

Molecular Structures

Middle School



Objectives

[MSPS1-1](#)

- Review atoms and elements.
- Learn how to decipher molecular formulas.
- Discover the different ways to diagram and visualize molecules.

Vocabulary

- Atoms
- Elements
- Molecules
- Bond
- Compound
- Molecular formula
- Structural Formula
- Ball and Stick model
- Space Fill Model
- Perspective Drawing



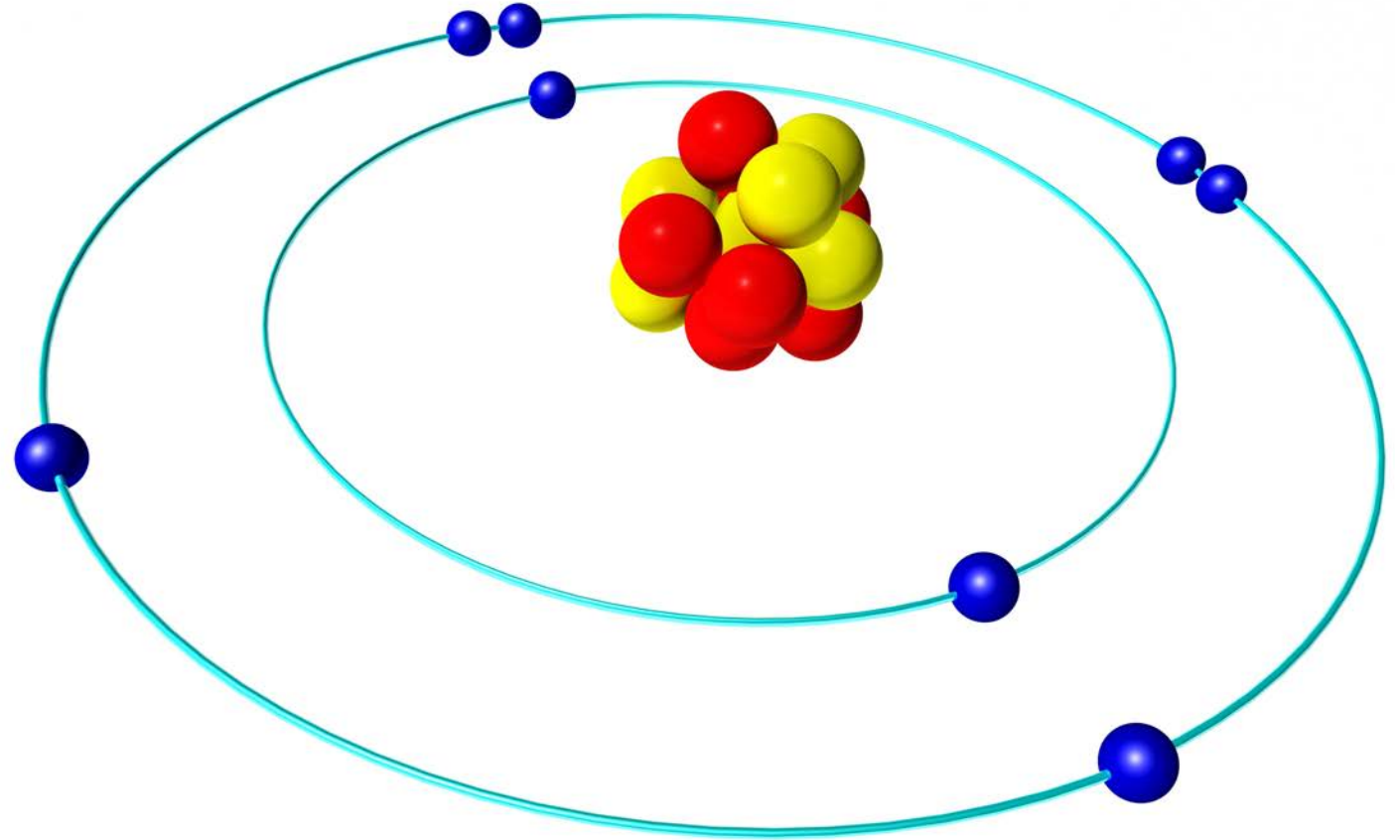
**Before we dive into molecular structures, we need to know what they are made of.
First, let's review atoms and elements.**



What is an atom?

Discuss with a partner for 30 seconds.

