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CORRECT ANSWERS ARE LOCATED IN THE 2ND HALF OF THIS DOC.

CHECK ALL THE APPLY. Choose all options that best completes the statement or answers the question.

1) Which of the following is a way that isotopes are useful in medicine?
   A) Radioactive isotopes can be used as tracers to detect molecular changes or to destroy abnormal or infectious cells.
   B) Radioactive isotopes can be used to regenerate damaged tissues.
   C) Radioactive isotopes can be used to detect Alzheimer's disease.
   D) Radioactive isotopes can be used to sterilize medical equipment.
   E) Radioactive isotopes can be used to prevent bacterial contamination of vegetables.

2) Given the chemical equation: $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$, identify which of the following statements are correct.
   A) CO_2 is a reactant.
   B) H_2O is a product.
   C) $C_6H_{12}O_6$ is both a reactant and a product.
   D) O_2 is a reactant.

3) Which of the following properties of water involve hydrogen bonds?
   A) cohesion
   B) high heat capacity
   C) surface tension
   D) polarity
   E) water expands as it freezes

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MULTIPLE CHOICE - Choose the one alternative that best completes the statement or answers the question.

4) Which of the following is a trace element in living things?
   A) oxygen
   B) carbon
   C) hydrogen
   D) nitrogen
   E) chromium

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5) Which one of the following is the smallest unit of matter that has all the properties of an element?
   A) molecule
   B) proton
   C) atom
   D) compound
   E) electron

6) Which of the following statements about atoms is correct?
   A) An element may be composed of more than one type of atom.
   B) The nucleus of an atom contains protons and electrons.
   C) The number and arrangement of electrons in an atom governs its chemical activity.
   D) The positive charges of an element are carried by the electrons.
   E) The neutral charges of an element are carried by the protons.

7) Elements that differ in their_____ are known as isotopes.
   A) proton number
   B) electron number
   C) neutron number
   D) type of bonds
   E) atomic number

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8) An atom's valence electron shell
   A) is the first shell to circle the nucleus.
   B) determines its chemical reactivity.
   C) determines its atomic mass.
   D) is filled with positively charged particles.
   E) always contains 8 electrons.

9) An atom that has an electrical charge is called a(n)
   A) ion.
   B) molecule.
   C) isotope.
   D) element.
   E) proton.

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10) A covalent bond occurs when
- A) protons are transferred from one atom to another.
- B) neutrons are shared between two atoms to form an isotope.
- C) electrons are shared between two atoms to complete their valence shells.
- D) the hydrogen of one water molecule is attracted to the oxygen of another water molecule.
- E) electrons are transferred from one atom to another.

11) The type of bond that would form from the transfer of an electron from one atom to another is a(n)_____ bond.
- A) covalent
- B) ionic
- C) hydrogen
- D) atomic
- E) isotopic

12) When a sodium atom transfers an electron to a chlorine atom
- A) the sodium atom becomes a negatively charged ion.
- B) the chlorine atom becomes a positively charged ion.
- C) the positive and negative ions will repel each other.
- D) the ions will separate in the presence of water.
- E) They form a covalent bond.

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13) Which of the following can be described as a molecule but not a compound?
- A) H_2O
- B) O^{-2-}
- C) NaCl
- D) CO_2
- E) $MgCl_2$

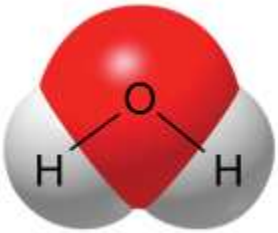
14) Sucrose, $C_{12}H_{22}O_{11}$, is best described as a(n)
- A) element.
- B) isotope.
- C) compound.
- D) ion.
- E) atom.

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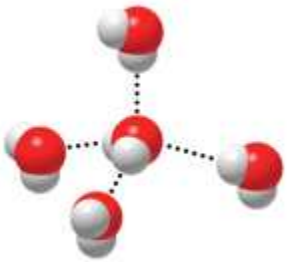
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15) A water molecule, as shown here, is polar because



A) of the transfer of electrons.
B) oxygen has a stronger electronegativity than hydrogen.
C) of its ability to freeze.
D) of its ability to form hydrogen bonds.
E) electrons spend more time near the hydrogen nuclei than near the oxygen nuclei.

