chemical reactions obey the laws of conservation of energy and conservation of matter.
Learning Outcome: 2.3.2.a Describe changes taking place during a chemical reaction.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

53. Which statement best explains how atoms change partners when propane combusts?
a. Carbon breaks a bond with hydrogen and forms a new bond with hydrogen.
b. Carbon breaks a bond with oxygen and forms a bond with hydrogen and oxygen.
c. Oxygen breaks a bond with carbon and forms a bond with hydrogen.
d. Oxygen breaks a bond with hydrogen and forms a bond with carbon.
e. Oxygen breaks a bond with oxygen and forms a bond with carbon or hydrogen.
Answer: e
Hint: Write out the chemical equation describing the reaction, and use it to think about which bonds are broken and which are formed.
Learning Outcome: 2.3.2.a Describe changes taking place during a chemical reaction.
Bloom's Level: 2. Understanding
Difficulty Level: Difficult

54. Consider the following statement: In a chemical reaction, the properties of the products are usually similar to the reactants.
a. This is true because chemical properties don't change much when chemical partners change.
b. This is true because redox reactions don't change the properties.
c. This is false because the chemical properties can be significantly altered when chemical partners change.
d. This is false because a chemical reaction usually changes the mass of the reactants but not their energy.
e. This is false because energy can't be created or destroyed.
Answer: c

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Hint: Consider that chemical reactions cause striking changes.
Learning Outcome: 2.3.3.a Compare the products and reactants of a chemical reaction.
Bloom's Level: 1. Remembering
Difficulty Level: Moderate

55. The Australian environmental protection agency defines bioremediation as a "process using microorganisms to degrade and detoxify organic substances to harmless compounds, such as carbon dioxide and water, in a confined and controlled environment." Bioremediation is being used to clean up oil spills, pesticide-contaminated estuaries, contaminated groundwater, and many other cases of pollution. Which statement would be true of bioremediations?
a. The products of a bioremediation process have very different properties than the reactants do.
b. Bioremediations do not obey the law of conservation of matter.
c. The law of conservation of energy does not apply to bioremediations.
d. In bioremediations, chemical bonds are conserved as reactants are converted to products.
e. Bioremediations involve no change in energy.
Answer: a
Hint: Consider that bioremediation processes are chemical processes that obey the laws of conservation of energy and matter.
Learning Outcome: 2.3.3.a Compare the products and reactants of a chemical reaction.
Bloom's Level: 3. Applying
Difficulty Level: Easy

56. Refer to the balanced chemical equation below.

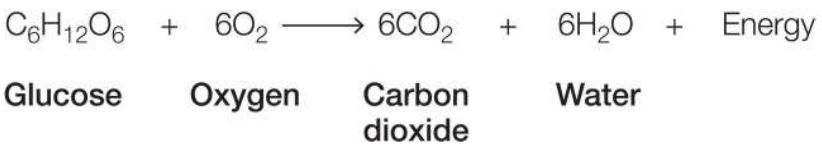
$$C_3H_8 + 5\ O_2 \rightarrow\ 4\ H_2O + 3\ CO_2$$

Which statement correctly describes this reaction?
a. The products contain the same chemical bonds as the reactants.
b. The combined mass of the products differs from the combined mass of the reactants.
c. The products contain the same elements in different numbers than the reactants do.
d. The products differ from the reactants in their elemental composition.
e. The products contain the same number and type of atoms present in the reactants.
Answer: e
Hint: Remember that products and reactants are not the same but that the laws of conservation of energy and matter must be obeyed whenever reactants are converted to products.
Learning Outcome: 2.3.3.a Compare the products and reactants of a chemical reaction.
Bloom's Level: 4. Analyzing
Difficulty Level: Moderate

57. Refer to the figure below.

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A living cell carries out this chemical reaction in many steps with a very small release of heat. The same chemical reaction can be carried out in one step in a chemistry lab using special equipment with the release of a very large amount of heat. Which statement related to this observation is correct?
a. Although the overall chemical reactions are the same, the cellular reaction involves less energy release than the reaction carried out in the lab.
b. The total amount of energy present before a reaction can change by the end of the reaction, depending on how the reaction proceeds.
c. Energy is not conserved in reactions carried out in laboratories; it is only conserved in reactions in living organisms.
d. Energy that escapes as heat is not considered when accounting for the changes in energy during any chemical reaction.
e. Energy in equals energy out in both cases, but most of the energy released is diverted to chemical bond energy in the cell instead of being released as heat.
Answer: e
Hint: Consider that the law of conservation of energy applies to all chemical reactions regardless of where they take place.
Learning Outcome: 2.3.4.a Explain how the law of conservation of energy applies to chemical reactions.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

58. The equation $C_4H_{10} + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$ + energy is *incorrect* because
a. two carbon atoms are missing from the products.
b. two hydrogen atoms are missing from the products.
c. two carbon atoms are missing from the reactants.
d. two hydrogen atoms are missing from the reactants.
e. two oxygen atoms are missing from the products.
Answer: d
Hint: Compare the number of each element on the reactant side to the number of each element on the product side.
Learning Outcome: 2.3.4.b Demonstrate an example to show that chemical reactions obey the law of conservation of matter.
Bloom's Level: 3. Applying
Difficulty Level: Easy

59. Which set of numbers correctly balances the chemical equation below, describing the combustion of hexane?
$2\ C_XH_Y + 19\ O_2 \rightarrow Z\ CO_2 + 14\ H_2O$ + energy
a. X = 6, Y = 12, Z = 10
b. X = 6, Y = 14, Z = 10
c. X = 6, Y = 14, Z = 12

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d. X = 6, Y = 14, Z = 14
e. X = 6, Y = 16, Z = 12
Answer: c
Hint: The number of hydrogen atoms is given in the equation and can be used as a starting point for finding the solution.
Learning Outcome: 2.3.4.b Demonstrate an example to show that chemical reactions obey the law of conservation of matter.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

60. When a chemical reaction occurs, changes in the form of _____ occur, which represents the capacity of the reaction to _____.
a. work; release energy
b. reactants; absorb energy
c. products; do work
d. reactants; make products
e. energy; do work
Answer: e
Hint: Remember that energy can be used to perform a useful task.
Learning Outcome: 2.3.5.a Explain how energy is involved in a chemical reaction.
Bloom's Level: 2. Understanding
Difficulty Level: Moderate