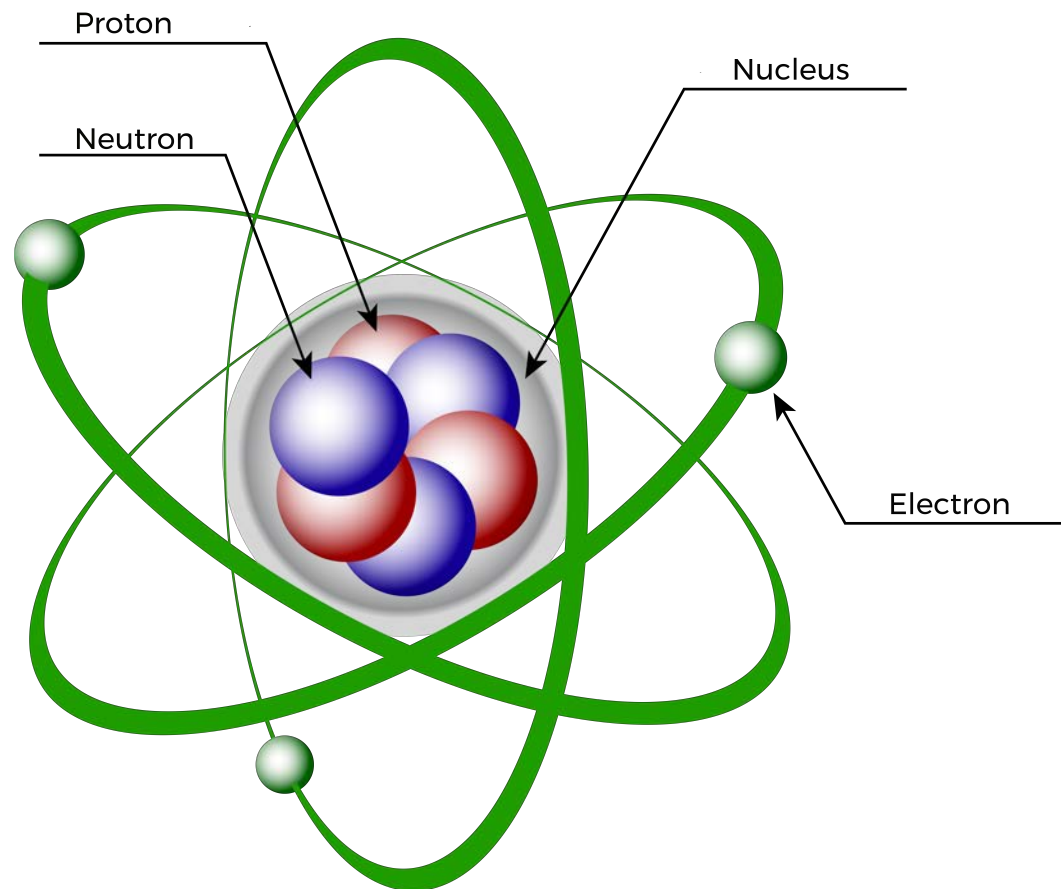
Make a list of all the words that come to mind when you think of an atom.



Atoms

Atoms are found in everything around us and are the building blocks of matter. They are like the tiny bricks that make up this world. The word “atom” comes from the Greek word “atomos” which means undividable.

Atoms are made up of particles called protons, neutrons and electrons. The protons and neutrons make up the nucleus. Protons have a positive charge and neutrons are neutral. Electrons have a negative charge and buzz around the nucleus.



Atoms & Elements

There are different types of atoms, called elements. Elements come in different sizes, shapes and colors.

Examples of elements include oxygen, gold, carbon, mercury neon and mercury.



Elements

There are 118 known elements and they can be found listed in the Periodic Table of Elements.

The Periodic Table tells us the name of an element, atomic symbol, the atomic number and its properties.

