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

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

1) Matter is composed of:
   A) atoms
   B) energy
   C) mass
   D) molecules

2) The number of protons in a given atom is equal to its:
   A) atomic number
   B) mass
   C) neutron number
   D) molecular number

3) Isotopes that are unstable and decay when their nucleus breaks up into elements with lower atomic numbers, and emit significant amounts of energy in the process, are called:
   A) energetic
   B) ionic
   C) radioactive
   D) isometric

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4) Atoms containing a specific number of protons are called:
   A) minerals
   B) elements
   C) metals
   D) molecules

5) Sugar dissolves completely in water because of water's_____.
   A) ionic bonds
   B) cohesiveness
   C) hydrophobic exclusion
   D) polarity

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6) The negative logarithm of the hydrogen ion concentration in a solution is referred to as:
   A) pH
   B) atomic mass
   C) -OH concentration
   D) electronegativity
   E) specific heat

7) Bicarbonate ions in the blood can absorb hydrogen ions, keeping the pH balanced. Bicarbonate acts as a_____ in blood.
   A) buffer
   B) acid
   C) base
   D) alkaline

8) Atomic nuclei contain protons and_____.
   A) isomers
   B) ions
   C) moles
   D) neutrons

9) Carbon-12, Carbon-13 and Carbon-14 are examples of:
   A) ions
   B) isotopes
   C) isomers
   D) molecules

10) Organisms are composed of molecules, which are collections of smaller units, termed:
   A) monomers.
   B) atoms.
   C) electrons.
   D) polymers.
   E) ions.

11) Negatively charged subatomic particles that have almost no mass are called:
   A) electrons.
   B) protons.
   C) neutrons.
   D) ions.
   E) polymers.

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12) Atoms of a single element that possess different numbers of neutrons are called:
A) polymers.
B) ions.
C) monomers.
D) isomers.
E) isotopes.

13) $Cl + e^- \rightarrow Cl^-$ is an example of a:
A) oxidation.
B) reduction.
C) polymerization.
D) ionization.

14) When atoms gain or lose electrons, they can become negatively or positively charged. These charged atoms are known as:
A) isotopes.
B) ions.
C) isomers.
D) unstable atoms.

15) When two atoms share a pair of electrons, this bonding is referred to as:
A) ionic.
B) covalent.
C) unstable.
D) hydrogen.

16) Water molecules are polar, with regions that exhibit partial positive or negative charges. These opposite charges allow water molecules to attract each other via:
A) ionic bonds.
B) covalent bonds.
C) hydrogen bonds.
D) peptide bonds.

17) An atom has 20 electrons and 20 neutrons. Assume it has a net charge of zero. What is the total mass of this atom?
A) 10
B) 20
C) 40
D) 80

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18) Sanai was monitoring the oil spill in the Gulf of Mexico from an oil tanker. From her observations, she noted that the oil was moving in large patches through the water. The oil did not appear to dissolve into the water. Why did the oil not dissolve into the water?
A) Hydrophobic interactions
B) Surface tension
C) Sea water acts as a solvent
D) Water forms hydration shells
E) Water has a high heat of vaporization

19) The atomic number of an element is equal to the number of:
A) protons only.
B) neutrons only.
C) protons plus electrons.
D) protons plus neutrons.
E) neutrons plus electrons.

20) Oxygen has an atomic mass of 16 and an atomic number of 8. How many neutrons are present?
A) 24
B) 8
C) 16
D) 4

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21) The pH of your small intestines is around 7.5 and the pH of your large intestine can be 5.5. As substances travel from the small intestines to the large intestine, what would happen to the H^+ ion concentration?
A) It decreases 100-fold.
B) It increases by 100-fold.
C) It increases 10-fold.
D) It increases 2-fold.
E) It decreases 10-fold.

22) Oxygen-16 is abundant in the environment and has 8 protons and 8 neutrons. Oxygen-18 has two extra neutrons. These two forms of oxygen are:
A) oxygen ions.
B) oxygen isotopes.
C) oxygen isomers.
D) oxygen dimers.

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23) Which element's isotope is commonly used to determine when biological samples such as fossils were formed?
A) oxygen
B) hydrogen
C) carbon
D) nitrogen
E) sulfur

24) A type of atom where the number of electrons does not equal the number of protons is also referred to as:
A) valences.
B) ions.
C) isotopes.
D) isomers.

25) The area around a nucleus where an electron is most likely to be found is the:
A) electrical space.
B) energy level.
C) polar space.
D) orbital.

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26) Regardless of its shape, a given orbital may contain no more than:
A) 1 electron.
B) 4 electrons.
C) 8 electrons.
D) 2 electrons.

27) All atoms tend to fill their outer energy levels with the maximum number of electrons, usually eight. Depending on whether atoms satisfy the octet rule, this will predict:
A) the chemical behavior of the atoms.
B) whether they will be found in nature.
C) whether they will dissolve in water.
D) their radioactive energy.

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28) Mendeleev found that when he arranged the known elements according to their atomic mass, the entries in the table exhibited a pattern of chemical properties that repeated itself in groups of eight elements. This led to the generalization now known as:
A) an atomic model.
B) valance electrons.
C) the periodic table.
D) the octet rule.

29) Sodium has 11 electrons arranged in three energy levels. In order to become stable, sodium forms an ion that contains:
A) no charge.
B) -1 charge.
C) -8 charge.
D) +1 charge.
E) +8 charge.

30) In the crystal matrix of ordinary salt, the sodium and chlorine are held together by:
A) peptide bonds.
B) covalent bonds.
C) ionic bonds.
D) hydrogen bonds.
E) nonpolar bonds.

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31) Two oxygen atoms bind to each other by sharing two pairs of electrons. This molecule forms a(n):
A) single bond.
B) ionic bond.
C) hydrogen bond.
D) double covalent bond.