61. Refer to the balanced chemical equation below.

$$2\ H_2 + O_2 \rightarrow\ 2\ H_2O + \text{energy}$$

When this reaction occurs, energy is released explosively in the form of heat and light. Based on this information and your knowledge of chemical reactions, which statement is correct?
a. More energy is stored in two $H_2$ and one $O_2$ than is stored in four O–H bonds.
b. The sum of the energy of two $H_2$ and one $O_2$ is equal to the sum of the energy of four O–H bonds.
c. A water molecule has more stored energy in its bonds than two $H_2$ and one $O_2$ combined.
d. Energy is conserved during this reaction, which means that the chemical bond energies in the products are the same as the chemical bond energies in the reactants.
e. Energy is observed during this reaction because all chemical reactions involve a release of energy; some reactions just release more than others.
Answer: a
Hint: Consider that energy must be put in to break bonds in the reactants and then energy is released when new, different bonds are formed.
Learning Outcome: 2.3.5.a Explain how energy is involved in a chemical reaction.
Bloom's Level: 4. Analyzing
Difficulty Level: Difficult

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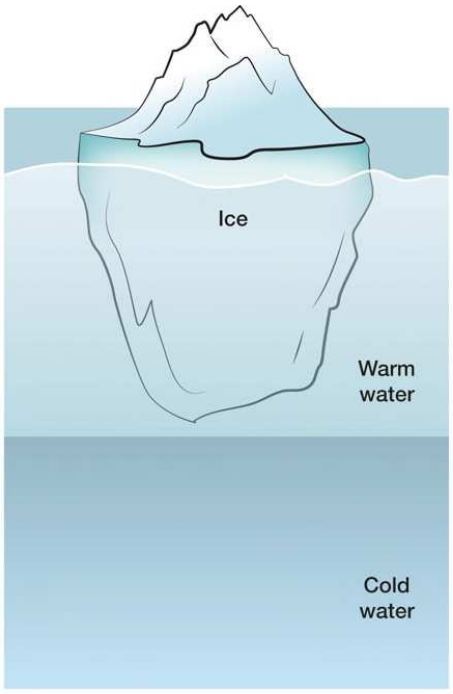
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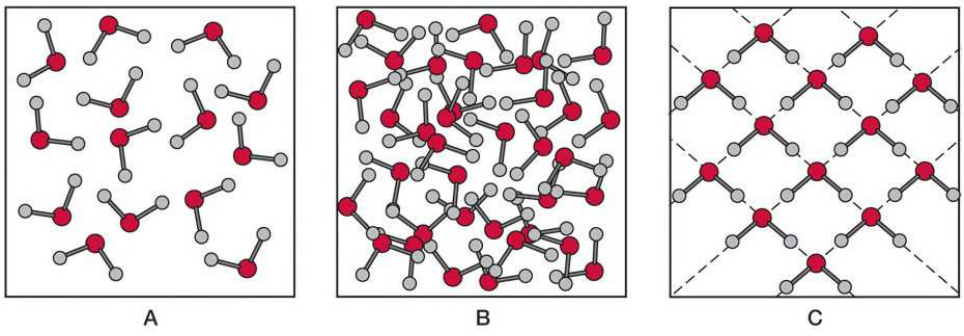
62. In an organic chemistry lab, chemical reactions are mainly carried out in organic solvents such as dichloromethane or hexane. Just down the hall in a biochemistry lab, chemical reactions are mainly carried out in aqueous buffers in which water is the solvent. If biochemical reactions involve organic compounds from biological sources, why aren't biochemical reactions carried out in organic solvents?
a. Organic solvents are more hazardous to use than water-based solvents.
b. Organic solvents require special disposal not required for water-based solvents.
c. Biochemical reactions can be slowed for easier study in aqueous solvents.
d. Biochemical reactions normally take place in a water-based solvent.
e. Biochemical reactions do not follow the same principles of chemistry that organic reactions follow.
Answer: d
Hint: Consider that water is the most abundant molecule in a living cell.
Learning Outcome: 2.4.1.a Explain why the study of water and its properties is relevant to the study of living organisms.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

63. Refer to the figures below.

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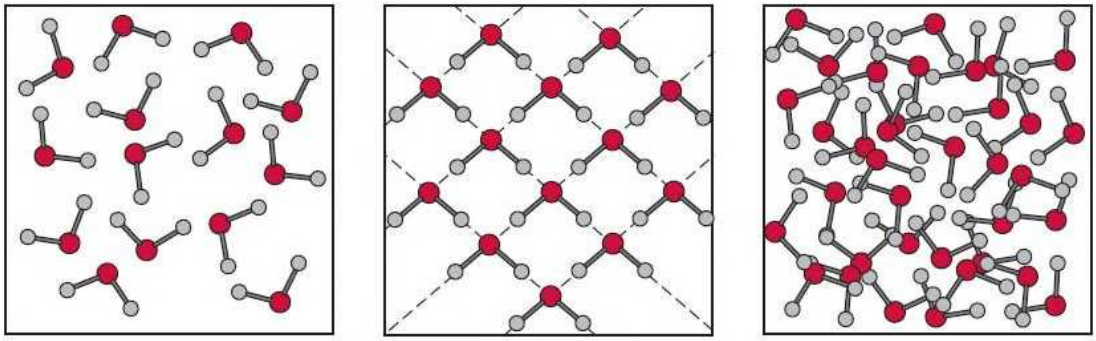




A student is creating a diagram to illustrate the structure of water in an Arctic lake. The student has identified three zones of the lake to label. How should the smaller images be attached to the larger one?
a. Ice = A, warm water = C, cold water = B
b. Ice = C, warm water = A, cold water = B
c. Ice = B, warm water = A, cold water = C
d. Ice = C, warm water = B, cold water = A
e. Ice = B, warm water = C, cold water = A
Answer: b
Hint: Which arrangement of water molecules is consistent with the observation that ice floats in liquid water?
Learning Outcome: 2.4.2.a Justify the difference in densities of ice and liquid water.
Bloom's Level: 4. Analyzing
Difficulty Level: Moderate

