SCIENCE LESSON
MOLECULAR STRUCTURES

Everything around us is made up of molecules. A molecule is a group of two or more atoms of the same or different element bonded together. We can’t see molecules without a powerful microscope, so scientists use a variety of models to showcase their properties.

FOR THE CLASSROOM

LESSON LENGTH
50-60 MINUTES

OBJECTIVE
LEARN ABOUT MOLECULES & MOLECULAR STRUCTURES

MATERIALS
SEE BELOW

VOCABULARY:
- Element
- Atom
- Molecule
- Bond
- Compound
- Molecular Formula
- Structural Formula
- Perspective Drawing
- Space Filled Model

PROCEDURE

1. Download and teach the MOLECULAR STRUCTURES POWERPOINT. We have provided a Future Engineers PPT. Feel free to customize it to suit your teaching needs.

2. Student Activity 1 Have your students complete the “Decoding Molecular Formulas” worksheet and follow the steps below.
   a. Take a look at the molecular formulas listed in your worksheet and use a periodic table and the steps below to decode what they are made of.
   b. Step 1: Underline the Capital Letters. This will tell you how many elements are in your molecule.
   c. Step 2: Symbols—Write the symbols the molecule has in the symbol column.
   d. Step 3: Element Name—Use the periodic table to identify what elements the symbol represents and write the down in the element column.
   e. Step 4: How many atoms? - Write the number of atoms of each element in the How many atoms column. 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.

3. Student Activity 2: Have your students complete the “Building Simple Molecules” worksheet and follow the steps below.
   Students can work individually or in groups to build simple molecules out of molecular model sets or marshmallows and toothpicks.
   Take a look at the molecular formulas listed in your worksheet and use a periodic table and the steps on the following page to decode what they are made of.

MATERIALS
Powerpoint, Worksheet, Computer, Internet, Toothpicks + Colored Mini Marshmallows or Ball & Stick Model Kit

NAME THAT MOLECULE CHALLENGE
ENTRIES OPEN MARCH 26, 2019- JULY 3, 2019

• Element
• Atom
• Molecule
• Bond
• Compound
• Molecular Formula
• Structural Formula
• Perspective Drawing
• Space Filled Model
• Compound
• Molecular Formula
• Structural Formula
• Ball and Stick Model
NAME THAT MOLECULE CHALLENGE
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ATOMS AND ELEMENTS

Atoms are found in everything around us and are the building blocks of matter. The word “atom” comes from the Greek word “atom-os” which means uncuttable or undividable. Atoms are made up of particles called protons, neutrons and electrons. The protons and neutrons make up the nucleus and the electrons buzz around the nucleus. Atoms differ from one another by the number of protons (atomic number) in the nucleus. This number tells us what element the atoms is. For example, atoms with the atomic number 1 are Hydrogen atoms.

All substances are made up of elements. There are currently 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. Hydrogen (atomic number 1) has one proton and Oganesson (atomic number 118) has 118 protons respectively.

MOLECULES

Even though there are 118 elements, there are over 50 million chemical substances registered with the American Chemical Society. These chemicals are molecules formed from a combination of the 118 elements. Molecules can be made from two or more atoms of the same element or different elements. For example, the oxygen (O2) molecule is made up of 2 oxygen atoms while water (H2O) molecule is made up an Oxygen and two Hydrogen atoms. When a molecule is made up of 2 or more different types of atoms, it is called a compound.

How do atoms combine to form molecules? Atoms combine by gaining, losing or sharing electrons. When atoms combine, they form bonds.

Generally speaking, we refer to molecules by their common names (ex. carbon dioxide) or their molecular formula (ex.CO2). One of the most practical ways to refer to molecules is by using their molecular formulas. Molecular formulas list the atomic symbol and numbers to show how many atoms are in a molecule. For instance, CO2 has one Carbon atom and two Oxygen atoms.

LESSON PLAN CONTINUED

MOLECULAR STRUCTURES

PROCEDURE (Continued)

3. Student Activity 2
   a. If using marshmallows, Oxygen is orange, Carbon is green, and Hydrogen is pink.
   b. Pass out a piece of paper to each student/group. Students/group should write the following key at the top of the paper
      “Orange=Oxygen Green=Carbon and Pink=Hydrogen”
   c. Students should fold the paper into 4 sections and label the sections with the following molecules: O2 (Oxygen), H2O (Water),
      CO2 (Carbon Dioxide), and CH4 (Methane)
   d. Pass out 20 colored marshmallows and 15 toothpicks to each group.
   e. Have the students use their worksheets as a guide to build each of the 4 molecules in the section designated section.
   f. If time allots, challenge them to reuse their supplies to build other molecular structures of your choice.

BACKGROUND INFORMATION

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BACKGROUND INFORMATION CONTINUED

WAYS TO VISUALIZE MOLECULES

Molecular structures consist of two or more atoms and can get pretty complex. There are many different ways we visualize them but let’s take a look at the most common ways.

Structural Formula

The structural formula of a molecule shows how the atoms are arranged. The chemical bonding can also be shown.

Perspective Drawing

A drawing that shows the bonds to atoms going into (bolded wedge) the viewer and away (hash wedge).

Ball and Stick Model

A ball a stick model of a chemical substance shows the 3D positions of the atoms and the bonds between them. The atoms are represented by spheres connected by sticks or rods representing the bond/s.

Space Fill Model

The space fill 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.

ADDITIONAL MOLECULAR STRUCTURE TEACHING RESOURCES:

- What is an atom and how do we know?: [https://www.youtube.com/watch?v=LhveTGbI3HY](https://www.youtube.com/watch?v=LhveTGbI3HY)
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LESSON PLAN CONTINUED
MOLECULAR STRUCTURES

NEXT GENERATION SCIENCE STANDARDS

**MS-PS1-1**: Matter and its Interactions Develop models to describe the atomic composition of simple molecules and extended structures. Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.