Periodic Table of the Elements

| | | | | | | | | | | | | | | | | | | |
|--|---|--|--|--|---|---|---|---|---|--|--|--|---|---|--|---|--|-------------|
| 1 IA H Hydrogen 1.008 | 2 IIA He Helium 4.002602 | | | | | | | | | | | | | | | | | 18 VIIIA |
| 3 Li Lithium 6.94 | 4 Be Beryllium 9.0122 | | | | | | | | | | | | | | | | | 10 |
| 11 Na Sodium 22.98976928 | 12 Mg Magnesium 24.305 | | | | | | | | | | | | | | | | | 18 |
| 19 K Potassium 39.0983 | 20 Ca Calcium 40.078 | 21 Sc Scandium 44.955912 | 22 Ti Titanium 47.88 | 23 V Vanadium 50.9415 | 24 Cr Chromium 51.9961 | 25 Mn Manganese 54.938044 | 26 Fe Iron 55.845 | 27 Co Cobalt 58.933194 | 28 Ni Nickel 58.6934 | 29 Cu Copper 63.546 | 30 Zn Zinc 65.38 | 31 Ga Gallium 69.723 | 32 Ge Germanium 72.630 | 33 As Arsenic 74.921595 | 34 Se Selenium 78.9718 | 35 Br Bromine 79.904 | 36 Kr Krypton 83.798 | 36 |
| 37 Rb Rubidium 85.468 | 38 Sr Strontium 87.62 | 39 Y Yttrium 88.90584 | 40 Zr Zirconium 91.224 | 41 Nb Niobium 92.90638 | 42 Mo Molybdenum 95.94 | 43 Tc Technetium 98 | 44 Ru Ruthenium 101.07 | 45 Rh Rhodium 102.90550 | 46 Pd Palladium 106.42 | 47 Ag Silver 107.8682 | 48 Cd Cadmium 112.411 | 49 In Indium 114.818 | 50 Sn Tin 118.710 | 51 Sb Antimony 121.757 | 52 Te Tellurium 127.6 | 53 I Iodine 126.90547 | 54 Xe Xenon 131.29 | 54 |
| 55 Cs Caesium 132.90545196 | 56 Ba Barium 137.327 | 57 - 71 Lanthanoids | 72 Hf Hafnium 178.49 | 73 Ta Tantalum 180.94788 | 74 W Tungsten 183.84 | 75 Re Rhenium 186.207 | 76 Os Osmium 190.23 | 77 Ir Iridium 192.222 | 78 Pt Platinum 195.084 | 79 Au Gold 196.966569 | 80 Hg Mercury 200.592 | 81 Tl Thallium 204.38 | 82 Pb Lead 207.2 | 83 Bi Bismuth 208.98040 | 84 Po Polonium [209] | 85 At Astatine [210] | 86 Rn Radon [222] | 86 |
| 87 Fr Francium [223] | 88 Ra Radium [226] | 89 - 103 Actinoids | 104 Rf Rutherfordium [261] | 105 Db Dubnium [262] | 106 Sg Seaborgium [266] | 107 Bh Bohrium [264] | 108 Hs Hassium [277] | 109 Mt Meitnerium [268] | 110 Ds Darmstadtium [281] | 111 Rg Roentgenium [282] | 112 Cn Copernicium [285] | 113 Nh Nihonium [286] | 114 Fl Flerovium [289] | 115 Mc Moscovium [290] | 116 Lv Livermorium [293] | 117 Ts Tennessine [294] | 118 Og Oganesson [294] | 118 |
| 57 La Lanthanum 138.90547 | 58 Ce Cerium 140.12 | 59 Pr Praseodymium 140.90766 | 60 Nd Neodymium 144.242 | 61 Pm Promethium [145] | 62 Sm Samarium 150.36 | 63 Eu Europium 151.964 | 64 Gd Gadolinium 157.25 | 65 Tb Terbium 158.92535 | 66 Dy Dysprosium 162.500 | 67 Ho Holmium 164.93033 | 68 Er Erbium 167.259 | 69 Tm Thulium 168.93422 | 70 Yb Ytterbium 173.045 | 71 Lu Lutetium 174.967 | | | | |
| 89 Ac Actinium [227] | 90 Th Thorium 232.0377 | 91 Pa Protactinium 231.03688 | 92 U Uranium 238.02891 | 93 Np Neptunium [237] | 94 Pu Plutonium [244] | 95 Am Americium [243] | 96 Cm Curium [247] | 97 Bk Berkelium [247] | 98 Cf Californium [251] | 99 Es Einsteinium [252] | 100 Fm Fermium [257] | 101 Md Mendelevium [258] | 102 No Nobelium [259] | 103 Lr Lawrencium [260] | | | | |



Elements

Let's take a look at carbon.

What is its atomic number?

What does it tell us about the carbon atom?