64. Refer to the table and three diagrams below.

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| Temperature (°C) | Density (g/cm$^3$) |
|---|---|
| 0.0 | 0.99987 |
| 4.0 | 1.00000 |
| 4.4 | 0.99999 |




How can the diagrams be used to justify the density measurements of water at the different temperatures given?
a. 0.0°C = Z, 4.0°C = Y, 4.4°C = X
b. 0.0°C = X, 4.0°C = Y, 4.4°C = Z
c. 0.0°C = Y, 4.0°C = Z, 4.4°C = X
d. 0.0°C = Z, 4.0°C = X, 4.4°C = Y
e. 0.0°C = Y, 4.0°C = X, 4.4°C = Z
Answer: b
Hint: Estimate the densities of water molecules in the diagrams, rank them from low to high, and then match them to the numerical densities in the table.
Learning Outcome: 2.4.2.a Justify the difference in densities of ice and liquid water.
Bloom's Level: 4. Analyzing
Difficulty Level: Moderate

65. Although air temperatures at a site on the coast of California can swing widely in very short periods of time, marine animals in the ocean at this site do not experience the same wide temperature swings. Which statement explains this observation?
a. Hydrogen bonding between water molecules results in the formation of a rigid lattice-like structure in the solid state.
b. The density of water changes with temperature as the average distance between water molecules changes.
c. A great deal of energy absorbed by water goes into breaking hydrogen bonds between water molecules.
d. Water molecules at the surface are hydrogen-bonded to other water molecules below them.
e. The polar nature of water molecules makes it an excellent solvent for dissolving polar substances.
Answer: c

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Hint: How do hydrogen bonds between water molecules enable water to absorb so much energy and yet only mildly raise its temperature?
Learning Outcome: 2.4.3.a Explain how the structure of water can be used to understand why water temperature changes slowly under the same conditions that cause the temperatures of other substances to change rapidly.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

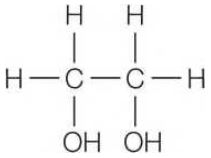
66. Which substance is predicted to have a greater heat capacity per mole than water?
a.



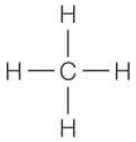
b.



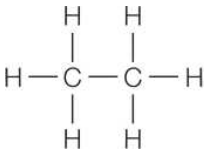
c.



d.

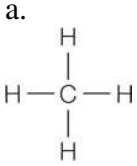


e.



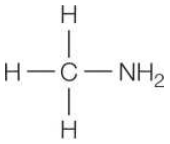
Answer: c
Hint: Which structure will have the most types of intermolecular forces of attraction?
Learning Outcome: 2.4.3.b Analyze the chemical structures of various compounds including water and predict their relative heat capacities.
Bloom's Level: 4. Analyzing
Difficulty Level: Easy

67. Which compound is expected to have a heat capacity per mole most similar to that of water?
a.

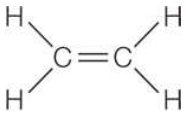


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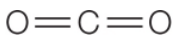
b.



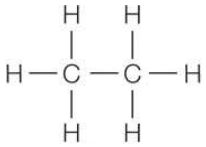
c.



d.

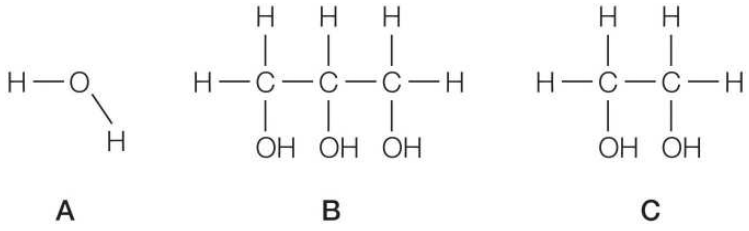


e.



Answer: b
Hint: Which compound has intermolecular forces of attraction most similar to those of water?
Learning Outcome: 2.4.3.b Analyze the chemical structures of various compounds including water and predict their relative heat capacities.
Bloom's Level: 4. Analyzing
Difficulty Level: Moderate

68. Refer to the figures below.

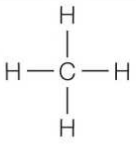
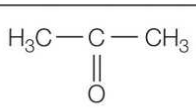



Rank the compounds in order of lowest to highest heat capacity per mole of compound.
a. C < A < B
b. A < C < B
c. B < A < C

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d. B < C < A
e. C < B < A
Answer: b
Hint: How do you think the ability to form a greater number of hydrogen bonds per molecule influences heat capacity?
Learning Outcome: 2.4.3.b Analyze the chemical structures of various compounds including water and predict their relative heat capacities.
Bloom's Level: 4. Analyzing
Difficulty Level: Difficult

69. Refer to the table below.

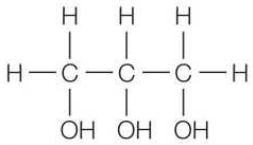
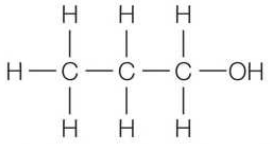
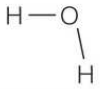
| Compound | Molecular structure | Heat of vaporization (kJ/mole) |
|---|---|---|
| Methane |  | 8.5 |
| Acetone |  | 31.3 |
| Water |  | 40.7 |

Which statement explains reasons for differences in the heat of vaporization for these compounds?
a. Methane has the lowest heat of vaporization because its molecules experience no intermolecular forces of attraction.
b. Water has the highest heat of vaporization because it is the smallest in mass and physical size.
c. Both acetone and water have higher heat of vaporization compared with methane because both are polar molecules capable of hydrogen bonding.
d. Water has a higher heat of vaporization compared with acetone and methane because it is a polar molecule and the other two are not.
e. Water has the highest heat of vaporization because it is the only compound that is both polar and capable of forming hydrogen bonds.
Answer: e
Hint: What intermolecular forces of attraction exist between molecules of each compound, and which compound has the most of these?
Learning Outcome: 2.4.4.a Compare water's heat of vaporization to the heat of vaporization of other substances and explain reasons for differences.
Bloom's Level: 4. Analyzing
Difficulty Level: Difficult

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70. Refer to the table below.