32) In a chemical analysis of a sample of animal tissue, which element would you expect to find in the least quantity?
A) carbon
B) hydrogen
C) nitrogen
D) oxygen
E) iodine

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33) Life is thought to have evolved from complex molecules formed by the interaction of smaller molecules in the oceans and atmosphere. The substance which brought these molecules together to interact is:
A) hydrogen.
B) acids.
C) water.
D) buffers.
E) salts.

34) Because oxygen is more electronegative than hydrogen, the water molecule is:
A) hydrophobic.
B) hydrophilic.
C) nonpolar.
D) ionic.
E) polar.

35) Water molecules are attracted to each other due to the opposite charges created by partial charge separations within the molecules. These attractions are called:
A) peptide bonds.
B) covalent bonds.
C) ionic bonds.
D) hydrogen bonds.
E) double bonds.

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36) How many hydrogen bonds can a water molecule form?
A) 1
B) 2
C) 3
D) 4
E) 5

37) Nitrogen has a higher electronegativity than hydrogen. As a result you would expect that ammonia (NH_3) molecules can form_____ with each other.
A) hydrogen bonds
B) hydrophilic bonds
C) ionic bonds
D) covalent bonds
E) cohesive bonds

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38) When water ionizes, it produces equal amounts of hydrogen and hydroxide ions that can reassociate with each other. The pH of water is:
A) 3
B) 4
C) 5
D) 6
E) 7

39) A scientist conducts a procedure that causes nitrogen atoms to gain neutrons. The resulting atoms will be:
A) ions of nitrogen.
B) positively charged.
C) negatively charged.
D) isotopes of nitrogen.
E) new elements with higher atomic numbers.

40) The half-life of Carbon-14 is approximately 5,700 years. Using this information scientists have been able to determine the age of some artifacts left by humans. A scientist wants to know approximately how old a piece of wood is that she found on the floor in an old cave that had recently been discovered. She removed the wood (with permission) and took it to her laboratory. Her wood sample contained 2 grams of Carbon-14. If the age of the wood was determined to be 22,800 years old, how much Carbon-14 originally existed in this piece of wood?
A) 32 grams
B) 16 grams
C) 12 grams
D) 8 grams
E) 4 grams

41) Plants transport water to their leaves through the xylem when water evaporates from the leaves. The evaporating water pulls other water molecules up the xylem by means of_____ .
A) hydrogen bonds
B) ionic bonds
C) covalent bonds
D) hydrophobic interactions

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42) Water is most dense and thus heaviest at 4°C. At 0°C, ice forms and can float on liquid water. Suppose ice was more dense then water at 0˚C. What would happen in a lake at this temperature?

A) The ice would cover the surface of the aquatic system and would never melt.
B) The ice would cover the bottom of the aquatic system and would build up in layers over time.
C) Ice would not form because solids are always less dense than liquids.
D) The cold temperatures and the subsequent ice formation would prevent hydrogen bonds from forming between the water molecules, thus causing the existing ice crystals to become disassociated from each other.

43) Your dog becomes ill and you rush him to the veterinarian's office. A technician draws blood from your dog's leg for a vet-ordered lab test. After a few minutes the lab results are given to the vet, who immediately grabs a bottle from a shelf and begins to fill a syringe with an unknown fluid. You inquire about the fluid, and the vet informs you that the fluid is necessary to manage your dog's metabolic acidosis. Based on the information provided, what is acidosis, and what is the likely effect of the veterinarian's injection?

A) Acidosis means that your dog's blood pH has dropped from its normal level, and an injection of saline is required to reverse the condition.
B) Acidosis means that your dog's blood pH has increased from its normal level, and an injection of saline is required to reverse the condition.
C) Acidosis means that your dog's blood pH has decreased from its normal level, and an injection of buffering solution is required to reverse the condition.
D) Acidosis means that your dog's blood pH has increased from its normal level, and an injection of buffering solution is required to reverse the condition.

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44) As you and a friend are entering a chemistry laboratory at your university, you see a sign that states: DANGER—RADIOACTIVE ISOTOPES IN USE. Your friend is an accounting major and has not had any science courses yet. She asks you what a radioactive isotope is and you respond correctly with:

A) Radioactive isotopes are atoms that are unstable and as a result emit energy in a process called radioactive decay.
B) Radioactive isotopes are atoms that are stable and as a result emit energy in a process called radioactive decay.
C) Radioactive isotopes are atoms that are stable and as a result only emit energy if they are exposed to higher temperatures.
D) Radioactive isotopes are atoms that are unstable but unless actively disturbed by some chemical process will remain intact and pose no problems.

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45) To increase the rate of a reaction you could:
- A) Add more products.
- B) Decrease the temperature.
- C) Add more reactants.
- D) remove a catlyst

46) The two nitrogen atoms in nitrogen gas (N_2) share six electrons forming a_____.
- A) triple covalent bond
- B) double covalent bond
- C) single covalent bond
- D) hydrogen bond
- E) double bond

47) Capillary action is one of the forces that aids water's upward movement in plants. The narrower the diameter of the tube, the farther the water column will rise. Capillary action is a result of water molecules:
- A) storing heat and thus moving faster because of heat of vaporization.
- B) producing sufficient surface tension to overcome the pull of gravity.
- C) having a strong cohesive force and attaching to the surrounding vessel walls.
- D) having an adhesive force, which allows them to attach to the vessel walls.
- E) being associated with hydrophobic molecules, which can result in upward movement.

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48) Which atomic particle has no charge and is located in the nucleus?
- A) electron
- B) ion
- C) neutron
- D) proton
- E) isotope

49) A subatomic particle with a positive charge is_____.
- A) an electron
- B) an ion
- C) a neutron
- D) a proton
- E) an isotope

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50) The smallest subatomic particle is the_____.
- A) electron
- B) ion
- C) isotope
- D) neutron
- E) proton

51) An atom that becomes negatively charged because it has accepted an electron is a(n):
- A) isomer.
- B) ion.
- C) isotope.
- D) monomer.