16) The figure below is depicting the interaction of water molecules with one another. The weak attractions between water molecules are known as



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A) covalent bonds.
B) hydrogen bonds.
C) ionic bonds.
D) positive and negative ions.
E) nonpolar interactions.

17) Which of the following property of water explains why a wet glass slide sticks to laboratory counter?
A) Water is a good solvent.
B) Water is cohesive.
C) Water has a high heat capacity.
D) Water can alternate between solid, liquid, and gaseous states.
E) Water is adhesive.

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18) Which of the following statements about basic solutions is true?
A) Basic solutions have more of H^+ than OH-.
B) Basic solutions have a pH under 7.
C) Basic solutions more OH^- than H+.
D) Basic solutions have equal concentrations of H+ and OH^-.
E) Basic solutions have a neutral pH.

19) The pH scale is a mathematical indicator of the
A) concentration of H^+ present in a solution.
B) concentration of OH^- present in a solution.
C) total amount of all ions in a solution.
D) the amount of buffer present in the solution.
E) ability to dissolve ionicly bonded substances in water.

20) After drinking a great deal of coffee (pH 5), a human's blood buffering system would need to_____ as the coffee was digested to lower the level of acid present in the blood stream.
A) release OH^-
B) take up H^+
C) release H^+
D) take up OH^-
E) release H^+ and take up OH^- TBEXAM.COM

21) A(n)_____ can be defined as a substance that keeps pH within established limits by taking up excess H^+ or OH^- in a solution.
A) equalizer
B) solute
C) buffer
D) acid
E) base

22) Which of the following is an example of the heat capacity of water?
A) Water is able to travel up a 100-foot tree.
B) Water expands as it freezes causing ice to float on the surface of a lake.
C) Living organisms are able to maintain their internal body temperatures because the water in their cells resists changes in temperature.
D) Small insects can walk on water.
E) Water molecules stick together.

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23) Sugar dissolves in coffee because
A) water has high heat capacity.
B) water is less dense than ice.
C) water is a good solvent.
D) water is cohesive.
E) water is able to change from a gas to a solid.

24) When water changes from a liquid to a gas
A) hydrogen bonds are broken between neighboring water molecules.
B) covalent bonds are broken between oxygen and hydrogen atoms.
C) ionic bonds are broken when the minerals in water are heated.
D) the bond between one water molecule and another becomes stronger.
E) the hydrogen atoms break away from the oxygen and escape as vapor.

25) Which of the following property of water helps an individual who is exercising vigorously maintain a constant body temperature?
A) Water has high heat capacity.
B) Water is less dense than ice.
C) Water is a good solvent.
D) Water molecules are cohesive.
E) Water moleculesare are adhesive.

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26) Although Oregon and South Dakota are at similar latitudes, winters in Oregon are warmer and summers in Oregon are cooler as compared to South Dakota. Which of the following might explain these differences between the climate of Oregon and the climate of South Dakota?
A) South Dakota has fewer trees.
B) Oregon is located near the Pacific Ocean.
C) Oregon receives more rainfall.
D) South Dakota has fewer lakes and rivers.
E) South Dakota has more prevailing winds from the west.

27) How does a strong acid differ from a weak acid?
A) A strong acid contains fewer H^+ in solution.
B) A weak acid dissociates only partially in water.
C) A strong acid is less likely to remain dissociated.
D) A weak acid dissociates nearly completely in water.
E) A strong acid dissociates only partly in water.

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28) Heartburn occurs when stomach acid escapes the stomach and burns the tissues of the esophagus. Baking soda is sometimes used as an antacid. How does baking soda help relieve symptoms of heartburn?
A) The baking soda is serving as a buffer to remove excess H^+ ions from stomach acid.
B) The baking soda is able to coat the lining of the esophagus thereby protecting it from the acid.
C) The baking soda increases the acidity of the stomach.
D) The baking soda releases salt which draws more water into the esophagus thereby diluting the acid.
E) The baking soda relaxes the stomach muscles.

29) What do lemons, tomatoes, and coffee all have in common chemically?
A) They all release OH^- ions in solution, making them bases.
B) They all release H^+ ions in solution, making them acids.
C) They all are fruits.
D) They are all neutral in pH.
E) They are all slippery to the touch.