| Compound | Molecular structure | Heat of vaporization (kJ/mole) |
|---|---|---|
| Glycerin |  | 91.7 |
| Propanol |  | 47.0 |
| Water |  | 40.7 |

Which statement explains reasons for differences in the heat of vaporization for these compounds?
a. Glycerin's high heat of vaporization compared with that of the other molecules can be explained because it is both polar and capable of forming hydrogen bonds.
b. The heat of vaporization of glycerin is twice as high as that of water because glycerin is so much larger in size than water.
c. The greater hydrogen-bonding capacity of glycerin explains its greater heat of vaporization when compared with water or propanol.
d. Water has a lower heat of vaporization compared with glycerin and propanol because its hydrogen bonds are weaker.
e. Molecules that are polar and capable of forming hydrogen bonds tend to have similar heats of vaporization.
Answer: c
Hint: What intermolecular forces of attraction exist between molecules of each compound, and which compound has the most of these?
Learning Outcome: 2.4.4.a Compare water's heat of vaporization to the heat of vaporization of other substances and explain reasons for differences.
Bloom's Level: 4. Analyzing
Difficulty Level: Difficult

71. Which is an example of how water's high heat of vaporization affects a living organism?
a. Mammals produce sweat, which cools their bodies by absorbing excess body heat as the water in sweat evaporates.
b. Ice forms on the top of a lake downward, protecting aquatic life living at the bottom of the lake during the winter months.
c. The temperature of a shallow pond full of fish heats up very slowly on a hot summer day even though rocks nearby heat up quickly.

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d. Water forms a long column inside a tree extending from its roots to its leaves, which continually provides a source of water to the uppermost regions of the tree.
e. Aquatic insects are able to land on water because water molecules are strongly attracted to one another along the surface and below.
Answer: a
Hint: Remember that the heat of vaporization is a measure of the energy needed to cause liquid water to move to the gas phase.
Learning Outcome: 2.4.4.b Describe how water's heat of vaporization affects living organisms.
Bloom's Level: 3. Applying
Difficulty Level: Easy

72. Horses sweat heavily during high-intensity activities. This physiological response takes advantage of which property of water?
a. Differing densities at different temperatures
b. Ability to dissolve polar substances
c. High heat of vaporization
d. High heat capacity
e. Strong surface tension
Answer: c
Hint: Which property of water enables the sweating process to reduce rising body temperatures during heavy physical activity?
Learning Outcome: 2.4.4.b Describe how water's heat of vaporization affects living organisms.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

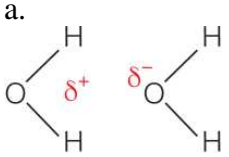
73. Which observation illustrates how water's heat of vaporization affects living organisms?
a. Seals can escape polar bear predation by diving through holes in the ice and hiding underwater.
b. Puddles resulting from a rainstorm become sites for mosquitoes laying eggs even though air temperatures become extremely hot.
c. If not left too long in a wilted state, a drooping plant can be revived by adding water to its soil.
d. Arctic ice is home to millions of species of organisms that live on its surface even though it is composed of water and is not a landmass.
e. Fish die when water temperatures rise as the result of the decreasing ability of water to dissolve oxygen at higher temperatures.
Answer: b
Hint: Remember that the heat of vaporization is a measure of the energy needed to cause liquid water to move to the gas phase.
Learning Outcome: 2.4.4.b Describe how water's heat of vaporization affects living organisms.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

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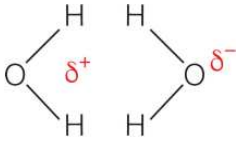
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74. Which illustration below represents the attractive forces responsible for the movement of water in a single column from the roots of a tree up through the stem and into leaves?

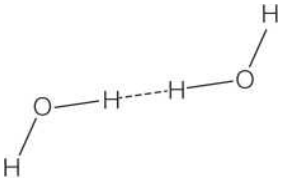
a.



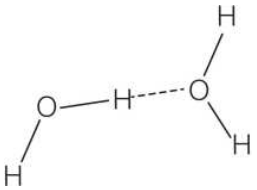

b.



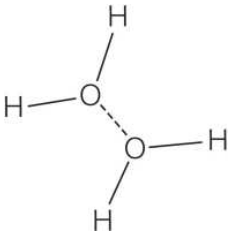

c.




d.



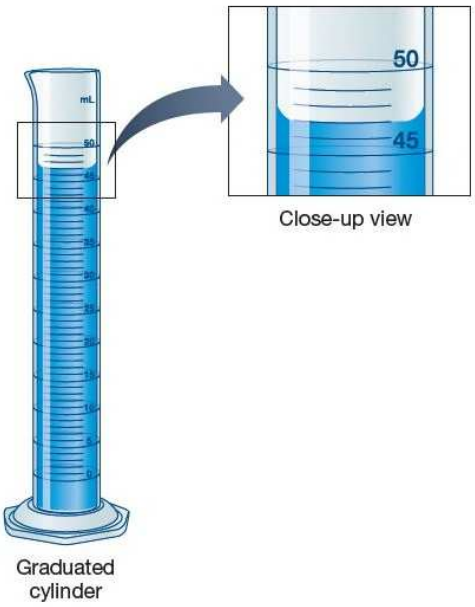

e.




Answer: d
Hint: What intermolecular forces that occur between water molecules are strong enough to keep the molecules together in a single column?
Learning Outcome: 2.4.5.a Draw a diagram representing molecular structures to explain water's cohesive and adhesive properties.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

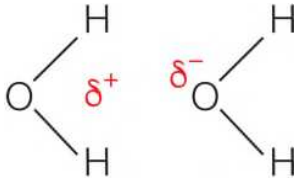
75. Refer to the figure below.

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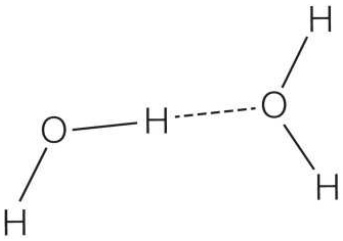



Which illustration represents the attractive forces responsible for the shape of the water surface in the glassware shown?

a.