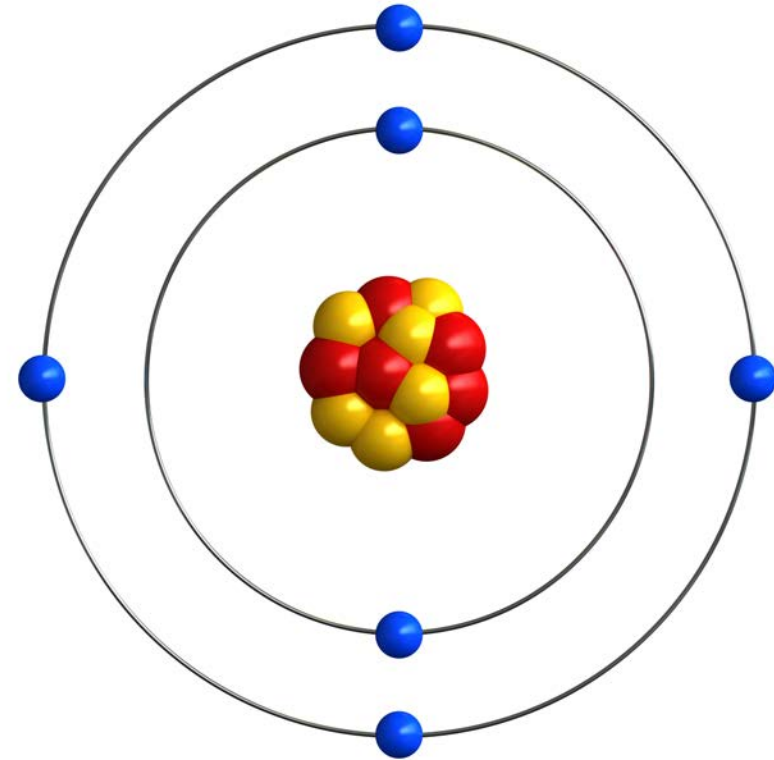
Periodic Table of the Elements

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Carbon

The atomic number tells us that carbon has 6 protons and 6 neutrons. If this carbon is neutral, it will also have 6 electrons.



● 6 Protons ● 6 Neutrons ● 6 Electrons



The American Chemical Society has over 50 million substances on record. How do you think 118 elements become over 50 million substances?

Discuss with a partner for 15 seconds



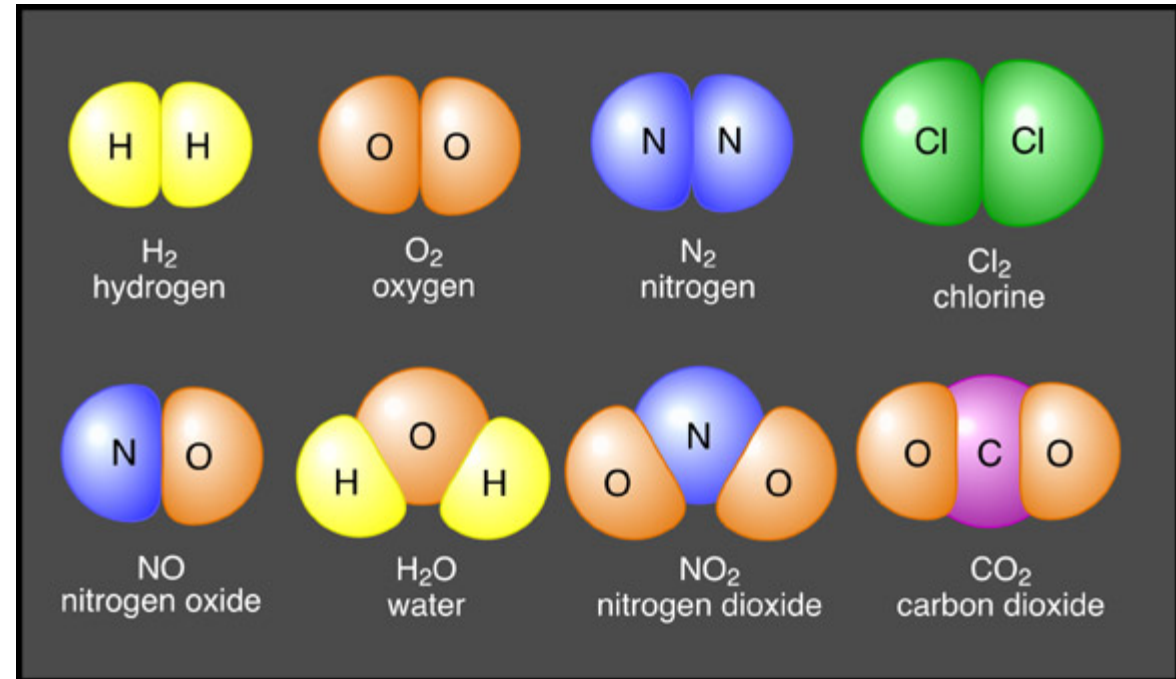
The atoms of elements combine to become molecules.