30) Of the following examples, which best demonstrates cohesiveness of water?
A) water moving up a 100-foot pine tree, from the roots to the leaves
B) a rock skipping across the surface of a lake
C) water requiring a great deal of heat to change from a liquid to a gas
D) a can of soda bursting when it is placed in the freezer
E) a large body of fresh water taking a long time to warm up after the winter season

31) Bananas have a pH of 5. This means a banana has an excess of_____ ions and would be called a(n)_____.
A) H^+; acid
B) OH^-; acid
C) H^+; base
D) OH^-; base
E) H^+; neutral solution

32) Isotopes of an atom differ in
A) their atomic number.
B) their atomic mass.
C) their number of electrons.
D) their ability to form ions.
E) the location of their valence shells.

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33) Which of the following is a property of bases?
A) Bases have a sharp or sour taste.
B) Bases feel slippery when touched.
C) Bases taste sweet.
D) Bases release H^+ when dissolved in a liquid.
E) Bases have a pH reading below 7.0.

34) An element has an atomic number of 76. The number of protons and electrons in a neutral atom of the element are
A) 152 protons and 76 neutrons.
B) 76 protons and 152 electrons.
C) 0 protons and 76 electrons.
D) 76 protons and 76 electrons.
E) 76 protons and 152 neutrons.

35) All atoms of the same element have the same
A) number of neutrons.
B) atomic number.
C) number of electrons.
D) atomic mass.
E) number of ions.

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36) Radioactive isotopes would be most harmful to a person when
A) unmonitored release into the environment makes changes in a cell's DNA.
B) they are used to trace molecular changes.
C) they are used to destroy abnormal cells.
D) they are used to determine the age of biological specimens.
E) they are used to trace the path of materials throughout the body.

37) The number of neutrons present in the nucleus of an average atom of any given element is best estimated by
A) adding the number of electrons and protons together.
B) subtracting the number of electrons from the number of protons.
C) adding the mass number to the number of electrons.
D) subtracting the number of protons from the mass number.
E) adding the atomic number and atomic mass together.

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38) An atom with a neutral charge has
A) equal numbers of neutrons and electrons.
B) more neutrons making it more neutral.
C) the same number of protons and neutrons.
D) equal numbers of protons and electrons.
E) more protons than it does electrons.

39) The atomic structure of water satisfies the octet rule by having
A) electrons shared between the two oxygen atoms.
B) electrons from hydrogen transferred to the oxygen atom.
C) electrons from oxygen transferred to the hydrogen atoms.
D) oxygen share electrons with two hydrogen atoms.
E) electrons shared between the two hydrogen atoms.

40) In the reaction $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ carbon dioxide is one of the
A) reactants.
B) products.
C) enzymes.
D) elements.
E) ions.

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41) Cells need buffering agents in order to
A) speed up chemical reactions.
B) carry out life functions in extremely acidic conditions.
C) minimize the changes in pH of their internal environment.
D) help transfer electrons from one atom to another.
E) increase the amount of OH^- in their surroundings.

42) Which of the following is a way in which chemical bonds can be formed?
A) sharing neutrons
B) losing protons
C) gaining electrons
D) attracting similar charges
E) gaining protons

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43) Phosphorus has an atomic number of 15. How many valence shell electrons does it have?
- A) one
- B) two
- C) three
- D) five
- E) six

44) Some insects can walk on the surface of water because water
- A) has a high specific heat.
- B) has a lower density when frozen.
- C) is a good solvent.
- D) has surface tension.
- E) resists temperature changes.

45) The pH of pure water is_____ because_____.
- A) 7.0; water contains an equal number of H^+ ions and OH^- ions
- B) 14.0; water contains more OH^- ions than H^+ ions
- C) 1.0; water contains more H^+ ions than OH^- ions
- D) 7.0; there are no ions formed in pure water
- E) 5; because pure water lacks minerals

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46) Which of the following best describes the structure of how water molecules form?
- A) Hydrogen atoms covalently bond with each other to create one stable valence shell of electrons. The hydrogen molecule then forms a hydrogen bond with an oxygen atom to create the water molecule.
- B) One oxygen atom transfers an electron to each of two hydrogen atoms, forming an ionic bond.
- C) One oxygen atom and two hydrogen atoms form a covalent bond with one another to create stable valence shells of electrons. The electrons are shared unequally resulting in a polar molecule.
- D) Hydrogen bonds are formed between the two hydrogen atoms and the oxygen atom.
- E) Because of its strong electronegativity, oxygen removes one electron from two different hydrogen atoms. This satisfies the valence shell of oxygen. Then hydrogen bonds form between the two hydrogen atoms which keeps them in the vicinity of the oxygen atom.