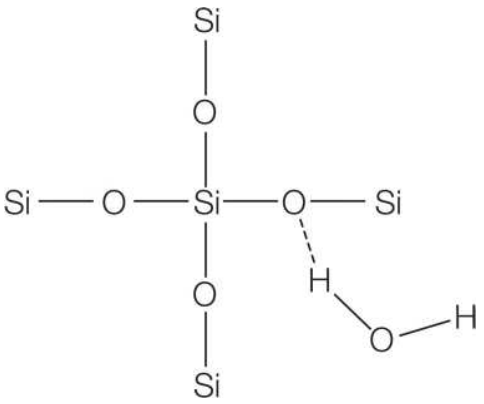



b.

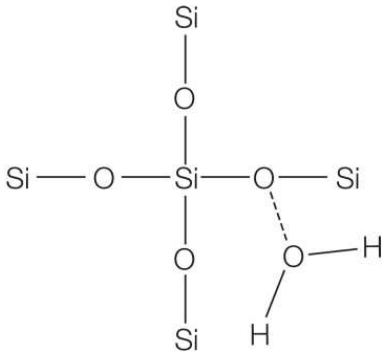



c.

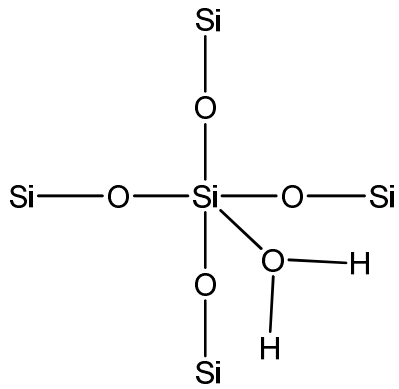
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d.




e.




Answer: c
Hint: Does the curved shape of the water surface indicate that the water molecules are more attracted to the molecules of the glass cylinder or to other water molecules?
Learning Outcome: 2.4.5.a Draw a diagram representing molecular structures to explain water's cohesive and adhesive properties.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

76. Consider the following statement: Most biochemical reactions take place in aqueous solutions. This statement is
a. true, because water is the solvent in an aqueous solution, and cells are full of water.

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b. true, because water is the reactant in the aqueous solution.
c. false, because water is the reactant and cannot also be the aqueous solution.
d. false, because most biochemical reactions love water.
e. false, because most biochemical reactions involve enzymes and not water.
Answer: a
Hint: Consider that the molecule found in greatest abundance in living things is water.
Learning Outcome: 2.4.6.a Explain why water's solvent properties are important in understanding events taking place inside cells.
Bloom's Level: 2. Understanding
Difficulty Level: Moderate

77. The _____ in an aqueous solution is water.
a. product
b. solute
c. solvent
d. ion
e. reactant
Answer: c
Hint: Remember that a solution is composed of two things. Which role does water play in a solution?
Learning Outcome: 2.4.6.a Explain why water's solvent properties are important in understanding events taking place inside cells.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

78. If carbon dioxide has a molecular weight of approximately 44, then 0.25 moles of carbon dioxide has
a. Avogadro's number of molecules.
b. a molecular weight of 22.
c. a molecular weight of 11.
d. approximately $1.5 \times 10^{24}$ molecules.
e. a molecular weight of 88.
Answer: d
Hint: Remember that molecular weight does not change with the quantity of a substance.
Learning Outcome: 2.4.7.a Perform quantitative analyses of biochemical compounds using the mole concept.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

79. What is the significance of Avogadro's number?
a. It is the total number of molecules found in the world.
b. It is the number of molecules in a mole.
c. It is the total number of moles of any molecule found in the world.
d. It is the number of molecules in 1 kg of a compound.
e. It is the number of moles in 1 kg of a compound.
Answer: b

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Hint: Remember that Avogadro's number can help you convert moles to molecules and vice versa.
Learning Outcome: 2.4.7.a Perform quantitative analyses of biochemical compounds using the mole concept.
Bloom's Level: 2. Understanding
Difficulty Level: Easy

80. What is the molarity of 14.5 g of NaCl dissolved in water to give a final solution volume of 0.500 liters?
a. 0.125 M
b. 0.250 M
c. 0.500 M
d. 0.750 M
e. 1.00 M
Answer: c
Hint: Remember that molarity is defined as the number of moles of solute per liter of solution.
Learning Outcome: 2.4.7.a Perform quantitative analyses of biochemical compounds using the mole concept.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

81. Which statement about water is *false*?
a. It is acidic.
b. It is a good solvent.
c. It has a high specific heat.
d. It is ubiquitous in living organisms.
e. It is an important habitat for living organisms.
Answer: a
Hint: Remember that the ionization of water produces both hydrogen ions and hydroxide ions.
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

82. What differentiates a strong acid from a weak acid?
a. A weak acid accepts $H^+$ ions, whereas a strong acid donates $H^+$ ions.
b. Ionization of a weak acid is irreversible, whereas ionization of a strong acid is reversible.
c. Ionization of a weak acid in water is incomplete, whereas ionization of a strong acid in water is complete.
d. A strong acid is more basic than a weak acid.
e. A strong acid has a pH below 7, whereas a weak acid has a pH above 7.
Answer: c

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Hint: Consider that the strength of an acid is a measure of how readily it gives up its $H^+$ ion.
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

83. The pH scale is a logarithmic scale. This means that
a. a solution with a pH of 7 is twice as acidic as a solution with a pH of 9.
b. a solution with a pH of 7 is twice as acidic as a solution with a pH of 5.
c. a solution with a pH of 7 is 10 times more acidic than a solution with a pH of 9.
d. a solution with a pH of 7 is 10 times more acidic than a solution with a pH of 5.
e. a solution with a pH of 7 is 100 times more acidic than a solution with a pH of 9.
Answer: e
Hint: Remember that when you move along a logarithmic scale, you are moving by factors of 10.
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

84. _____ capacity is a term used to describe the ability of a solution to prevent large changes in pH with the addition of a base or acid.
a. Heat
b. Buffering
c. Cohesive
d. Vaporization
e. Freezing
Answer: b
Hint: What is the name given to solutions that tend to maintain a constant pH?
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 1. Remembering
Difficulty Level: Easy