52) One mole of a substance contains 6.02×10^{23} molecules. The atomic number of Li is 3 and the atomic mass is approximately 7. If you have three moles of Li, how many grams does it weigh?
- A) 9
- B) 21
- C) $7 \times 6.02 \times 10^{23}$
- D) $3 \times 6.02 \times 10^{23}$

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53) After taking your biology exam, you return to your car to find that you had left the lights on and now the car battery is dead. Your friend offers to jump-start your car, but when you go to hook up the jumper cables you find that the battery terminals are covered with corrosion due to battery acid condensation. Based off your knowledge, what substance could be used to clean the corrosion?
- A) coffee (pH of 5)
- B) water (pH of 7)
- C) vinegar (pH of 3)
- D) baking soda (pH of 9)

54) The amino acid glycine ($C_3NO_2H_6$) is a(n):
- A) organic molecule
- B) inorganic molecule
- C) element
- D) vitamin

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55) Consider the following electronegativity values:
Boron (B) = 1.8
Carbon (C) = 2.5
Chlorine (Cl) = 3.2
Selenium (Se) = 2.6
Which of the following bonds is the most polar?
A) B-Cl
B) C-Cl
C) Se-Cl
D) It cannot be determined from the information provided.

56) The reaction ($H_2 + F_2 \rightarrow 2HF$) is an example of a redox reaction. In reality, two half reactions are occurring. The half reaction ($H_2 \rightarrow 2H^+ + 2e^-$) is a(n):
A) reduction reaction
B) oxidation reaction
C) redox reaction
D) potential energy reaction

57) The electronic configuration of the noble gas Neon, which has an atomic number of 10, can be written as follows: $1s^22s^22p^6$. What is the electronic configuration of the noble gas Argon, which has an atomic number of 18?
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A) $1s^22s^23p^64s^25p^6$
B) $1s^22s^62p^23s^63p^2$
C) $1s^22s^22p^63s^23p^6$
D) $1s^22s^83p^8$

58) You identify an enzyme involved in a cellular reaction. How does the enzyme affect the reaction equilibrium between reactants and products and the time needed to reach equilibrium?
A) It alters the reaction equilibrium and shortens the time needed to reach equilibrium.
B) The reaction equilibrium is unaffected, but it shortens the time needed to reach equilibrium.
C) It alters the reaction equilibrium and lengthens the time needed to reach equilibrium.
D) The reaction equilibrium is unaffected, but it lengthens the time needed to reach equilibrium.

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59) You walk down into your basement to find that the carpeting on the floor is damp. Concerned, you look around for large puddles of water or broken pipes, but find none. In fact, only the basement floor and carpeting is damp. You realize that water must have wicked into the carpet from the floor by_____.
A) adhesion and cohesion
B) adhesion and solubility
C) adhesion, cohesion, and solubility
D) cohesion and solubility

60) You recently discovered a new element, and find that this particular element has one electron in its outer energy level. What do you expect will happen to an atom of this element if placed in water?
A) It will lose an electron forming a positive ion.
B) It will lose an electron forming a negative ion.
C) It will gain an electron forming a positive ion.
D) It will gain an electron forming a negative ion.

61) Why is it necessary to take special safety precautions when using radioactive materials?
A) Radioactive substances will ionize cells.
B) Radioactive substances have the potential to cause damage to living cells.
C) Radioactive substances decay.
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D) Radioactive substances will perforate plasma membranes.

62) The high heat of vaporization of water helps you to feel cooler when you sweat because the transition of water from a liquid to a gas requires a_____ of energy to break hydrogen bonds. The energy is_____ from heat produced by your body, thus helping to lower the surface temperature of your body.
A) release; released
B) release; obtained
C) input; obtained
D) input; released

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63) Salt is often used to melt ice on roads during the winter because it lowers the freezing/melting point of water. When salt dissolves in water, individual Na^+ and Cl^- ions break away from the salt lattice and become surrounded by water molecules. Why would this cause ice to melt?

A) Hydrogen bonds are broken, and the salt ions interfere with interactions between H and O. As a result, it is more difficult for water molecules to bond and form ice.
B) Hydrogen bonds are formed, and the salt ions bond with O. As a result, it is more difficult for water molecules to bond and form ice.
C) Hydrogen bonds are broken, and the salt ions bond with O and H respectively. As a result, it is more difficult for water molecules to bond and form ice.

64) A chemist adds a chemical to pure water and there is a 100-fold increase in the concentration of hydrogen ions. What is the best approximation of the new pH value?

A) 0
B) 5
C) 7
D) 9
E) 14

65) The electronegativity of nitrogen (N) is 3.0, while the electronegativity of hydrogen (H) is 2.1. Knowing this, consider how the electrons will be shared in ammonia (NH_3). What do you predict about the polarity of ammonia?

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A) Each H atom has a partial positive charge
B) The N atom has a partial positive charge
C) Each H atom has a partial negative charge
D) The N atom has a strong positive charge

66) Magnesium chloride ($MgCl_2$) is a salt formed with ionic bonds between one magnesium ion and two chloride ions. Magnesium has two electrons in its outer shell and chlorine has seven electrons in its outer shell. How are the electrons transferred between these atoms?

A) Both magnesium and chlorine are reduced.
B) Both magnesium and chlorine are oxidized.
C) Chlorine is oxidized and magnesium is reduced.
D) Magnesium is oxidized and chlorine is reduced.