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47) The subatomic particles that are found within the nucleus of an atom are the
A) protons and electrons.
B) neutrons and protons.
C) electrons only.
D) protons only.
E) electrons and neutrons.

48) The reactivity of an atom depends on the number of
A) protons.
B) neutrons.
C) protons plus neutrons.
D) valence electrons.
E) protons and electrons.

49) Chemical bonds involve
A) the giving and taking of electrons.
B) the giving and taking of protons.
C) the giving, taking, or sharing of electrons.
D) the giving, taking, or sharing of protons.
E) the sharing of electrons.

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50) The electron arrangement for silicon, which has an atomic number of 14, is
A) 2 in the inner electron shell, 8 in the second electron shell, and 4 in the outer electron shell.
B) 8 in the inner electron shell, 4 in the second electron shell, and 2 in the outer electron shell.
C) 4 in the inner electron shell, 6 in the second electron shell, and 4 in the outer electron shell.
D) 5 in the inner electron shell, 6 in the second electron shell, and 3 in the outer electron shell.
E) 7 in the inner electron shell, 6 in the second electron shell, and 1 in the outer electron shell.

51) An ionic bond forms when
A) an atom gives away or takes in a neutron.
B) an atom gives away or takes in a proton.
C) a positively charged ion is attracted to a negatively charged ion.
D) two atoms come close enough to share one or more electrons.
E) two positively charged ions are attracted to each other.

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52) A covalent bond involves the sharing of
A) neutrons.
B) protons.
C) pairs of protons.
D) at least three electrons.
E) pairs of electrons.

53) Positron-emission tomography (PET) generally utilizes a radioactive form of_____ to determine the comparative activity of tissues.
A) glucose
B) table salt
C) DNA
D) ATP
E) iodine

54) Both radioactive isotopes and stable isotopes of the same element
A) contain the same number of electrons and protons.
B) contain the same number of electrons and neutrons.
C) contain the same number of protons and neutrons.
D) have the same mass number.
E) are equally useful in medicine for determining the comparative activity of tissues.

55) When a positively charged hydrogen in a water molecule become attracted to the negatively charged oxygen in a nearby water molecule, this is referred to as a(n)
A) ionic bond.
B) hydrogen bond.
C) hydrophobic interaction.
D) polar covalent bond.
E) van der waals force.

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Answer Key

Test name: Chapter 02

1) [A, C, D, E]
Radioactive isotopes can be used for everything list above except regenerating damaged tissue.

2) [B, D]
In a chemical equation, everything to the left of the arrow is a reactant and everything to the right of the arrow is a product.

3) [A, B, C, E]
Hydrogen bonds are involved in all the properties of water except polarity. Polarity is due to the unequal sharing of electrons in the covalent bonds holding the water molecule together.

4) E
Four elements, carbon, hydrogen, nitrogen, and oxygen, make up about 96% of the body weight of most organisms. A number of elements, including minerals such as zinc and chromium, are found at very low, or trace, levels.

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5) C
Elements are comprised of one kind of atom. These atoms all have the same atomic number, which means they all have the same number of protons. Molecules have more than one atom present, and compounds are composed of two or more distinct types of elements. Therefore, neither molecules nor compounds are in their simplest form.

6) C
An atom is comprised of subatomic particles. Protons are positively charged, while electrons are negatively charged, and neutrons have no charge (they are neutral). The neutrons and protons are located within the atomic nucleus and contribute to the majority of an atom's mass. The electrons, which orbit the nucleus, are negatively charged and govern the element's reactivity.

7) C
Isotopes are atoms of the same element that differ in the number of neutrons. They have the same number of protons, but because they have different numbers of neutrons, they have different mass numbers.