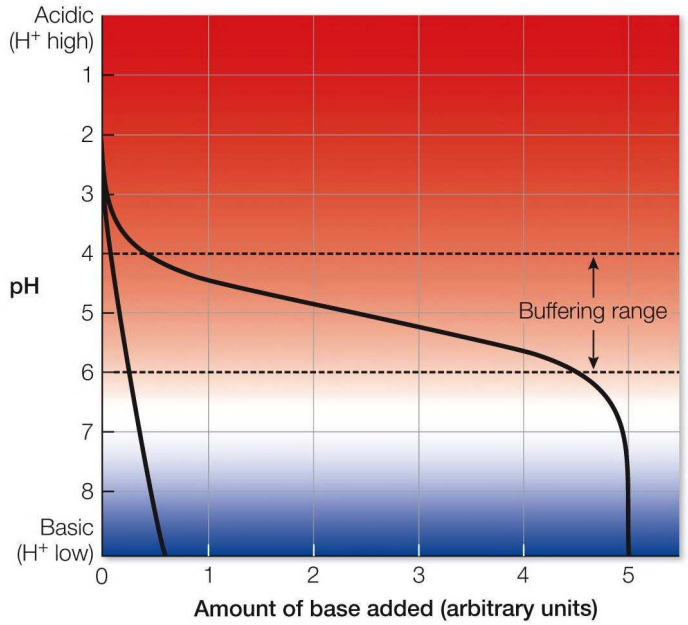
85. An aqueous solution with a mixture of a _____ acid and its corresponding _____ is called a(n) _____.
a. strong; base; molar solution
b. weak; base; buffer
c. strong; acid; ionic solution
d. strong; acid; buffer
e. weak; base; acid
Answer: b
Hint: How do you make a solution that resists changes in pH?
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.

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Bloom's Level: 1. Remembering
Difficulty Level: Easy

86. Refer to the figure below.




For the solution containing a buffer, the pH range with greatest buffering capacity is
a. 2–4.
b. 3–5.
c. 4–6.
d. 5–7.
e. 6–8.
Answer: c
Hint: Be sure to use the *x* axis when you are determining the pH range of greatest buffering capacity.
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 3. Applying
Difficulty Level: Moderate

**Fill in the Blank**

87. The subatomic particles that make up the majority of the mass of an atom are protons and _____.
Answer: neutrons
Hint: Remember that the mass of an electron is negligible compared with the mass of a proton or neutron.

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Learning Outcome: 2.1.2.a Compare and contrast the properties of protons, neutrons, and electrons.
Bloom's Level: 2. Understanding
Difficulty Level: Easy

88. Refer to the table below.

| Element | Percentage in plant dry matter | Percentage in soil dry matter |
|---|---|---|
| Oxygen | 42.9 | 47.3 |
| Carbon | 44.3 | 0.19 |
| Hydrogen | 6.1 | 0.22 |
| Nitrogen | 1.62 | 0 |
| Calcium | 0.62 | 3.47 |
| Phosphorus | 0.56 | 0.12 |
| Potassium | 1.68 | 2.46 |
| Sodium | 0.43 | 0 |
| Chlorine | 0.22 | 0.06 |
| Sulfur | 0.37 | 0.12 |
| Magnesium | 0.38 | 2.24 |
| Iron | 0.04 | 4.50 |

The table shows results from elemental analyses performed on a plant sample and a soil sample. These samples were dried prior to the analysis to remove all water. A scientist wants to use this information as the basis for identifying samples of unknown origin as either plant or soil material. Because running so many chemical tests can be time-consuming and expensive, she wants to limit future tests to one element. She would have the best chance of distinguishing between soil and plant material if she chose the element _____ for analysis.
Answer: carbon
Hint: Which element shows the largest difference in abundance when you compare the two samples?
Learning Outcome: 2.1.5.a Given an atomic number of an atom, identify the element represented by the atom.
Bloom's Level: 5. Evaluating
Difficulty Level: Moderate

89. A(n) _____ atom has 7 neutrons and a mass number of 15.
Answer: oxygen

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Hint: Remember that the mass number is the sum of the protons and neutrons in an atom's nucleus.
Learning Outcome: 2.1.5.a Given an atomic number of an atom, identify the element represented by the atom.
Bloom's Level: 3. Applying
Difficulty Level: Easy

90. An atom of $^{72}_{35}Br$ has _____ neutrons and 35 protons.
Answer: 37
Hint: Remember that the mass number is the sum of the protons and neutrons in an atom's nucleus.
Learning Outcome: 2.1.6.a Analyze the number of protons and neutrons present in an atom from its atomic number and mass number.
Bloom's Level: 3. Applying
Difficulty Level: Difficult

91. The covalent bonds in methane, $CH_4$, are very strong and require a great deal of energy to break. This is because in forming each bond, electrons are shared between carbon atoms and hydrogen atoms such that the _____ of each atom become filled, which is a highly stable condition.
Answer: valence shells
Hint: Remember that the mass number is the sum of the protons and neutrons in an atom's nucleus.
Learning Outcome: 2.2.3.a Explain why covalent bonds are so strong.
Bloom's Level: 3. Applying
Difficulty Level: Easy

92. A large number of weak _____ that are inconsequential by themselves can amount to an important, large, attractive force between the two surfaces of large interacting biomolecules, such as a small protein and the larger protein bound to it.
Answer: van der Waals forces
Hint: Remember that a certain type of intermolecular force exists between any two molecules.
Learning Outcome: 2.2.9.a Identify instances in which van der Waals forces are important.
Bloom's Level: 3. Applying
Difficulty Level: Easy

93. One mole of ADP undergoes a condensation reaction with inorganic phosphate to form 1 mole of ATP. This reaction requires the input of 32 kJ of energy, which is stored as chemical bond energy in the ATP until it is later released when 1 mole of ATP is hydrolyzed to form 1 mole of ADP and inorganic phosphate. The same quantity of energy is released in the hydrolysis reaction, a fact that illustrates the law of _____.
Answer: conservation of energy
Hint: How is energy affected as chemical reactions take place?

