

# The Chemistry of Life

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## Simple Review Questions

1. How many types of atoms can you expect to find in a pure sample of any element?

2. Distinguish between an atom and an element.

3. What is the atomic symbol for the element cobalt?

4. Is it possible to see an atom using visible light?

5. What is at the center of every atom?



6. Are elements made of atoms or are atoms made of elements?

## **2.2 Chemical Compounds**

7. How does an ion differ from an atom?

8. To become a negative ion, does an atom lose or gain electrons?

9. Which elements tend to form ionic bonds?

10. Which elements tend to form covalent bonds?

## **2.3 Mixtures**

11. What is a dipole?

12. What defines a material as being a mixture?



13. Distinguish between a solute and a solvent.

## **2.4 Chemical Reactions**

14. What generally happens to the rate of a chemical reaction with increasing temperature?

15. What net effect does a chemical reaction have on a catalyst?

16. Why are catalysts so important to our economy?

17. What is released by an exothermic reaction?

## **2.5 Two Types of Chemical Reactions**

18. When an acid is dissolved in water, what ion does the water form?



19. When a chemical loses a hydrogen ion, is it behaving as an acid or a base?

20. What does the pH of a solution indicate?

21. Which elements have the greatest tendency to behave as oxidizing agents?

## **2.6 Organic Molecules**

22. What is an organic molecule?

23. Why is the carbon atom so unique?

24. Why do non-carbon atoms make such a difference in the properties of an organic molecule?



## 2.7 Macromolecules Needed for Life

25. What are some of the different functions of proteins?

26. Give an example of (a) a carbohydrate that functions in energy storage and (b) a carbohydrate that has a structural function.

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27. Describe the structure of DNA.

28. The macromolecules made from folded chains of amino acids are

- (a) proteins.
- (b) carbohydrates.
- (c) lipids.
- (d) nucleic acids.

**(CLICK TO CHECK YOUR ANSWERS)**



## Challenging Review Questions

### 2.1 Atoms and Molecules

29. A cat strolls across your backyard. An hour later, a dog with its nose to the ground follows the trail of the cat. Explain what is going on from a molecular point of view.



30. Where did the atoms that make up a newborn baby originate?

31. The atoms that compose your body are mostly empty space, and structures such as the chair you're sitting on are composed of atoms that are also mostly empty space. So why don't you fall through the chair?

32. Why isn't water an element?

33. Name some elements you have access to macroscopic samples of as a consumer here on the Earth.



## 2.2 Chemical Compounds

34. Which is more polar: a carbon–oxygen bond or a carbon–nitrogen bond?

35. Magnesium ions carry a 2+ charge, and chloride ions carry a 1- charge. What is the chemical formula for the ionic compound magnesium chloride?

36. Barium ions carry a 2+ charge, and nitrogen ions carry a 3- charge. What would be the chemical formula for the ionic compound barium nitride?

37. In each molecule, which atom carries the greater positive charge?

H-Cl

Br-F

C O

Br-Br

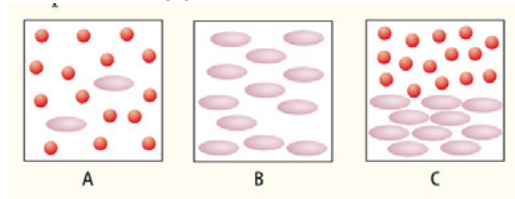
38. The charges with sodium chloride are all balanced—for every positive sodium ion there is a corresponding negative chloride ion. Since its charges are balanced, how can sodium chloride be attracted to water, and vice versa?



## 2.3 Mixtures

39. The air we breathe is not considered by chemists to be an element. Why not?

40. What happens to the volume of a sugar solution as more sugar is dissolved in it?



41. The above boxes depict a view at the level of atoms and molecules. Which best represents a suspension? Which best represents a solution? Which best represents a compound?

42. Why is the oxygen atom of a water molecule slightly negative in charge?

43. Why is it not practical to have a macroscopic sample that is 100 percent pure?

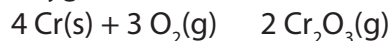
44. How might you separate a mixture of sand and salt? How about a mixture of iron and sand?





## 2.4 Chemical Reactions

45. How many oxygen atoms are indicated on the right side of this balanced chemical equation:

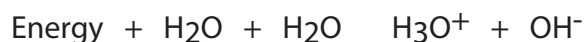


46. Are the chemical reactions that take place in a disposable battery exothermic or endothermic? What evidence supports your answer? Is the reaction going on in a rechargeable battery while it is recharging exothermic or endothermic?

## 2.5 Two Types of Chemical Reactions

47. What happens to the polarity of oxygen atoms as they transform from molecular oxygen,  $\text{O}_2$ , into water molecules,  $\text{H}_2\text{O}$ ?