8) B

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An atom's valence shell determines its chemical reactivity. Atoms (except for hydrogen) with fewer than eight electrons in the outer shell react with other atoms in such a way that each has a completed outer shell after the reaction.

9) A
When an atom either loses or gains electrons in a reaction, the resulting atom now bears an overall net charge. An atom with a positive or negative charge is called an ion.

10) C
A covalent bond results when two atoms share electrons in order to complete their valence shell.

11) B
An ionic bond forms when two atoms are held together by the attraction between opposite charges. An ionic bond occurs when one atom gives up one or more electrons (and becomes positively charged) and another atom gains one or more electrons (and becomes positively charged).

12) D
Ionic bonds are formed when two atoms are held together by an attraction between ions. Sodium transfers a negatively charged electron over to chlorine. The result is sodium having a positive charge (Na^+) and chlorine now having a negative charge (Cl^-). These ions have an attraction that creates the ionic bond that holds them together. Ionic compounds are often found as salts, solid substances that usually separate and exist as individual ions in water.

13) B
A group of atoms bonded together is called a molecule. When a molecule contains atoms of more than one element, it can be called a compound.

14) C
The glucose molecule is a compound made up of three different elements.

15) B
Atoms differ in their affinity for electrons in a covalent bond (electronegativity). Oxygen is more electronegative than hydrogen. Consequently, the shared electrons spend more time near the oxygen nucleus than the hydrogen nuclei. This gives the oxygen a slight negative charge and the hydrogen atoms slight positive charges. This unequal sharing of electrons makes it a polar molecule.

16) B

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The positive hydrogen forms a hydrogen bond with the negative oxygen from a nearby molecule. No electron transfer or sharing is occurring in this type of bond. It is a weak attraction between polar molecules.

17) E
Water has four key properties that support life: solvency, cohesion/adhesion, surface tension, high heat capacity, and varying density. Adhesion occurs when a water molecule sticks to something other than another water molecule.

18) C
Basic solutions have more hydroxyl anions (OH^-) than H^+. Consequently, they have a pH higher than 7.

19) A
pH indicates the number of hydrogen ions in a solution. It is used to indicate the acidity or basicity of a solution.

20) B
Human physiologic pH should be 7.4. Coffee acidifies the blood. To maintain homeostasis, buffers would need to remove excess H^+.

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21) C
A buffer is a chemical that serves to neutralize an acid or a base in solution. Buffers help to resist pH changes because they can remove excess hydrogen ions (H^+) or hydroxide ions (OH^-).

22) C
Water has the ability to absorb heat without greatly changing in temperature. Because the temperature of water rises and falls slowly, organisms are better able to maintain their normal internal temperatures and are also protected from rapid temperature changes.

23) C
The polarity of water makes it a good solvent. The water forms hydrogen bonds with the sugar promoting its ability to dissolve in the coffee.

24) A
Hydrogen bonds link water molecules together. As they absorb heat, the bonds begin to break causing water to enter into a gaseous state and evaporate into the environment.

25) A

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Water has a high heat capacity. Blood plasma is primarily comprised of water, which provides the ability to moderate temperature changes even under rigorous exercise. This feature of water allows organisms to better maintain their internal temperatures.

26) B
Because of water's high heat capacity and high heat of vaporization, temperatures along the Earth's coasts are moderate. During the summer, the ocean absorbs and stores solar heat, and during the winter, the ocean releases it slowly.

27) B
A strong acid, such as HCL, dissociates nearly completely in water. A weak acid dissociates only partially.

28) A
Baking soda acts as a buffer and takes up the excess hydrogen ions (H^+) in the esophagus and stomach. This helps to relieve the symptoms of heartburn.

29) B
Acidic solutions have a sour taste and are often associated with indigestion. Lemons, tomatoes, and coffee are all acidic substances that dissociate in water, releasing hydrogen ions (H^+).

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30) A
Cohesion refers to the ability of water molecules to cling to each other due to hydrogen bonding. Within the long narrow vessels of a plant, water molecules cling to each other and form a long chain that stretches from the roots to the leaves. When one water evaporates from the leaves, is immediately replaced with a water molecule below it.

31) A
A pH below 7 is acidic. Bananas release H^+ in water and are considered acidic.