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Learning Outcome: 2.3.4.a Explain how the law of conservation of energy applies to chemical reactions.
Bloom's Level: 3. Applying
Difficulty Level: Easy

94. Refer to the two balanced chemical equations below.

(1) $CH_4 + 2\ O_2 \rightarrow\ CO_2 + 2\ H_2O + 890$ kJ

(2) $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O + 2{,}220$ kJ

According to the information given, reaction 2 involves a _____ change in energy than reaction 1.
Answer: greater
Hint: Consider that the amount of energy involved in each reaction is given in kilojoules.
Learning Outcome: 2.3.5.a Explain how energy is involved in a chemical reaction.
Bloom's Level: 4. Analyzing
Difficulty Level: Easy

95. Many desert plants have thick waxy cuticles that cover leaf and stem surfaces exposed to the environment. Many also have deep root systems that extend far below ground. These adaptations are critical to plant survival in the desert because _____ is the most abundant compound found in plant cells and plants need special features to maintain its abundance in their tissues.
Answer: water
Hint: What resource that is critical for life is difficult to find in a desert?
Learning Outcome: 2.4.1.a Explain why the study of water and its properties is relevant to the study of living organisms.
Bloom's Level: 3. Applying
Difficulty Level: Easy

96. A fish swimming in a shallow pool of water on a hot summer day has a certain amount of protection from becoming too warm. This happens because a large amount of heat energy goes into breaking the _____ between water molecules before additional energy goes into raising the water temperature.
Answer: hydrogen bonds
Hint: What strong intermolecular forces of attraction are responsible for water's high heat capacity?
Learning Outcome: 2.4.3.a Explain how the structure of water can be used to understand why water temperature changes slowly under the same conditions that cause the temperatures of other substances to change rapidly.
Bloom's Level: 3. Applying
Difficulty Level: Easy

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## SUMMATIVE QUIZ QUESTIONS

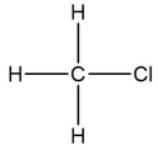
1. Refer to the table below.

| | A | B | C |
|---|---|---|---|
| Mass | $1.7 \times 10^{-24}$ g | $9 \times 10^{-28}$ g | $1.7 \times 10^{-24}$ g |
| Charge | −1 | +1 | 0 |
| Location in an atom | nucleus | orbital | nucleus |

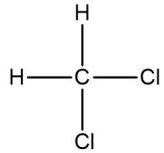
What change would make the table accurate?
a. Change heading A to "Electron," B to "Proton," and C to "Neutron."
b. Change heading A to "Proton," B to "Electron," and C to "Neutron."
c. Switch the masses in columns A and B, then change heading A to "Electron," B to "Neutron," and C to "Proton."
d. Switch the charges in columns A and B, then change heading A to "Proton," B to "Electron," and C to "Neutron."
e. Switch the locations in columns B and C, then change heading A to "Proton," B to "Neutron," and C to "Electron."
Answer: d
Learning Outcome: 2.1.2.a Compare and contrast the properties of protons, neutrons, and electrons.
Bloom's Level: 2. Understanding

2. A molecule contains five atoms and has a molecular weight of 85 g per mole. The atoms are of elements with atomic numbers 1, 6, and 17. Which molecular structure could represent this molecule?

a.



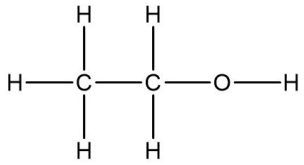

b.



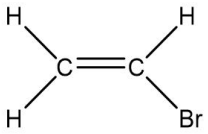

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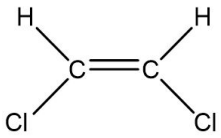
c.




d.




e.




Answer: b
Learning Outcome: 2.1.5.a Given an atomic number of an atom, identify the element represented by the atom.
Bloom's Level: 4. Analyzing

3. Refer to the table below.

| Atom | Atomic number | Mass number |
|---|---|---|
| 1 | 7 | 15 |
| 2 | 11 | 22 |
| 3 | 14 | 28 |
| 4 | 15 | 30 |

Which statement about the atoms in the table is accurate?
a. Atom 1 and atom 2 are isotopes of the same element.
b. Atom 1 and atom 4 have the same number of electrons in their outer shells.
c. Atom 3 and atom 4 have the same number of neutrons in their nuclei.

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d. Atom 2 and atom 3 differ by six neutrons in their nuclei.
e. Atom 1 and atom 4 gain stability when they each lose one electron.
Answer: b
Learning Outcome: 2.1.5.b Use the periodic table to compare and contrast the atomic structures of different elements.
Bloom's Level: 4. Analyzing

4. Which statement about isotopes is *false*?
a. Isotopes vary in the number of neutrons but not the number of protons.
b. Radioisotopes are unstable and spontaneously emit radiation.
c. Isotopes have the same atomic number but not the same atomic weight.
d. Isotopes have virtually the same chemical reactivity.
e. Deuterium is an isotope of hydrogen containing one proton and two neutrons.
Answer: e
Learning Outcome: 2.1.7.a Draw the atomic structures of three isotopes of hydrogen.
Bloom's Level: 2. Understanding

5. Isotopic analysis of biological samples can be a useful tool in the study of
a. how a drug moves through the body.
b. life-spans of ancient animals.
c. social patterns of ancient people.
d. the genetic makeup of dinosaurs.
e. the mating preferences of a bird species.
Answer: a
Learning Outcome: 2.1.8.a Justify the use of radioisotopes as a tool in biological research and as a treatment in medicine.
Bloom's Level: 3. Applying

6. The reactivity of an atom arises from the
a. energy differences between the orbitals that contain its electrons.
b. number of electrons in the outermost electron shell.
c. number of electron shells in the atom.
d. sum of the potential energies of all electron shells.
e. potential energy of the outermost electron shell, or valence shell.
Answer: b
Learning Outcome: 2.1.9.a Explain the role that the outermost electron shell plays in determining how an atom may combine with other atoms.
Bloom's Level: 2. Understanding

7. Covalent bond formation depends on the ability of atoms to _____ other atoms.
a. share one or more pairs of electrons with
b. donate electrons to
c. receive electrons from
d. share neutrons with
e. donate protons to
Answer: a

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Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.
Bloom's Level: 2. Understanding

8. Which shows the elements carbon (C), hydrogen (H), oxygen (O), nitrogen (N), and phosphorus (P) in decreasing order by the number of covalent bonds they usually form?
a. C > P > N > O > H
b. P > O > C > N > H
c. P > C > N > O > H
d. P > C > O > N > H
e. P > C > O > H > N
Answer: c
Learning Outcome: 2.2.2.a Give an example of a covalent bond and show how electrons are involved in formation of the bond.
Bloom's Level: 3. Applying