- **PS1.A**: Structure and Properties of Matter Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., Crystals).
- **Crosscutting Concepts**: Scale, Proportion, and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too small.

email: support@futureengineers.org/ web: www.futureengineers.org
Molecular formulas tell us what elements and atoms are in a molecule. Learn how to decode them with help from the Periodic Table of Elements.

HOW TO DECODE A MOLECULAR FORMULA

Use these steps to figure out what each molecule below are made of.
Take a look at the CO₂ sample below, then move on to the next page.
Step 1: Underline the Capital Letters. This will tell you how many elements are in your molecule.
Step 2: Symbols—Write the symbols the molecule has in the symbol column.
Step 3: Element Name—Use the periodic table to identify what elements the symbol represents and write the down in the element column.
Step 4: How many atoms?—Write the number of atoms of each element in the How many atoms column. 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

**Molecular Formula: CO₂ (Carbon Dioxide)**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Element Name</th>
<th>How many atoms?</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Carbon</td>
<td>1</td>
</tr>
<tr>
<td>O</td>
<td>Oxygen</td>
<td>2</td>
</tr>
</tbody>
</table>
Use the Periodic Table of Elements to decode the following molecules.

**Molecular Formula: NH₃ (Ammonia)**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Element Name</th>
<th>How many atoms?</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Molecular Formula: CH₄ (Methane)**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Element Name</th>
<th>How many atoms?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Molecular Formula: H₂SO₄ (Sulfuric Acid)**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Element Name</th>
<th>How many atoms?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

NAME THAT MOLECULE CHALLENGE
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SCIENCE LESSON WORKSHEET

BUILDING SIMPLE MOLECULES

There are more than 50 million different types of molecules. Molecules consist of two or more atoms bonded together. Scientists use a variety of different ways to visualize them including structural formulas, perspective drawings, ball and stick and space fill models.

BUILDING SIMPLE MOLECULES

Use colored mini marshmallows and toothpicks or ball and stick model kits to build the molecules listed below. The lines represent which atoms are bonded.

1) O₂ (Oxygen)

2) H₂O (Water)

3) CO₂ (Carbon Dioxide)

4) CH₄ (Methane)
<table>
<thead>
<tr>
<th>Name</th>
<th>Symbol</th>
<th>Atomic Number</th>
<th>Atomic Mass</th>
<th>Periodicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>H</td>
<td>1</td>
<td>1.008</td>
<td>1, S, Group 1</td>
</tr>
<tr>
<td>Americium</td>
<td>Am</td>
<td>95</td>
<td>243</td>
<td>7, Actinide Series</td>
</tr>
<tr>
<td>Lanthanum</td>
<td>La</td>
<td>57</td>
<td>138.91</td>
<td>5, Lanthanide Series</td>
</tr>
<tr>
<td>Plutonium</td>
<td>Pu</td>
<td>94</td>
<td>244</td>
<td>7, Actinide Series</td>
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<tr>
<td>Uranium</td>
<td>U</td>
<td>92</td>
<td>238</td>
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<tr>
<td>Thorium</td>
<td>Th</td>
<td>90</td>
<td>232</td>
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</tr>
<tr>
<td>Polonium</td>
<td>Po</td>
<td>84</td>
<td>209</td>
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</tr>
<tr>
<td>Radon</td>
<td>Rn</td>
<td>86</td>
<td>222</td>
<td>8, Noble Gases</td>
</tr>
<tr>
<td>Krypton</td>
<td>Kr</td>
<td>36</td>
<td>83.80</td>
<td>8, Noble Gases</td>
</tr>
<tr>
<td>Xenon</td>
<td>Xe</td>
<td>54</td>
<td>131.30</td>
<td>8, Noble Gases</td>
</tr>
<tr>
<td>Cesium</td>
<td>Cs</td>
<td>55</td>
<td>132.90</td>
<td>7, Alkaline Earth Metals</td>
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<tr>
<td>Rubidium</td>
<td>Rb</td>
<td>37</td>
<td>85.47</td>
<td>7, Alkaline Earth Metals</td>
</tr>
<tr>
<td>Francium</td>
<td>Fr</td>
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<td>223</td>
<td>7, Actinide Series</td>
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<tr>
<td>Actinium</td>
<td>Ac</td>
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<td>227</td>
<td>7, Actinide Series</td>
</tr>
<tr>
<td>Lutetium</td>
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<td>71</td>
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<tr>
<td>Lawrencium</td>
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<tr>
<td>Rutherfordium</td>
<td>Rf</td>
<td>104</td>
<td>267</td>
<td>7, Actinide Series</td>
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<tr>
<td>Dubnium</td>
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<td>268</td>
<td>7, Actinide Series</td>
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<tr>
<td>Seaborgium</td>
<td>Sg</td>
<td>106</td>
<td>269</td>
<td>7, Actinide Series</td>
</tr>
<tr>
<td>Bohrium</td>
<td>Bh</td>
<td>107</td>
<td>270</td>
<td>7, Actinide Series</td>
</tr>
<tr>
<td>Hassium</td>
<td>Hs</td>
<td>108</td>
<td>271</td>
<td>7, Actinide Series</td>
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<tr>
<td>Meitnerium</td>
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<tr>
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<td>110</td>
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<tr>
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<td>Rg</td>
<td>111</td>
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<tr>
<td>Copernicium</td>
<td>Cn</td>
<td>112</td>
<td>275</td>
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</table>

Entries open March 26, 2019 - July 3, 2019