32) B
Isotopes are atoms of the same element that differ in the number of neutrons. They have the same number of protons, but they have different mass numbers.

33) B
Acids have a sharp sour taste, a pH below 7.0, and release hydrogen ions in water. Bases have a bitter taste, feel slippery, a pH above 7.0, and release hydroxide ions when dissolved in water.

34) D

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The number of protons an element has is called the atomic number.In a neutral atom, there are the same number of protons and electrons. Protons carry a positive charge. Because neutral atoms have no charge, there must be an equal number of negative charges (electrons).

35) B
Atoms of the same element all have the same number of protons (also known as the element's atomic number).

36) A
Radioactive isotopes are important in biology and medicine. They can be used to trace molecular changes, destroy abnormal cells, and play a significant role in the ability to determine the age of biological specimens. Their danger comes in their unmonitored release into the environment, where they can make changes in cells, damage DNA, cause cancer, or at their worst be lethal.

37) D
Since the mass of an atom is determined primarily by the protons and neutrons, the number of neutrons can be determined by subtracting the number of protons (also known as the atomic number) from the mass number.

38) D
In a neutral atom, there are the same number of positively charged protons and negatively charged electrons. Since there are the same number of positive and negative charges, they cancel each other out.

39) D
In order to complete their valence shells, two hydrogen atoms share their lone electrons by way of a covalent bond with an oxygen atom.

40) B
The reactants are the molecules that participate in the reaction and are shown on the left side of the reaction arrow. The products are the molecules that are formed by the reaction and are shown on the right.

41) C
Living organisms are very sensitive to changes in pH. Buffers are necessary to maintain homeostasis because they are able to keep pH within its normal limits by removing excess hydrogen ions (H^+) or hydroxide ions (OH^-) in solution.

42) C

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Compounds and molecules are formed when atoms form either ionic or covalent bonds. These two result from either the sharing of outer shell electrons or the transfer of the electrons from one atom that loses electrons to another that gains electrons.

43) D
Phosphorus has two electrons in the first shell, eight electrons in the second shell, leaving five electrons in its outer valence shell.

44) D
Because the water molecules at the surface are more strongly attracted to each other than to the air above, water molecules at the surface cling so tightly to each other (surface tension) that some insects (and even one type of lizard) can walk on water.

45) A
A pH of 7 represents a neutral state in which the hydrogen ion and hydroxide ion concentrations are equal, as in pure water.

46) C
In a water molecule, one oxygen atom and two hydrogen atoms form a covalent bond with one another to create stable valence shells of electrons. The oxygen is more electronegative than hydrogen. Consequently the shared electrons spend more time near the oxygen nucleus than the hydrogen nuclei. This unequal sharing of electrons makes it a polar molecule.

47) B
An atom is comprised of subatomic particles. Protons and neutrons are located in the nucleus of the atom while the electrons orbit around the nucleus.

48) D
The bonds between different atoms arise from the giving, taking, or sharing of the electrons in the valence shell.

49) C
As atoms give, take, or share electrons so that the valence level of the atom is full, they form bonds with the other atom(s) involved in the exchange.

50) A

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The electrons of an atom are found in shells that surround the nucleus. The first electron shell, which fills first, can only hold 2 electrons, the second electron shell can only hold up to 8 electrons, and the final one can also hold up to 8. Since the atomic number of silicon is 14, an atom (which is electrically neutral) of silicon has 14 positively charged protons and 14 negatively charged electrons. Two electrons would be found in the first shell, 8 in the second shell, and 4 in the third shell.

51) C
Ions form when an atom gives away or takes in an electron. An ionic bond forms when two oppositely charged ions attract.

52) E
In order to form covalent bonds each atom must contribute an equal number of electrons. Therefore, electrons are shared in pairs.

53) A
Positron-emission tomography (PET) is an example of how isotopes are useful in medicine. PET generally uses a radioactive form of glucose to determine the comparative activity of tissues.

54) A
Both radioactive isotopes and stable isotopes contain the same number of electrons and protons. They differ however, in their numbers of neutrons and therefore in their mass numbers. Only radioactive isotopes are useful in medicine for determining the comparative activity of tissues.