48. This reaction between two water molecules is endothermic, which means the reaction requires the input of heat energy in order to proceed:



The warmer the water, the more heat energy is available for this reaction, and the more hydronium and hydroxide ions are formed. So, which has a lower pH: pure water that is hot or pure water that is cold? Explain.



49. The general chemical equation for photosynthesis is shown below. Through this reaction are the oxygens of the water molecules,  $\text{H}_2\text{O}$ , oxidized or reduced? Explain.

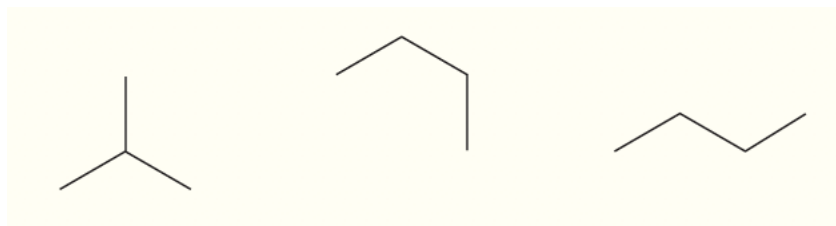


50. Water is 88.88 percent oxygen by mass. Oxygen is exactly what a fire needs to grow brighter and stronger. So why doesn't a fire grow brighter and stronger when water is added to it?

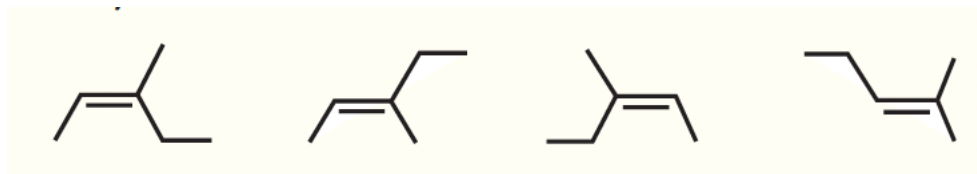
51. Why is the air over an open flame always moist?

## 2.6 Organic Molecules

52. Organic molecules can be represented by "stick structures" as shown below. At each end and each corner, there is an implied carbon atom. For example, each of the three stick structures shown below consist of four carbon atoms. The stick structure is helpful in showing the basic structure or "framework" of a particular organic molecule. But of the three structures shown below, two are identical molecules. Which two are identical molecules?



53. Warning: This is a super hard question. Remember that carbon-carbon single bonds can rotate while carbon-carbon double bonds cannot rotate. How many different structures are shown below.



## 2.7 Macromolecules Needed for Life

54. Are you made up of the same macromolecules as a sea urchin? Explain your answer.

55. When birds migrate south for the winter, they may fly hundreds or even thousands of kilometers in a relatively short period of time. Why do birds put on a layer of fat before their annual migration? What would happen if they stored this energy in the form of carbohydrate?

56. Swimming mammals such as sea otters and beavers are often described as having “waterproof” fur that keeps them relatively dry as they swim. A close look at their fur coats shows that they have very dense fur. In addition, the fur is covered with an oil that helps repel water. Which macromolecules make up fur and oil and are involved in keeping swimming mammals dry?



57. DNA uses only four different kinds of nucleotides. How can only four nucleotides code for all the different kinds of genes that are found in different living things?

**(CLICK TO CHECK YOUR ANSWERS)**

### **APPLY AND DISCUSS QUESTION**

58. Why does an inflated and securely tied rubber balloon slowly deflate over several days?



## End of Chapter Solutions

### Simple Review Solutions

1. An element consists of only one type of atom.
3. As can be found in the periodic table, the atomic symbol for the element cobalt is Co.
5. The atomic nucleus.
7. An ion has a charge and an atom does not.
9. Elements on opposite sides of the periodic table tend to form ionic bonds.
11. A dipole is an uneven distribution of electrons in a chemical bond caused by a difference in the attraction for electrons between two atoms.
13. A solute is the component of lesser quantity in a solution (that being dissolved; e.g., salt in water). A solvent is the component of greater quantity in a solution (e.g., water in salt water solution).
15. A catalyst is unchanged by a chemical reaction.
17. Energy is released by an exothermic reaction.
19. A chemical that loses a hydrogen ion is behaving as an acid.
21. The elements in the upper right of the periodic table have the greatest tendency to behave as oxidizing agents. Not discussed in this chapter is that the elements in the last vertical column (group 18) tend to be inert.
23. Unlike all other elements of the periodic table, carbon is able to form repeated covalent bonds with other carbon atoms. And it can do so in various directions. This makes the carbon atom a good “building block” allowing for complex chemical structures. That carbon is also able to bond with other non-carbon atoms provides for even greater versatility.
25. **Proteins** perform a wide range of functions in living organisms. The protein keratin provides structure in the form of skin, hair, and feathers. Insulin is a protein that acts as a hormone, allowing one type of cell in the body to communicate with other types. Actin and myosin are proteins that allow muscles to contract. Hemoglobin, a protein found in red blood cells, transports oxygen to body tissues. Antibodies are proteins that protect the body from disease. And proteins known as digestive enzymes break down food during digestion.
27. Nucleic acids are made up of strands of smaller units called nucleotides. A nucleotide includes a sugar molecule, a phosphate group, and a nitrogenous base. DNA consists of two nucleic acid strands twisted into a spiral, which is why it is sometimes called a double helix. Four kinds of nucleotides are found in DNA—adenine, cytosine, guanine, and thymine, or A, C, G, T for short.