When 2 or more atoms combine, molecules are formed. Molecules help make up the 50 million plus substances/chemicals on Earth.



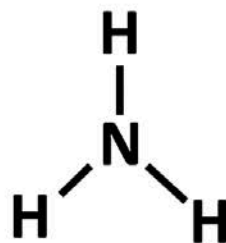
Molecules

Mostly everything around us is molecules. Molecules make up the air we breathe, the food we eat, the clothes we wear, the plastics our electronics come in, and the cells in our body.

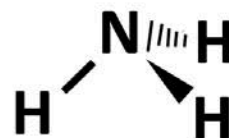


Molecules

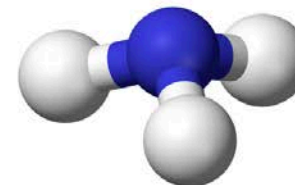
Even though molecules are everywhere, they are way too small to see. So, scientists have come up with different ways to represent and visualize them.



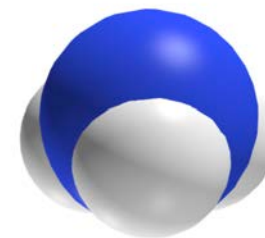
Structural
Formula



Perspective
Drawing



Ball and Stick
Model



Space Fill
Model



Molecular Formula

The molecular formula is the simplest way to represent a molecule. This chemical formula shows the total number and kinds of atoms in a molecule. However, it does not show how they are structurally arranged.

H₂O (Water)

NH₃ (Ammonia)

CH₄O (Methanol)

C₈H₁₀N₄O₂ (Caffeine)



Decoding the Molecular Formula

In order to decode what the molecular formula is telling us, we need a periodic table and a few steps to follow.

Step 1) Number of Elements: Underline the capital letters. This will tell you how many elements are in your molecule.

How many elements are in Methanol? Caffeine?

H₂O (Water) 2 elements

N H₃ (Ammonia) 2 elements

C H₄ O (Methanol) ?

C₈H₁₀N₄O₂ (Caffeine) ?



Decoding the Molecular Formula

Step 3) How many atoms of each element?

If there is a small number beside the symbol, this indicates how many atoms of this element there are in the molecule. If there is NO small number beside the Atomic Symbol, it has 1 atom.

How many atoms of each element are there in Caffeine?

H₂O (Water) 2 Hydrogen & 1 Oxygen

N H₃ (Ammonia) 1 Nitrogen and 3 Hydrogen

C H₄ O (Methanol)

1 Carbon, 4 Hydrogen and 1 Oxygen

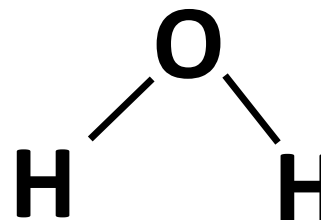
C₈H₁₀N₄O₂ (Caffeine) ?



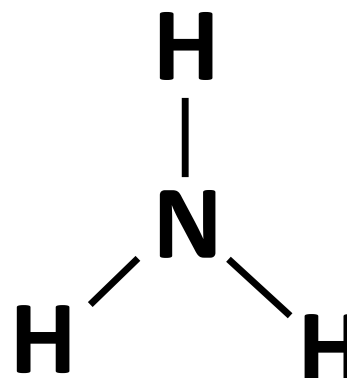
Structural Formula

Since molecular formulas are limited to telling us what is in molecules, we use structural formulas to show us where the molecules are bonded.

Let's take a look at water and ammonia molecules.



H₂O (Water)



