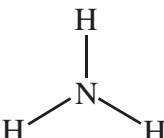


Build Models of Molecules Worksheet

Part A. Teacher Demonstration

1. Observe the models of ammonia, water, and carbon dioxide. How do the bonds in a water molecule fulfill the octet rule for hydrogen and oxygen?
2. How are the bonds in the carbon dioxide molecule different than the bonds in the water or ammonia molecules? Explain why carbon and oxygen bond this way.
3. Complete Data Table A by filling in the chemical formula and structural formula for water and carbon dioxide.

Data Table A

Name	Chemical Formula	Structural Formula
Ammonia	NH ₃	
Water		
Carbon dioxide		

Part B. Single, Double, and Triple Bonds

1. Build models of hydrogen, nitrogen, and oxygen molecules as found in air according to the chemical formulas in Data Table B. Refer to the chart in *Pre-Activity Question #3* for the number of bonds needed for each atom. Complete Data Table B by filling in the type of bond formed and the structural formula for each molecule.

Data Table B

Name	Chemical Formula	Type of Bond	Structural Formula
Hydrogen	H ₂		
Nitrogen	N ₂		
Oxygen	O ₂		

2. How many total electrons are shared by the two nitrogen atoms?

Part C. Hydrocarbons

1. *Hydrocarbons* are compounds containing only carbon and hydrogen. The simplest hydrocarbon is methane, CH_4 , the largest component of natural gas. Ethane has two carbon atoms linked together with a single bond; the rest of the bonded atoms are hydrogen. Build a molecule of ethane and determine its chemical formula. Record the chemical and structural formulas for ethane in Data Table C.
2. A *substituted hydrocarbon* has one or more of its hydrogen atoms replaced by an atom or group of atoms of other elements. Ethanol, or ethyl alcohol, is a compound in which one hydrogen atom has been replaced by an $-\text{OH}$ (hydroxyl) group. Modify the model of ethane to build a model of ethanol. Fill in the information for ethanol in Data Table C.
3. Some hydrocarbons have double or triple carbon bonds. Ethylene (also called ethene) has two carbon atoms double-bonded together. Build a molecule of ethylene, adding the correct number of single hydrogen bonds. Complete Data Table C for ethylene.

Data Table C

Name	Use	Chemical Formula	Structural Formula
Ethane	2nd largest component of natural gas		
Ethanol	Fuel additive		
Ethylene	Ripens fruit		

Part D. Isomers

1. Butane, C_4H_{10} , is a *hydrocarbon* (a compound containing only carbon and hydrogen) with two possible structures. Build one model of butane with the carbon atoms linked together in a long chain and draw its structural formula in Data Table D. Then rearrange the atoms to build a second model (isobutane) and draw its structure.

Data Table D

Name	Use	Chemical Formula	Structural Formula
Butane	Fuel in camping stoves and lighters	C_4H_{10}	
Isobutane	Aerosol propellant and refrigerant	C_4H_{10}	

2. The two possible structural formulas for butane represent *isomers*. Write a definition of isomers that describes the relationship between these two molecules.

Part E. Organic Acids

1. Organic, or carbon-based acids called *carboxylic acids* are formed when a $-\text{CH}_3$ group of atoms is displaced by a $-\text{COOH}$ (carboxyl) group. The simplest carboxylic acid is formic acid, also known as methanoic acid because it is based on a methane molecule. Build a formic acid molecule and draw its structural formula in Data Table E. *Note:* Chemical formulas may be written to indicate a group (such as a hydroxyl or carboxyl group) is part of the molecule.
2. Describe how the atoms in a carboxyl group are linked together.
3. Build a model of acetic (ethanoic) acid, CH_3COOH . Note that the carboxyl group stays intact. Draw the structural formula for acetic acid in Data Table E.

Data Table E

Name	Use	Chemical Formula	Structural Formula
Formic acid	Causes painful sting from ants, bees, and wasps	HCOOH or CH_2O_2	
Acetic acid	Vinegar	CH_3COOH	

Post-Activity Questions

1. Hydrocarbons in which all of the C—C bonds are single bonds follow a general formula. Based on the chemical formula for methane and ethane, determine the general formula for these hydrocarbons. *Hint:* The formula for propane is C_3H_8 .
2. Without building models, draw out the possible structural formulas for three isomers of pentane, C_5H_{12} .
3. Complete the following sentence.
“Carboxylic acids are (hydrocarbons/substituted hydrocarbons) because _____.”
4. Organic compounds are molecules that contain carbon. More than nine million organic compounds are known. Why do you think carbon is a part of so many different compounds?