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67) Carbonic acid and bicarbonate buffer in blood are extremely important to help maintain homeostasis. What would happen to the pH of the blood if bicarbonate were removed?
A) Removing bicarbonate from the blood would increase the pH
B) Removing bicarbonate from the blood would decrease the pH
C) Removing bicarbonate from the blood would not affect the pH

68) The common basilisk lizard will run across water on its hind legs in an erect position when startled by predators. This lizard has large feet and flaps of skin along its toes. What properties of water allow this lizard to walk on water?
A) Hydrogen bonds absorb heat when they break and release heat when they form. This helps to minimize temperature changes.
B) The surface tension created by hydrogen bonds is greater than the weight of the lizard initially.
C) Polar molecules are attracted to ions and polar compounds, making these compounds soluble.
D) Hydrogen bonds hold water molecules together; many hydrogen bonds must be broken for water to evaporate.

69) How is the bond in F_2 different from the bond in KCl?
A) F_2 is covalent and KCl is ionic
B) F_2 and KCl are both ionic
C) F_2 is ionic and KCl is covalent

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70) Carbon has 4 valence electrons and oxygen has 6. Carbon dioxide would contain _____.
A) one single covalent bond
B) four hydrogen bonds
C) two double covalent bonds
D) two single covalent bonds

71) If water were nonpolar it would not form hydrogen bonds. At normal room temperature this nonpolar water would be_____.
A) a gas
B) a liquid
C) a solid

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72) Proteins are three dimensional molecules made from strands of amino acids (imagine a string of beads). There are 20 different amino acids that can be used in proteins found in living organisms. Some of these amino acids are polar and others are nonpolar. In the watery cytosol of a cell, the protein folds into the three dimensional structure. Where would a series of nonpolar amino acids most likely be located in a protein that is found in the cytosol of an animal cell?

A) On the surface of the protein
B) In the interior of the protein
C) At the very top of the protein
D) At the very bottom of the protein

73) According to most car mechanics, plain water is the best coolant to use in an engine provided the engine is not being exposed to freezing temperatures. If the car is subject to freezing temperatures then a mixture of water and ethylene glycol (antifreeze) is recommended but it does not cool as efficiently as plain water. Why would ethylene glycol reduce the cooling efficiency of water?

A) Ethylene glycol has a lower heat capacity than water.
B) Ethylene glycol has a higher heat capacity than water.
C) Hydrogen bonds in water allow high levels of heat absorption and a large increase in temperature.
D) Ethylene glycol raises the freezing point of water.

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74) Dennis had a history of heart disease in his family and was reducing his intake of saturated fats. Saturated means each carbon atom is bonded to as many hydrogen atoms as it can accept. If a carbon were bonded to two carbons, how many hydrogens could it accept?

A) 0
B) 1
C) 2
D) 3
E) 4

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Answer Key

Test name: Chapter 02

1) A
2) A
3) C
4) B
5) D
6) A
7) A
8) D
9) B
10) B
11) A
12) E
13) B
14) B
15) B
16) C
17) C

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about calculating the mass of an atom.
- You are being asked to apply the definition of atomic mass to calculate the atomic mass.
- Atomic mass is the sum of the masses of protons and neutrons in a single atom. We assume the mass of electrons is so small it doesn't contribute to total mass.
- The masses of a single proton and single neutron are both 1 each.
- There are 20 protons and 20 neutrons, each with a mass of 1 within this atom.
- 20 protons + 20 neutrons = an atomic mass of 40.
- This question asked you to apply the definition of atomic mass to calculate an atomic mass. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you confuse atomic number (the number of protons alone) with the atomic mass (the sum of protons and neutrons)?

18) A

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Clarify Question *What is the key concept addressed by the question?*

- The question asks why oil and water don't mix.
- You are being asked to apply your knowledge of the properties of water and oil, in order to explain why the oil did not dissolve in water.
- Dissolve: when one compound mixes completely with a solvent, like water.
- Water is a polar molecule, meaning other polar molecules or ions will dissolve in it. These water loving molecules are called hydrophilic.
- Oil is a nonpolar molecule and will dissolve better in a nonpolar solvent. These molecules are called hydrophobic, or water fearing.
- Water is a solvent with a high heat of vaporization and also forms surface tension. However, none of these properties explain why oil does not dissolve in water.
- The best answer is that oil is hydrophobic, meaning it does not interact well with water. This is because water is a polar molecule and oil is nonpolar. Water has -O-H bonds which do not share electrons equally and give O a partial negative charge and H a partial positive charge. In contrast, oil is made up of -C-H bonds where the electrons are shared more equally, leading to no partial charges. Because oil does not have these charges it is not attracted to the charges in water, and thus does not dissolve well in water.
- This question asked you to apply the properties of water to explain why oil and water do not mix well. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you know what the word hydrophobic meant? Did you have difficulty remembering which properties of water make it a good solvent for other polar molecules?

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19) A
20) B

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Clarify Question*What is the key concept addressed by the question?*

- The question asks you to calculate the number of neutrons from the atomic mass and number of an atom.
- You are being asked to apply your knowledge of how atomic mass and atomic number are calculated.
- Atomic mass: the number of neutrons plus protons in an atom.
- Atomic number: the number of protons in an atom.
- Atomic mass refers to the combined number of neutrons and protons in an atom.
- Atomic number is defined by the number of protons in an atom.
- To calculate the number simply take atomic mass (P + N) and subtract the atomic number (P).
- In this example: 16 – 8 = 8 neutrons
- This question asked you to apply the structure of an atom to predict some of its properties. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you know the definitions of how atomic mass and atomic numbers? Did you have difficulty figuring out how to calculate the number of neutrons by subtracting the atomic number from the atomic mass?

21) B

Clarify Question*What is the key concept addressed by the question?*

- The question asks about relating pH to H+ concentration.
- You are being asked to apply the definition of pH to a specific example.
- pH: this is calculated as –log[H+]
- Because the relationship between H+ concentration and pH is on a log scale, a change in pH of 1 corresponds to a change in H+ concentration by 10-fold.
- Because the relationship is calculated as negative, an increase in pH of 1 means there is a decrease in H+ concentration by 10-fold.
- When moving from the small intestines to the large intestines, the pH goes from 7.5 to 5.5, which means the substance is moving to a more acidic environment. This means that the H+ concentration will increase.
- Because the pH drops by 2 pH units, the H+ concentration will increase by 10 × 10 or %media:1formula4.mml% = 100 fold.
- This question asked you to apply the definition of pH to calculate H+ concentration. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you recall that pH is on a log scale? Did you recall that pH has a negative relationship to H+ concentration, so an increase in pH leads to a decrease in H+ concentration?