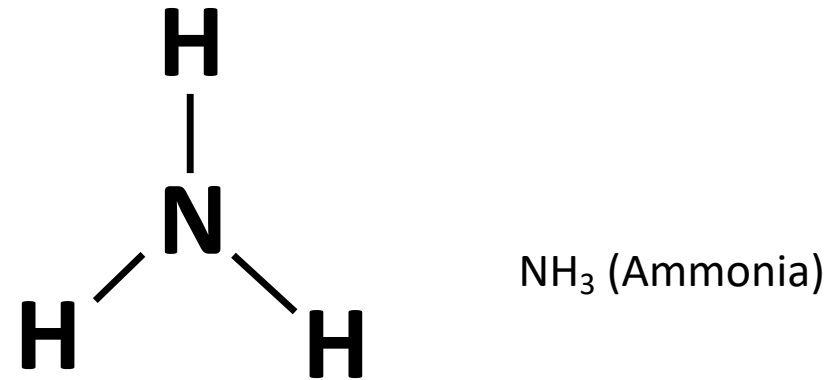
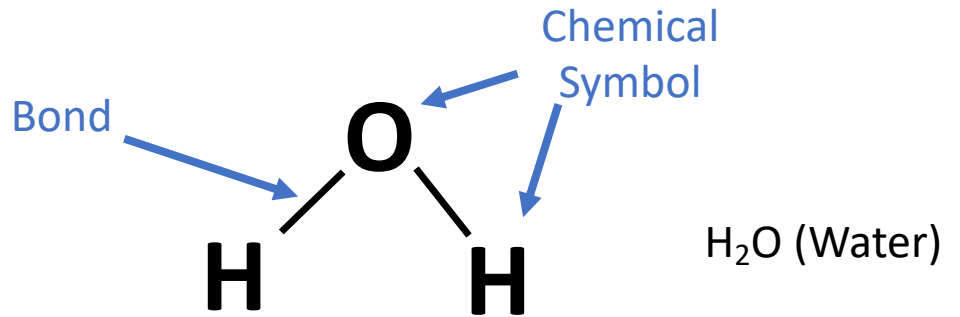
NH₃ (Ammonia)



Structural Formula

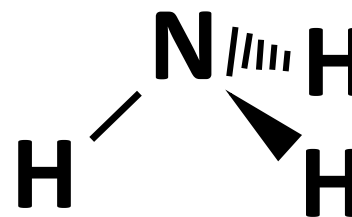
The structural formula shows what elements are in the molecule and how the atoms are bonded.

What elements are in ammonia? How many atoms does it have of each element?

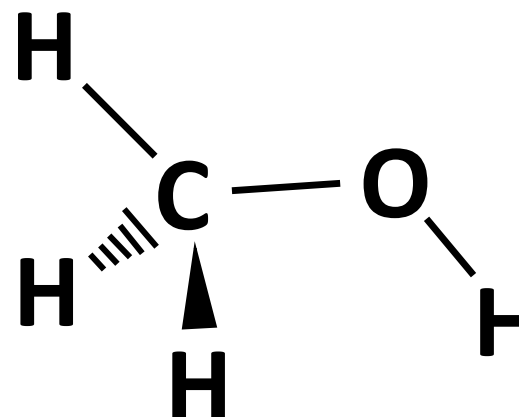


Perspective Drawing

A perspective drawing of a molecule shows the bonds to atoms coming toward you (bolded wedge) or away (hash wedge).



