

Worksheet 02

20 points

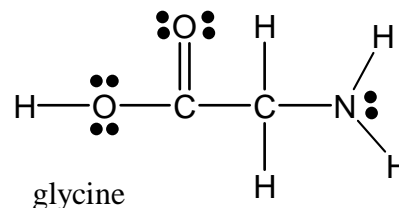
Due Friday, August 29

Molecules are made up atoms held together by covalent bonds. The models we use represent an atom as a colored ball and a bond as a plastic rod. Each atom has holes that correspond to the number of covalent bonds that the particular atom can participate in.

Element	Symbol	Color	Number of holes
Carbon	C	Black	4
Nitrogen	N	Blue or green	3 (one is stopped up)
Oxygen	O	Red	2
Hydrogen	H	White or yellow	1

Molecules can be constructed by connecting atoms according to their rules of connectivity. For example, with 2 Carbons, 5 Hydrogens, 1 Nitrogen, 2 Oxygens and 10 bonds you can construct glycine, the smallest amino acid. Glycine has the molecular formula $C_2H_5NO_2$. Here is how the structure looks on paper:

Assemble the structure of glycine with your kit.



- (1 point) What are two differences between your model and the drawing?
- (1 point) What are two differences the between the vertical Carbon-Oxygen bond and the other bonds in the molecule?

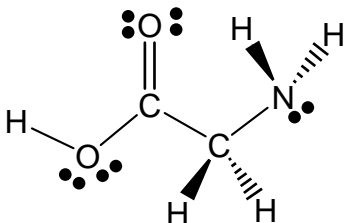
The models use in this experiment show the correct angles between chemical bonds, but they do not accurately show the relative sizes of atoms or the correct bond lengths. Nevertheless, they help us appreciate: 1) the different possible arrangements of the atoms in a molecule, 2) the different shapes that a molecule can assume and 3) the ways in which these shapes can be represented by two-dimensional formulas.

- (1 point) How would you describe the shape of glycine to someone who was not familiar with molecular models?
- (1 point) How does rotating bonds change molecular shape?

The conformation of his mind was such that whatever was little seemed to him great, and whatever was great seemed to him little.

Thomas Babington Macaulay, Literary Essays, 'Horace Walpole'

Different spatial arrangements of a molecule that are generated by rotation around single bonds are called **conformations**. Here is the drawing of one of the conformations of glycine:



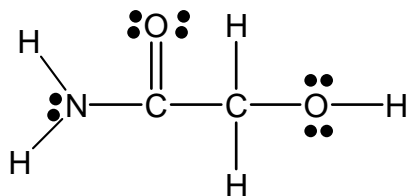
The regular lines are bonds in the plane of the paper. The solid wedges represent bonds that stick out in front of the paper. The dashed wedges represent bonds that stick out in back of the paper.

5. (1 point) Draw a different conformation of glycine than the one above using the dashed and solid wedge technique. Draw all structures using neutral atoms.

Do not quench your inspiration and your imagination;
do not become the slave of your model.

Vincent Van Gogh

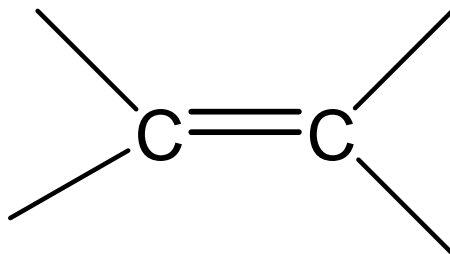
You can use the same atoms and bonds but assemble them in a different order. Compounds that have the same molecular formula but different connectivity are called **constitutional isomers**. For example a constitutional isomer of glycine would be:



6. (1 point) How is this compound different than glycine?

Assemble a constitutional isomer of glycine with a double bond between the two carbons.

7. (2 points) Draw your isomer by completing the structure below. Draw all structures using neutral atoms. Use all 10 atoms.



Assemble a constitutional isomer of glycine with a double bond between a carbon and the nitrogen.

8. (2 points) Draw your isomer. Draw all structures using neutral atoms. Use all 10 atoms.

Assemble a constitutional isomer of glycine with no double bonds.

9. (2 points) Draw your isomer. Draw all structures using neutral atoms. Use all 10 atoms.

10. (1 point) Draw the molecule in the previous question in dash-wedge form.

Assemble a constitutional isomer of glycine with all five hydrogens bonded to either one of the two carbons.

11. (2 points) Draw your isomer. Draw all structures using neutral atoms. Use all 10 atoms.

Assemble a constitutional isomer of glycine with only one hydrogen bonded to carbon.

12. (2 points) Draw your isomer. Draw all structures using neutral atoms. Use all 10 atoms.

13. (1 point) Circle the number that represents your best estimate of how many constitutional isomers with the molecular formula $C_2H_5NO_2$ could one make.

5 10 20 40 400

Take out one atom and assemble a structure with the remaining 9 atoms.

14. (1 point) Draw your structure. Draw all structures using neutral atoms. Use 9 of the 10 atoms.

15. (1 point) Make a carbon-carbon triple bond between the carbons with three “bendy” bonds. Complete the molecule using as many of the 1 Nitrogen, 2 Oxygens, and 5 Hydrogens as you can. Draw your structure.