22) B

23) C

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24) B
25) D
26) D
27) A
28) D
29) D

Clarify Question*What is the key concept addressed by the question?*

- The question asks about predicting an atom's ionic form.
- You are being asked to apply your knowledge of the structure of an atom to predict ion formation.
- Energy levels: the first level holds 2 electrons and each higher level holds 8 electrons.
- If you make an electron diagram of the structure of a sodium atom, there are 2 electrons in the first shell, 8 in the second shell and 1 in the outer (valence) shell.
- If there is one valence electron then the atom could lose that electron or gain 7 more to have a full outer shell (octet).
- The atom will lose its single valence electron, losing the -1 charge carried by the electron. This will give the Na ion a +1 charge.
- This question asked you to apply the structure of an atom to predict if it will form an ion. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you have trouble drawing the structure of a sodium ion? Did you recognize that the sodium atom would lose an electron to have a stable outer shell?

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30) C
31) D
32) E
33) C
34) E
35) D
36) D

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about the formation of hydrogen bonds in water.
- You are being asked to apply your knowledge of the structure of water to predict the formation of hydrogen bonds.
- Hydrogen bonds: weak ionic interactions between a partial positive charge on one atom/molecule and a partial negative charge on another atom/molecule.
- Water has the structure H-O-H
- Oxygen has a stronger attraction for electrons than hydrogen and ends up with two partial negative charges.
- Hydrogen has a weaker attraction for electrons than oxygen and ends up with a partial positive charge.
- Hydrogen bonds will form between the H atom on one water molecule and the O atom on a second water molecule.
- Each H atom can form one hydrogen bond with an O atom on another water molecule.
- Each O atom can form hydrogen bonds with two H atoms on other water molecules.
- Water can form hydrogen bonds with 4 water molecules. Two bonds will be through the H atoms and two through the O atom.
- This question asked you to interpret the structure of a water molecule to predict how many hydrogen bonds it could form. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Could you draw the structure of a water molecule? Could you identify which atoms would be involved in forming a hydrogen bond?

37) A

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about electronegativity.
- You are being asked to apply your knowledge of electronegativity to predict what types of bonds a molecule could form.
- Electronegativity: the pull of an atom on an electron.
- Nitrogen has a higher electronegativity than hydrogen. This means that the nitrogen atoms will have a partial negative charge and the hydrogen atoms will have a partial positive charge.
- The partial charges on N and H atoms on adjacent %media:1formula5.mml% molecules will be attracted to each other.
- These are not covalent bonds which share electrons.
- These are partial charges, so they are not ionic bonds.
- Because these are charged they are hydrophilic and not hydrophobic.
- The best answer is that the attraction through partial charges is a hydrogen bond between the N on one NH3 and the H on another.
- This question asked you to interpret the structure of a molecule to predict some of its properties. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Could you draw the structure of an NH3 molecule? Did you realize how hydrogen bonds form?

38) E

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39) D

40) A

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about radioactive carbon.
- You are being asked to analyze data on radioactive decay.
- Half-life: the amount of time in which half of a dose of radioactivity in a sample will be lost to decay.
- The first step is to figure out how many half-lives have occurred: 22,800 ÷ 5,700 = 4.
- 4 half-lives means the amount of radiation will have been cut in half 4 times.
- %media:1formula7.mml%, which means that the total amount of radiation will have decreased by 16-fold.
- 2 grams of Carbon-14 remain, and this represents the amount left after a 16-fold decrease. This means the original amount should be 2 grams × 16 = 32 grams.
- This question asked you to analyze radioactive decay and calculate the original amount of radioactive carbon from a sample. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you recall that the amount of sample would be cut in half with each decay? One common misconception is to think that 4 rounds of decay would decrease the radioactivity 4-fold. Each round cuts the amount of radioactivity in half, so this leads to a 16-fold decrease.

41) A

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about attraction interactions between water molecules.
- You are being asked to apply your knowledge about the properties of water.
- Ionic bonds: a full positive charge on one molecule attracted to a full negative charge on another molecule
- Hydrophobic interactions: hydrophobic groups repel water and clump together
- Hydrogen bonds: a partial negative charge on one atom is attracted to a partial positive charge on another atom. One of these atoms would be a hydrogen atom.
- Covalent bonds: when two atoms share a pair of electrons
- Water is a polar molecule with partial negative charges on oxygen atoms and partial positive charges on hydrogen atoms.
- Covalent bonds form between atoms within the same molecule. The question refers to interactions between water molecules, so these cannot be covalent.
- Ionic bonds involve full charges, while water has partial charges.
- Hydrophobic interactions are found in non-polar molecules, and water is polar.
- The best answer is that hydrogen bonds form between water molecules. As one water molecule evaporates it pulls the next water molecule up, moving water through the xylem.
- This question asked you to apply principles of hydrogen bonding to the properties of water. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you recall the structure of water and types of bonds it forms?

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42) B

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Clarify Question

What is the key concept addressed by the question?

- The question asks about the properties of liquid water and ice.
- You are being asked to apply your knowledge of the relative densities of liquid water and ice to what happens in a lake in the winter.
- Density: this is the measure of mass/volume.
- Because ice has a more rigid structure than liquid water it occupies more volume. Thus the same mass of liquid water and ice vary in their density. Because liquid water occupies less volume it has a larger density than ice. This is why ice floats on top of liquid water.
- As with many molecules, solids are denser than liquids. The question asks you to predict what would happen if ice was denser than liquid water.
- If ice were denser than water it would sink to the bottom of a lake during the winter. Over time the ice would fill in the lake from the bottom up, eventually freezing everything in the lake.
- This question asked you to apply the properties of water to predict what would happen if ice was denser than water. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you realize that if ice was denser than liquid water it would sink? The density would not affect water's ability to form or break hydrogen bonds.