55) B
When a positively charged hydrogen in a water molecule become attracted to the negatively charged oxygen in a nearby water molecule, this is called a hydrogen bond.

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Instructor's Manual

Chapter 2 The Chemical Basis of Life

Learning Outcomes

2.1 Atoms and Atomic Bonds

1. Distinguish among the types, locations, and charges of subatomic particles.

2. Relate how the arrangement of electrons determines an element's reactivity.

3. Explain how isotopes are useful in the study of biology.

4. Contrast ionic and covalent bonds.

5. Identify the reactants and products in a chemical equation.

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2.2 Water's Importance to Life

1. Describe the general structure of a water molecule.

2. List the properties of water that are important to life.

3. Understand the importance of hydrogen bonds to the properties of water.

2.3 Acids and Bases

1. Distinguish between an acid and a base.

2. Interpret the pH scale.

3. Explain the purpose of a buffer.

Extended Lecture Outline

2.1 Atoms and Atomic Bonds

Matter is anything that takes up space and has mass. All matter is composed of elements.

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Atomic Structure

Atoms are made up of protons, neutrons, and electrons in an organized fashion. The atomic mass of an element depends on the number of protons and neutrons in the nucleus; the atomic number indicates the number of protons of an element.

The Periodic Table

Chemists have organized all known elements in the periodic table, grouping them by shared characteristics.

Isotopes

Isotopes are atoms of the same element with extra neutrons in their nucleus. Sometimes a nucleus with extra neutrons is unstable, may decay, and emit radiation. Radioactive isotopes are used in many medical and research procedures.

Arrangement of Electrons in an Atom

Electrons are arranged by their energy levels, illustrated by electron shells in models of atoms. The octet rule states that an atom is most stable if it has 8 electrons in its valence shell.

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Types of Chemical Bonds

When two or more atoms bond together, they form a molecule. If the molecule contains atoms of more than one element, it can be called a compound. Two primary types of chemical bonds are ionic bonds and covalent bonds.

Chemical Formulas and Reactions

Chemical reactions can be represented by equations showing reactants (shown on the left of the arrow) and products (shown on the right of the arrow).

2.2 Water's Importance to Life

The Structure of Water

Because of the electronegativity of hydrogen and oxygen, these atoms form polar covalent bonds, giving water a consistent shape and important properties.

Properties of Water

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Because of the polar covalent bonds and the ability to form hydrogen bonds, water has the following properties important to life: it is a solvent; it is cohesive and adhesive; it has a high surface tension; it has a high heat capacity; as a solid, it is less dense than as a liquid.

2.3 Acids and Bases

Acidic Solutions (High H^+ Concentration)

Acidic solutions have a high hydrogen ion (H^+) concentration. An example of a strong acid is hydrochloric acid (HCl), which dissociates in this manner:

$HCl \rightarrow H^+ + Cl^-$

Basic Solutions (Low H^+ Concentration)

Basic solutions have a low hydrogen ion (H^+) concentration. An example of a strong base is sodium hydroxide, which dissociates in this manner:

$NaOH \rightarrow Na^+ + OH^-$

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pH and the pH Scale

The pH scale was created to indicate the hydrogen ion concentration of a solution. The lower the pH, the more acidic the solution, and the higher the pH, the more basic the solution. The pH scale ranges from 0 to14. A pH of 7 represents a neutral state.

Buffers and pH

Buffers are important substances found in living organisms that help maintain a certain range of pH.

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Lecture Enrichment Topics

2.1 Atoms and Atomic Bonds

1. Present Dmitry Mendeleyev's story. Mendeleyev was a professor of chemistry in the mid-1800s and author of *The Principles of Chemistry*. Throughout the 1800s, scientists were discovering the elements and their properties and trying to find patterns of similarity. Mendeleyev worked on the puzzle of how to organize the elements for nearly

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20 years. He wrote each element and its properties on a card and would arrange and rearrange these cards, looking for patterns. Finally, he realized a logical pattern in a dream. “I saw in a dream a table where all the elements fell into place as required. Awakening, I immediately wrote it down on a piece of paper.” Mendeleyev published the periodic table in 1869 in a paper titled, “A Suggested System for the Elements.”