9. Which interaction between atoms is the strongest?
a. Hydrophobic interactions
b. Ionic attraction
c. Covalent bonds
d. van der Waals forces
e. Hydrogen bonds
Answer: c
Learning Outcome: 2.2.3.a Explain why covalent bonds are so strong.
Bloom's Level: 2. Understanding

10. For a covalent bond to be polar, the two atoms that form the bond must have
a. differing atomic weights.
b. differing numbers of neutrons.
c. differing melting points.
d. differing electronegativities.
e. similar electronegativities.
Answer: d
Learning Outcome: 2.2.4.a Identify examples of polar covalent and nonpolar covalent bonds.
Bloom's Level: 2. Understanding

11. Polar molecules
a. have electric charges that are unequally distributed.
b. have the ability to form ions when dissolved in water.
c. have electric charges that are equally distributed.
d. have bonds with an overall negative charge.
e. have bonds with an overall positive charge.
Answer: a
Learning Outcome: 2.2.5.a Explain why water is a polar molecule.
Bloom's Level: 2. Understanding

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12. Hydrocarbons are _____ and _____, whereas salts are _____ and _____.
a. nonpolar; hydrophobic; polar; hydrophilic
b. nonpolar; hydrophilic; polar; hydrophobic
c. nonpolar; hydrophobic, nonpolar, hydrophilic
d. polar; hydrophilic; nonpolar; hydrophobic
e. polar; hydrophobic; nonpolar; hydrophilic
Answer: a
Learning Outcome: 2.2.8.a Distinguish between hydrophilic and hydrophobic interactions using examples.
Bloom's Level: 3. Applying

13. Which finding can be used to justify the claim that living organisms are dynamic?
a. Microscopic examination of tissue removed from a multicellular organism reveals cells as the underlying basic units of structure.
b. Combustion of living plants results in formation of carbon dioxide and water along with a great deal of heat.
c. Examination of fossilized remains of dinosaurs indicates that these organisms share some anatomical features with modern birds.
d. Elemental analysis of living tissue reveals the presence of many elements in trace quantities.
e. Radioisotopic tracing shows that living organisms transform glucose and oxygen to carbon dioxide and water.
Answer: e
Learning Outcome: 2.3.1.a Justify the claim that living organisms are dynamic.
Bloom's Level: 5. Evaluating

14. Which statement about chemical reactions is *false*?
a. They occur when atoms combine or change their bonding partners.
b. They may lead to the creation or destruction of energy.
c. They may go to completion.
d. They may lead to changes in forms of energy.
e. They convert reactants into products.
Answer: b
Learning Outcome: 2.3.2.a Describe changes taking place during a chemical reaction.
Bloom's Level: 2. Understanding

15. Which equation represents a chemical reaction that obeys the law of conservation of matter?
a. $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$
b. $C_6H_{12}O_6 + 8\ O_2 \rightarrow 6\ CO_2 + 8\ H_2O$
c. $C_6H_{12}O_6 + 12\ O_2 \rightarrow 3\ CO_2 + 8\ H_2O$
d. $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$
e. $2\ C_6H_{12}O_6 + 6\ O_2 \rightarrow 12\ CO_2 + 6\ H_2O$
Answer: d

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Learning Outcome: 2.3.4.b Demonstrate an example to show that chemical reactions obey the law of conservation of matter.
Bloom's Level: 4. Analyzing

16. Of the statements below, which best explains why the study of water is relevant to the study of living organisms?
a. Water is produced when amino acids polymerize to form proteins and when nucleotides polymerize to form RNA and DNA.
b. Ninety-six percent of water on Earth is found in the oceans, 1 percent is found in bays and estuaries, and 3 percent is found in freshwater locations.
c. An average rainstorm drops about 100,000 liters of water over 1 acre of land.
d. Sixty percent of an adult human's body weight is due to water, with two-thirds of this water located inside cells and one-third outside cells.
e. Water is the only compound on Earth that can be found as a gas, a liquid, and a solid in different natural settings.
Answer: d
Learning Outcome: 2.4.1.a Explain why the study of water and its properties is relevant to the study of living organisms.
Bloom's Level: 5. Evaluating

17. Which property of water contributes most to the ability of fish in lakes to survive very cold winters?
a. Strong cohesive forces
b. High heat capacity
c. Density differences at different temperatures
d. High surface tension
e. High heat of vaporization
Answer: c
Learning Outcome: 2.4.2.a Justify the difference in densities of ice and liquid water.
Bloom's Level: 3. Applying

18. Sweating is a useful cooling device for humans because water
a. absorbs a great deal of heat in changing from its liquid state to its gaseous state.
b. absorbs a great deal of heat in changing from its solid state to its liquid state.
c. can exist in three states at temperatures common on Earth.
d. is an outstanding solvent.
e. ionizes readily.
Answer: a
Learning Outcome: 2.4.4.b Describe how water's heat of vaporization affects living organisms.
Bloom's Level: 3. Applying

19. Given that Avogadro's number is $6.02 \times 10^{23}$, how many molecules of KCl are there in $10^{-13}$ liter of a 1 M KCl solution?
a. $6.02 \times 10^{36}$
b. $6.02 \times 10^{10}$

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c. $6.02 \times 10^{-10}$
d. $6.02 \times 10^{3}$
e. $6.02 \times 10^{13}$
Answer: b
Learning Outcome: 2.4.7.a Perform quantitative analyses of biochemical compounds using the mole concept.
Bloom's Level: 4. Analyzing

20. Why is the pH of a 0.1 M solution of acetic acid in water higher than that of a 0.1 M solution of HCl in water?
a. HCl is a weaker acid than acetic acid.
b. The acetic acid does not fully ionize in water, whereas HCl does.
c. HCl does not fully ionize in water, whereas acetic acid does.
d. Acetic acid is a better buffer than HCl.
e. Acetate (ionized acetic acid) is a strong base.
Answer: b
Learning Outcome: 2.4.8.a Predict and explain changes in pH caused by changes in concentration of weak acids or bases in living tissue.
Bloom's Level: 3. Applying

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