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43) C

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about the treatment of acidosis.
- You are being asked to apply your knowledge of acids to explain how acidosis is treated.
- Acidosis: when the blood is more acidic.
- Buffers: solutions used to adjust the pH of a solution.
- Saline: a salt solution with the same osmolarity of blood.
- Acids will lower the pH of a solution.
- Buffers can be used to neutralize acids.
- Saline is a salt solution and will not affect pH.
- If your dog has acidosis then the pH of his blood is too low. A buffer will be used to neutralize the acid and raise the pH back to a healthy level.
- This question asked you to apply the properties of a buffer to neutralize an acid. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you recall that acids will lower pH? Did you recall that buffers will neutralize pH?

44) A

45) C

46) A

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about the formation of covalent bonds.
- You are being asked to apply your knowledge of covalent bonds to predict how many bonds are present in N2.
- Covalent bonds: when two atoms share a pair of electrons
- Two atoms share a pair of electrons to form a covalent bond.
- Atoms can form more than one covalent bond.
- If the two N atoms are sharing 6 electrons, and there are 2 electrons shared in one covalent bond, then there are 6 ÷ 2 = 3 covalent bonds.
- There are 3 covalent bonds between the two N atoms in N2.
- This question asked you to analyze the structure of a covalent bond to predict the number formed in N2. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you realize that a covalent bond contains 2 shared electrons? Did you realize that two atoms can have more than one covalent bond?

47) D
48) C
49) D
50) A
51) B
52) B

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about calculating the mass of 3 moles of Li.
- You are being asked to apply the atomic mass of a compound to calculate the mass of 3 moles.
- Atomic mass: the mass (in grams) of one mole of an element
- Atomic number: the number of protons in an atom
- %media:1formula12.mml% atoms/mole: this is defined as Avagadro's number, and is universal for each atom.
- If you have 3 moles of Li, you will want to multiply that by a factor with the units 'grams/mole' so the moles unit cancels and you are left with grams.
- Atomic number has the units protons/atom and won't be useful in calculating grams.
- Avagadro's number has the units atoms/mole and won't be useful in calculating grams.
- Atomic mass has the units grams/mole.
- 3 moles of Li × 7 grams/mole = 21 grams of Li
- This question asked you to apply the concept of moles and atomic mass to calculate the mass of 3 moles of Li. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you recall the units for atomic mass, atomic number, and Avagadro's number? Were you able to set up the calculation properly?

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53) D

Clarify Question*What is the key concept addressed by the question?*

- The question asks about pH.
- You are being asked to apply your knowledge of pH to neutralize an acid.
- Acid: solution with a pH less than 7.
- Base: solution with a pH greater than 7
- Acids have a pH less than 7, so to neutralize the acid you would want to use a base (solution with a pH greater than 7).
- Water is neutral (pH 7) and will not neutralize an acid.
- The only base on the list of answers is baking soda (pH 9). Adding a base with a high pH will neutralize an acid with a low pH.
- This question asked you to apply the definition of an acid to neutralize an acid. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you recall that acids have a low pH? Did you realize that a base with a high pH would neutralize an acid?

54) A

55) A

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about the link between electronegativity and polar bonds.
- You are being asked to analyze the relative electronegativities of two atoms in a bond to predict which would be most polar.
- Electronegativity: the attraction of an atom for an electron.
- Polar bond: a covalent bond in which the electrons are not shared equally.
- The greater the difference in electronegativity between two atoms in a covalent bond, the more polar the bond will be.
- To calculate the relative polarity of the bonds, simply subtract the electronegativities of each atom in the bond.
- Se-Cl: 3.2-2.6 = 0.6
- C-Cl: 3.2-2.5 = 0.7
- B-Cl: 3.2-1.8 = 1.4
- The largest difference is between B and Cl, so the B-Cl bond will be the most polar with Cl pulling the electrons away from B.
- This question asked you to apply the definition of electronegativity to predict the polarity of a covalent bond. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you know what electronegativity and polar bonds were? Did you know how to compare the difference in electronegativity between the two atoms to determine the polarity of the bond?

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56) B

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about redox reactions.
- You are being asked to apply the definition of reactions that lose an electron.
- Redox reaction: contains an oxidation and a reduction reaction.
- Oxidation: reaction involving a loss of an electron(s) (the charge of the atom or molecule losing the electron is oxidized)
- Reduction: reaction involving a gain of an electron(s) (the charge of the atom or molecule gaining the electron is reduced)
- In a redox reaction electron(s) are transferred from one atom or molecule to another.
- This is made up of an oxidation half reaction where the electrons are lost by one reactant, and a reduction half reaction where the electrons are gained by the second reactant.
- In the half reaction %media:1formula18.mml%, %media:1formula19.mml% is losing 2 electrons
- Because %media:1formula19.mml% is losing 2 electrons this is an oxidation half reaction.
- This would be balanced by the reduction half reaction %media:1formula22.mml%
- Finally the %media:1formula23.mml%
- Putting this all together you get the reaction: %media:1formula16.mml%
- This question asked you to apply the definition of an oxidation reaction. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you have trouble recognizing that an oxidation half reaction was being shown? Did the mention of a redox reaction confuse the problem for you?