2. Book recommendation for instructor and student: Oliver Sacks, *Uncle Tungsten: Memories of a Chemical Boyhood*. Vintage Books, 2001.
3. In order to reinforce their understanding of the organization in the periodic table, quiz the students by asking for the element that, for example, has four electrons in its valence shell and has two shells [carbon]. Repeat with other elements; create a contest between groups.
4. More information on radioactivity: ionizing radiation, the radiation given off by isotopes, has enough energy to remove electrons from atoms. There are three types of ionizing radiation: alpha particles, beta particles, and gamma rays. Some of the sources of ionizing radiation are the rocks and soil, which may contain radioactive isotopes of uranium or radon; cosmic radiation; and human-produced radiation from weapons, energy reactors, and medical technology. Household products such as smoke detectors use radioactive isotopes enclosed in a protective housing.

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2.2 Water’s Importance to Life

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1. Ask the students why water beads on a freshly washed or freshly waxed car. What characteristics of water and the car’s finish or wax cause this? [Cohesion of water molecules along with the hydrophobic nature of the car’s waxy finish repel water.]
2. Demonstrate water uptake in a plant. Leave two large, leafy celery stalks with some leaves remaining out at room temperature overnight. They should be limp and bendable in the morning. Make a fresh cut and place one stalk in a container of water. After one to two hours, the stalk should be firmer, showing uptake of water through the stem. Compare it to the other stalk, which was not placed in water. Additionally, food coloring could be added to the water, which should show as the fluid is taken up into the celery stalk. This is the process florists use to color white daisies.
3. Animals other than insects can use the surface tension of water to walk across the surface. The green basilisk lizard, *Basiliscus plumifrons*, a type of iguana that is about two and a half feet from head to tip of tail and found in Central America, can run across the surface of the water to escape predators. (This lizard is sometimes referred to as the Jesus lizard.) Its feet are webbed, but it must run fast in order to stay on top of the water.

2.3 Acids and Bases

1. Give a preview of how blood pH impacts respiration and how increasing atmospheric CO_2 affects the pH of the oceans. Present the equation $CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$ and then ask students how it will be impacted when people

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hold their breath. Have students investigate ocean acidification online or steer them to the PMEL Carbon Program website.

Critical Thinking Questions

1. Define radioactivity, including a description of the structure of an atom that is radioactive. Explain why irradiating something does not make it radioactive.

Ans: Radioactivity involves the instability of an atom's nucleus, which has excess neutrons. High-energy radioactive particles are given off—this is called radiation. The property of radioactivity originates within the radioactive atom. Exposure to radiation may cause damage to living things or sterilize food, but it does not create radioactive atoms with excess neutrons.

2. Why is water critical for metabolic processes?

Ans: Cells are composed mostly of water. One property of water is that it is a solvent that dissolves many substances, including those that participate in metabolic reactions in cells. When dissolved in water, these substances can move about and interact.

3. The cohesive and adhesive abilities of water are critical in moving water up the conducting vessels of a plant. Since adhesion is important for this process, what must be true of the conducting vessels of a plant?

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Ans: Molecules in the walls of plant-conducting vessels must also be polar (hydrophilic) so that water molecules can adhere to them.

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Essay Questions

1. An oxygen atom has 8 protons, 8 neutrons, and 8 electrons. Its atomic mass is 16. Do electrons have mass?

Ans: Yes, electrons are composed of matter and do have mass; however, it is so slight that it is not included in an atomic mass number.

2. Why is it important for our blood to be buffered?

Ans: Digestion of different types of food can create H^+ and OH^- ions that are absorbed into the bloodstream. These ions, which cause acidic or basic conditions, can harm other molecules in our body if in excess, so the blood is buffered to maintain pH within a range that is not harmful.

3. Describe the two ways water maintains temperatures appropriate for living organisms.

Ans: Water is a polar molecule that links to other water molecules through hydrogen bonding. Because of these hydrogen bonds, water can absorb some heat (energy) without greatly changing temperature because the hydrogen bonds hold the water molecules together. This is called a high heat capacity. The resistance to temperature change protects living organisms.

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Also, due to the nature of hydrogen bonding, a great deal of energy is needed to break these bonds, separating water molecules and creating gaseous water in evaporation. This is called high heat of vaporization, which provides a way for organisms to get rid of excess heat (energy).

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