## Challenging Review Solutions

29. The cat leaves a trail of molecules across the yard. These molecules leave the ground and mix with the air, where they enter the dog's nose, activating the sense of smell.

31. The outsides of the atoms of the chair are made of negatively charged electrons, as are the outsides of the atoms that make up your body. Atoms don't pass through one another because of the repulsive forces that exist between these electrons. When you sit on the chair these repulsive forces hold you up against the force of gravity, which is pulling you downward.

33. Here is a list of sixteen. Aluminum (as in aluminum foil); tin (as in tin foil and tin cans); carbon (as in graphite and diamond); helium (as in a helium balloon); nitrogen (which comprises about 78% of the air we breathe); oxygen (which comprises about 21% of the air we breathe); argon (which comprises about 1% of the air we breathe); silicon (as in integrated circuits for computers and calculators); sulfur (a mineral used for many industrial processes); iron (as in most metal structures); chromium (as in chromium bumpers on cars); zinc (as in the coating of any galvanized nail or as the insides of any post 1982 copper penny); copper (as in copper pennies); nickel (as in nickel nickels); silver (as in jewelry and old silver coins); gold (as in jewelry); platinum (as in jewelry).

35.  $\text{MgCl}_2$  (Two single negatively charged chlorine ions are needed to balance the one doubly positively charged magnesium ion). A shortcut way of solving these sorts of problems is to take the charge of one ion and make it the subscript of the opposite ion. For example, take the 2+ charge of the magnesium and make it the subscript on the chlorine. Then take the 1- charge on the chlorine and make that the subscript of the magnesium. Because numeral 1 subscripts are implied when not written, we have not  $\text{Mg}_1\text{Cl}_2$ , but  $\text{MgCl}_2$ .

37. The atoms found closer to the lower left-hand corner of the periodic table are those that will bear the positive charge: a) hydrogen b) bromine c) carbon d) neither!

39. An element is a material made of only one type of atom. Air is a mixture of different kinds of atoms, mostly nitrogen and oxygen.

41. Box "c" best represents a suspension. What may be depicted in "c" is the interface between a solid and liquid phase within a suspension. Box "a" shows oval molecules dissolved within smaller circle molecules, which best illustrates a solution. Box "b" shows a pure material, which may be indicative of a compound.

43. Atoms and molecules are very small so if one atom or molecule out of a trillion is different, then the sample is no longer pure.

45. There are six oxygen atoms on the right hand side of this equation. Note the coefficient of 2 indicates that there are two chromium oxide,  $\text{Cr}_2\text{O}_3$ , molecules.

47. The oxygen atoms become more negatively charged, which is to say they are gaining electrons.

49. Within any water molecule,  $\text{H}_2\text{O}$ , the oxygen carries a slight negative charge. Why? Because this oxygen atom is able to pull the shared electrons away from the hydrogen atoms. Within any oxygen molecule,  $\text{O}_2$ , the bonding electrons between the two oxygen atoms are evenly shared. Why? Because the two atoms are equally strong at pulling on the electrons. Thus, an oxygen atom moving from being in a water molecule



to an oxygen molecule is going to lose its negative charge. The loss of a negative charge is an example of oxidation. So, within photosynthesis, the oxygen is being oxidized. This is unusual. Why? Because oxygen prefers to have a negative charge and here we're taking that negative charge away. How so? By using the energy of sunlight. This is why photosynthesis is an endothermic reaction.

51. One of the products of combustion is water vapor.

53. The second and the fourth structures are the same. In all, there are three different structures shown.

55. Birds need a large energy supply to complete long, strenuous migratory flights. If they store the energy as fat rather than as carbohydrate, they won't weight themselves down as much, since 1 gram of fat contains a lot more energy than 1 gram of carbohydrate.

57. The four nucleotides in DNA can be strung together in a huge number of ways to code for many unique genes. It's a lot like the way you can make lots of different English sentences using only the 26 letters in the alphabet—you can string the letters together in different ways.