Ammonia



Methanol

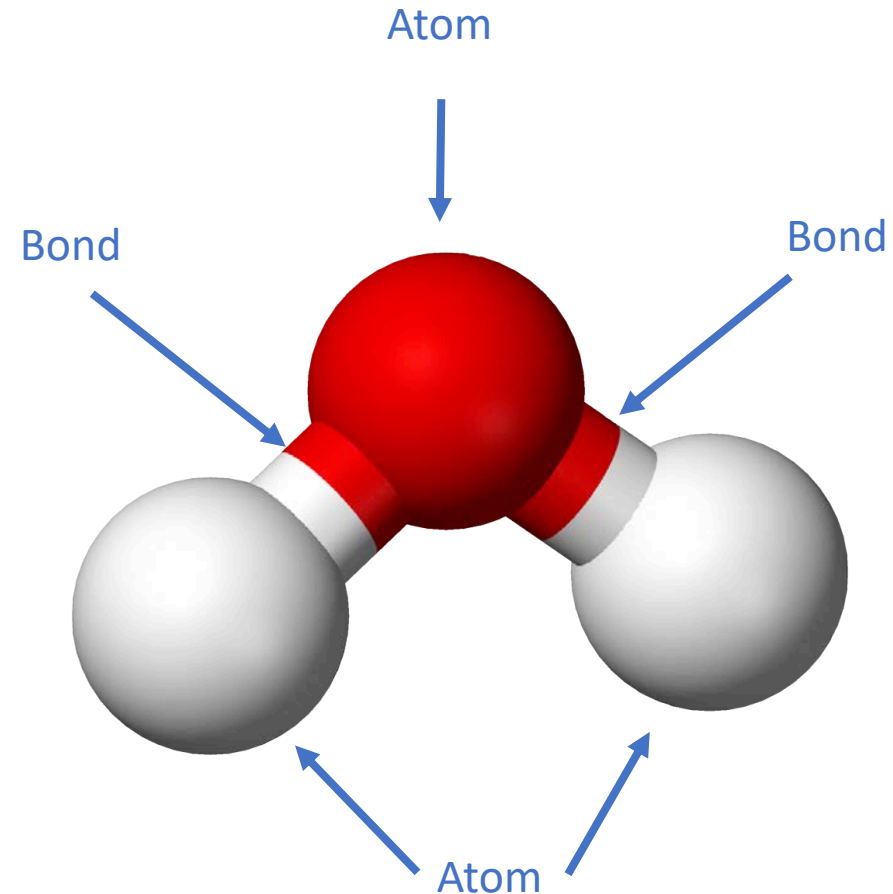


Ball and Stick Model

The ball and stick model shows the 3D positions of the atoms and bonds between them. The atoms are represented by spheres and the bonds are sticks.

Typically, the color of the spheres represent specific elements. In this case the red sphere is oxygen and the white spheres are Hydrogen.

What molecule is this?

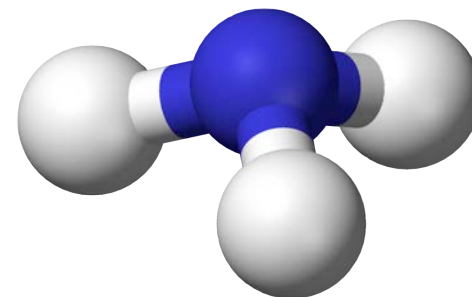


Ball and Stick Model

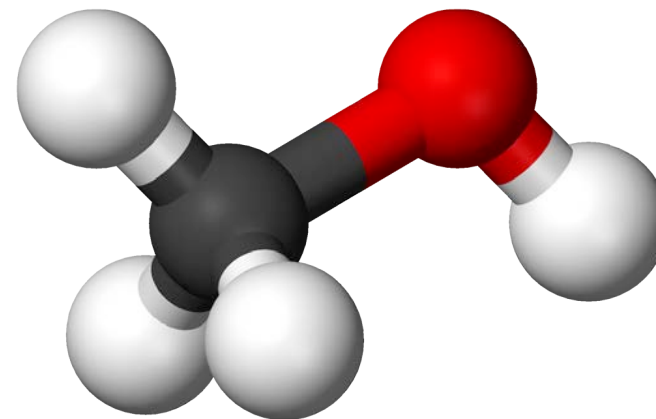
Take a look at these other examples of ball and stick models.

Can you identify the atoms and bonds?

Ammonia



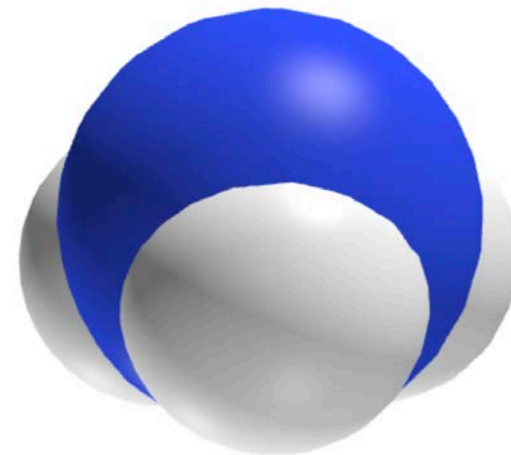
Methanol



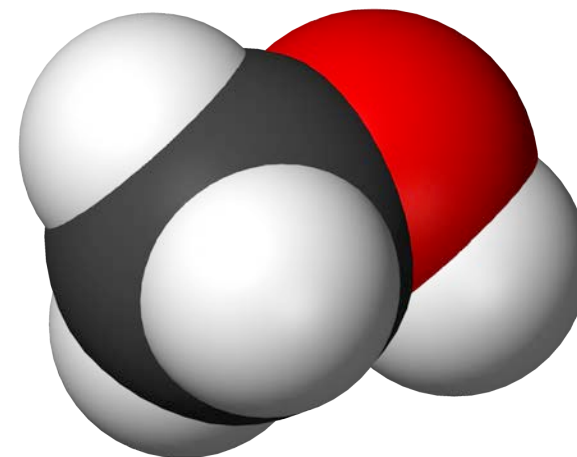
Space Fill

The Space Fill Model or calotte model is a 3D model where atoms and the space they take up are represented by spheres. The sphere size is typically proportionate to the size of the atom.