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57) C

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about the configuration of electrons in an atom.
- You are being asked to apply your knowledge of electron configuration to create one for Argon.
- Electron configuration: the occupancy of electrons in different shells.
- Atomic number: the number of protons in an atom, and thus also the number of electrons.
- The first shell contains 2 electrons in an "s" orbital. A full first shell is represented by %media:1formula29.mml% .
- The next shells each contain 8 electrons: 2 electrons in an "s" orbital and 6 electrons in a "p" orbital. A full second shell is represented by %media:1formula30.mml%.
- Argon has an atomic number 18 and Neon is 10. Thus Argon has 8 more electrons than Neon, which adds one more shell.
- Adding a third shell to Neon will add 8 more electrons, 2 electrons in an "s" orbital and 6 electrons in a "p" orbital.
- Following the same numbering as with Neon this would add %media:1formula31.mml%.
- The complete electron configuration for Argon will be %media:1formula32.mml%.
- This question asked you to apply the orbitals of electrons in an atom to write an electron configuration. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you have trouble understanding what was being represented in the numbering system of an electron configuration? Did you realize that the 8 electrons in shells 2 and 3 were split between "s" and "p" orbitals?

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58) B

59) A

Clarify Question*What is the key concept addressed by the question?*

- The question asks about properties of water.
- You are being asked to apply your understanding of properties of water to explain an observation.
- Wicked: this means the water moved upward, in this case from the floor to the carpet
- Water is a polar molecule that forms hydrogen bonds with other water molecules and polar compounds. This allows water to move upward by wicking.
- Adhesion: water sticking to other molecules through hydrogen bonds.
- Cohesion: water molecules sticking to each other.
- Solubility: substances dissolving in water.
- Both adhesion and cohesion will allow water molecules to bind to polar molecules in the carpet and wick upward from the floor.
- This question asked you to apply the properties of water to explain wicking. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you recall the definitions of adhesion, cohesion, and solubility?

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60) A

Clarify Question*What is the key concept addressed by the question?*

- The question asks about the formation of ions.
- You are being asked to apply your knowledge of electron energy levels to the formation of ions.
- Outer energy level: an atom is most stable when its outer energy level is full. Also called a valance shell.
- To be most stable, an atom may gain or lose electrons to end up with a full outer shell of electrons.
- This atom has one extra electron in its outer shell.
- If it gains an electron it will still have a partially full outer shell (2 electrons).
- If the atom loses an electron it will have a full outer shell (8 electrons).
- Losing an electron will give the atom a full outer shell.
- Because an electron has a -1 charge, losing the electron will give the atom a +1 charge, forming a positive ion.
- This question asked you to analyze the structure of an atom to predict the formation of its ion. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you realize that the atom would be most stable if it lost an electron? Did you recognize that losing an electron would lead to the formation of a positively charged ion?

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61) B

62) C

63) A

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Clarify Question*What is the key concept addressed by the question?*

- The question asks how salt would prevent ice from forming.
- You are being asked to apply your knowledge of the properties of water to explain how salt melts ice.
- Freezing point: the temperature below which water molecules hydrogen bond to each other in a solid lattice commonly known as ice
- Ice forms because the water molecules are in a 3-dimensional lattice with each water molecule hydrogen bonded to 4 other water molecules.
- When salt dissolves in water the NaCl dissociates into %media:1formula33.mml% and %media:1formula34.mml% ions. Each of these ions interact with water molecules. The %media:1formula33.mml% will be attracted to the partial negative charge on O in water and the %media:1formula34.mml% ions will be attracted to the partial positive charge on H in water.
- Because %media:1formula33.mml% and %media:1formula34.mml% ions interact with water molecules through the partial charges on water, this interferes with the ability of water molecules to hydrogen bond with each other.
- Because water molecules can no longer form hydrogen bonds with each other, they cannot form a lattice and ice does not form.
- This question asked you to apply the properties of water to explain why salt melts ice. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you realize that ice forms because of hydrogen bonding between water molecules? Did you understand that salt ions interfere with this hydrogen bonding, reducing water's ability to form ice?

64) B

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about the relationship between pH and hydrogen ion concentration.
- You are being asked to apply your knowledge of pH to predict what would happen to water when the hydrogen ion concentration is increased.
- pH: this is from the formula, pH= −log[H+]
- Because pH is the −log[H+], as the H+ concentration goes up the pH goes down.
- Because it is a log scale, each 10-fold change in H+ concentration results in a change in pH of 1.
- In this case, a 100-fold increase in H+ concentration would lead to a decrease in pH of 2.
- Next we need to figure out what the pH was before the chemical was added to water. Pure water has a pH of 7.
- Pure water has a pH of 7 and the chemical dropped the pH by 2, so the new pH will be about 5.
- This question asked you to apply the definition of pH to predict what would happen if a chemical was added that raised the H+ concentration. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you have trouble using the equation of pH? Did you recall that there is a negative log relationship between pH and H+ concentration, so the pH decreases? Did you recall that the pH of water is 7?

65) A

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about electronegativity.
- You are being asked to apply your knowledge of electronegativity to predict the effect of partial charge on an atom.
- Electronegativity: the attraction of an atom for an electron.
- Partial charges: if two atoms in a covalent bond have different attractions for an electron, this is called a polar covalent bond.
- The atom with the stronger attraction will have a partial negative charge and the atom with the weaker attraction will have a partial positive charge.
- The electronegativity of N is 3.0 and that of H is 2.1.
- N has a stronger attraction for the electrons in its covalent bond with H.
- Because electrons have a negative charge, the N will have a partial negative charge.
- Based on the same logic, each H atom will have a partial positive charge as the electrons are pulled towards N.
- This question asked you to apply the definition of electronegativity to predict the partial charges on atoms in a polar covalent bond. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you recognize that the higher electronegativity on N meant it had more attraction for electrons than H? Did you realize that a stronger pull for electrons gave N a partial negative charge, while this led to a partial positive charge on each H?