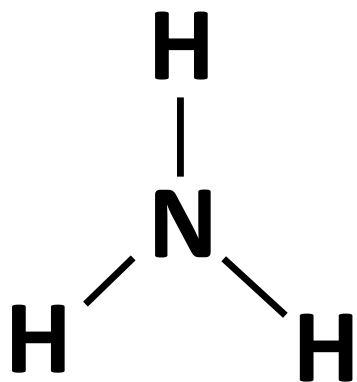
Ammonia



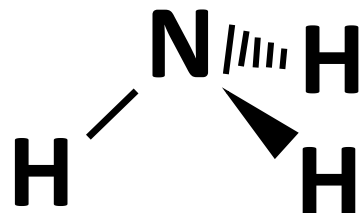
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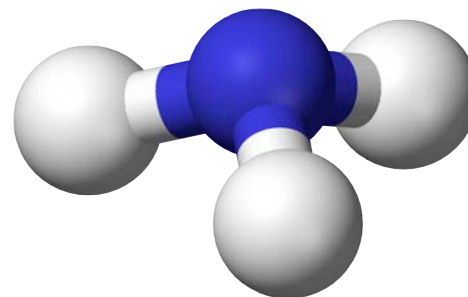
Molecule Visualizations NH₃ (Ammonia)



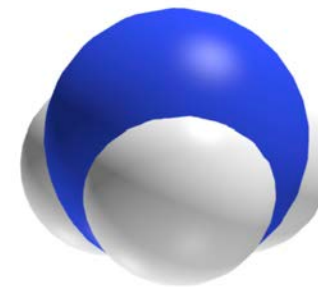
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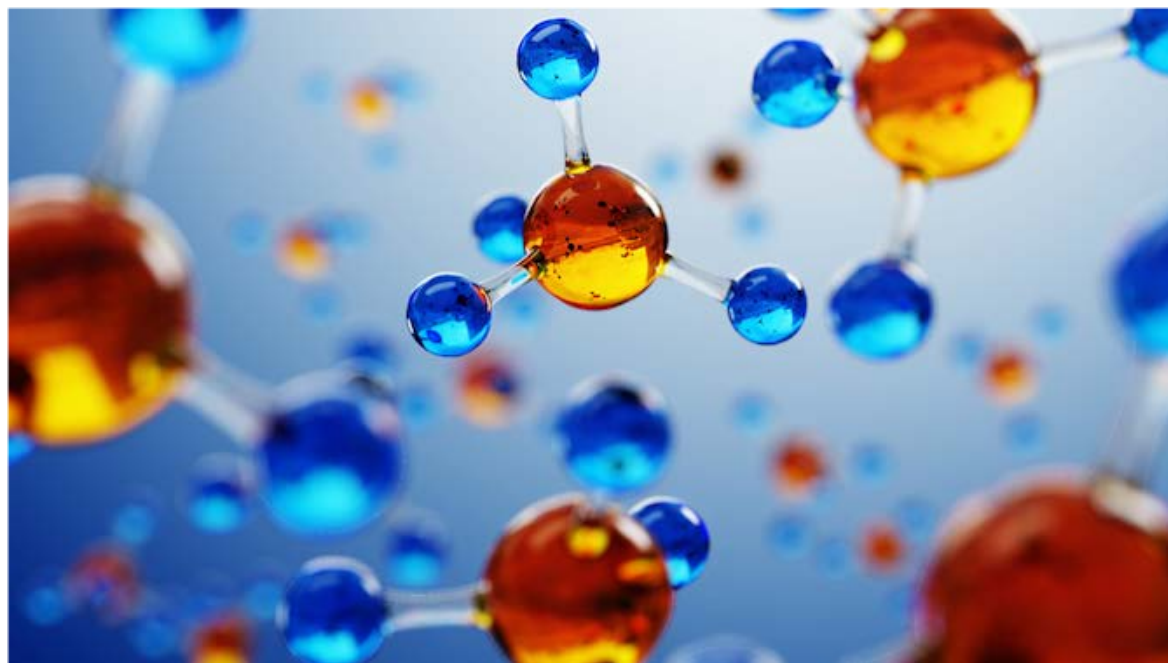


Space Fill
Model



Optional Activity: Decoding Molecular Formulas

Learn what molecules are made up of by learning to decoding molecular formulas. See the Molecular Structures Lesson Plan for the Worksheet



Optional Activity: Building Simple Molecules

Use toothpicks and marshmallows or a molecular ball and stick kit to build a variety of simple molecules. See the Molecular Structures Lesson plan for sample molecules to build. Then proceed to the Brainstorming lesson to explore your “Name that Molecule”.