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66) D

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about reduction and oxidation reactions.
- You are being asked to apply your knowledge on the formation of ions through reduction and oxidation.
- Outer shell of electrons: an atom is most stable with a full outer shell of electrons. This can be obtained by gaining or losing electrons.
- If an atom loses an electron it becomes oxidized and forms a positive charge.
- If an atom gains an electron it becomes reduced and forms a negative charge.
- Mg has 2 extra electrons in its outer shell, so it will be most stable losing two electrons.
- Cl has 7 electrons in its outer shell, so it will be most stable gaining one electron.
- Mg will lose two electrons, forming %media:1formula36.mml% and becoming oxidized in the process.
- Cl will gain one electron, forming %media:1formula37.mml% and becoming reduced in the process.
- This question asked you to apply the structure of an atom to predict if it would become reduced or oxidized in forming an ion. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you realize that Mg would lose electrons and Cl would gain them? Did you remember that oxidations lose electrons and reductions gain electrons?

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67) B

Clarify Question*What is the key concept addressed by the question?*

- The question asks about buffers.
- You are being asked to apply your knowledge of buffers to predict what would happen if a base was removed.
- Carbonic acid: this is the acid of the buffer.
- Bicarbonate: this is the base of the buffer.
- Buffers contain a weak acid and its complementary base.
- Acids lower the pH of a solution and bases raise the pH.
- If the bicarbonate was removed from the solution all that would be left is the carbonic acid.
- Acids lower the pH of a solution, so the pH of blood would drop.
- This question asked you to apply the definition of a buffer to determine what would happen if the base was removed. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you realize that bicarbonate was the base in the problem? One clue was that carbonic acid had to be the acid, based on its name. Did you recall that acids lower the pH and bases raise the pH?

68) B

69) A

70) C

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about the formation of covalent bonds.
- You are being asked to apply your knowledge of the structure of atoms to predict how many covalent bonds carbon dioxide could form.
- Valence electrons: electrons in the outer shell of an atom.
- Typically an atom is most stable if it has a full outer shell. This can be accomplished by gaining, losing, or sharing electrons. When two electrons are shared between two atoms this forms a covalent bond.
- The name carbon dioxide indicates that there are one carbon atom and two oxygen atoms in this molecule.
- Carbon has 4 valence electrons, so it needs to share 4 more electrons to get a full outer shell. This means it can form 4 covalent bonds.
- Oxygen has 6 valence electrons, so it needs to share 2 more electrons to get a full outer shell. This means each oxygen atom can form 2 covalent bonds
- The carbon atom can form a double bond with each of the oxygen atoms. That will give the carbon atom 4 bonds and each oxygen atom 2 bonds needed to fill their outer shells. The structure O=C=O would thus contain two double covalent bonds.
- This question asked you to apply the structure of an atom to predict how many bonds would form in carbon dioxide. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you have trouble figuring out how many bonds carbon and oxygen each needed to form to be stable? Were you confused on whether all of the bonds were between C and O or did you try to make some O-O bonds?

71) A
72) B

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Clarify Question

What is the key concept addressed by the question?

- The question asks about nonpolar amino acids.
- You are being asked to apply your knowledge of polarity to predict how this would affect the structure of a protein.
- Polar: molecules in which electrons are not shared equally between atoms, leading to partial charges on the atoms.
- Nonpolar: molecules in which electrons are shared equally between atoms, leading to no partial charges.
- Nonpolar molecules do not interact well with water, which is a polar molecule. These nonpolar molecules actually interfere with the formation of hydrogen bonds between water molecules.
- The inside of an animal cell contains cytoplasm which is made up of a lot of water. Thus the inside of the cell is a polar environment.
- Nonpolar amino acids in the inside of a cell do not interact well with and are repelled by the water of the cytoplasm.
- The repulsion of nonpolar amino acids by water will cause them to cluster in the center of the protein where they are shielded from water. This is why most proteins are ball shaped, with the nonpolar or hydrophobic amino acids in the center of the ball.
- This question asked you to apply polar and nonpolar definitions to predict the structure of a protein. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you understand the difference between polar and nonpolar amino acids? Did you realize that the inside of the cell would be a polar environment? Did you know that nonpolar groups will cluster near each other to be shielded from water?

73) A

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Clarify Question*What is the key concept addressed by the question?*

- The question asks about the ability of water to absorb heat.
- You are being asked to apply your understanding of the properties of water to explain the effect of adding antifreeze.
- Cooling efficiency: a measure of how well a solution can absorb heat.
- Water has a very high heat capacity. This means that it can absorb a lot of heat.
- Adding ethylene glycol decreases the cooling efficiency of water in the radiator. This is done to lower the freezing point of water, which keeps the radiator from freezing solid in the winter.
- The ethylene glycol has a lower heat capacity than water, so adding ethylene glycol to the radiator decreases the amount of heat that the water can absorb.
- This question asked you to apply the properties of water to explain the ability of water to absorb heat. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you realize that the property of water relevant to cooling efficiency was its heat capacity? Did you recognize that the question was not asking about changes in the freezing point?

74) C

Clarify Question*What is the key concept addressed by the question?*

- The question asks about forming covalent bonds.
- You are being asked to apply your knowledge of the structure of an atom to predict how many bonds it can form.
- Saturated fat: molecules with a backbone of C-C bonds, with as many C-H bonds as possible.
- Carbon has 4 valence electrons, and needs to share an additional 4 electrons to have a full outer shell. This means it needs to form 4 covalent bonds.
- In a saturated fat there is a backbone of C atoms attached by covalent bonds giving a structure like: -C-C-C-
- These covalent bonds provide 2 additional electrons, leaving a need for 2 more for carbon to have a full outer shell.
- To obtain the remaining 2 electrons, each C atom forms covalent bonds with two H atoms.
- This question asked you to apply the structure of an atom to predict how many bonds would form in a saturated fat. If you got the correct answer, great job! If you got an incorrect answer, where did the process break down? Did you understand what was meant by a saturated fat? Could you figure out how many total covalent bonds each C atom would form?

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