

# Types of Bonds

## Teacher's Guide

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### 1.0 Summary

The “Types of Bonds” activity is the fifth activity in the Chemical sequence. This activity should take students approximately 20 minutes to complete.

### 2.0 Learning Goals

**Driving Question:** What are the different types of bonds in an atom?

This activity provides an overview of covalent, polar covalent and ionic bonds. Students will learn about how electronegativity affects electron distribution in chemical bonds. They will also explore electronegativity on the periodic table.

#### Learning Goals

- Students will review how to recognize different graphical representations of chemical bonds.
- Students will understand that electrons in bonds are not evenly distributed.
- Students will understand how electronegativity affects chemical bonds.
- Students will be able to classify bonds as covalent, polar covalent, or ionic.
- Students will be able to predict the effects of polarity on macroscopic properties.

#### Additional Teacher Background

Bonds that form between atoms are usually more stable than un-bonded atoms. Thus these bonds form to reduce the potential energy of atoms. These bonds form when negatively charged electron clouds can be shared between two different positively charged nuclei. Each atomic nucleus has its own attraction for additional electrons. This attraction is dependent upon the number of protons in the nucleus, the number of its electrons, and the distance of these electrons from the nucleus. This attraction is called electronegativity. This is a unit-less number that simply compares the pull of different nuclei for electrons: the higher the number, the stronger the pull.

Comparing electronegativity between different atoms allows us to classify bonds. When the difference is greater than 1.8 we say that the bonds are ionic. When the difference is between 0.7 and 1.8 we say that the bonds are polar covalent or polar. When the difference is less than 0.7 we say that the bonds are covalent. It is worth noting that these divisions are somewhat arbitrary and help us to classify the bonds. The difference in electronegativity represents a continuum and the classification values are not unchangeable.

### 3.0 Standards Alignment

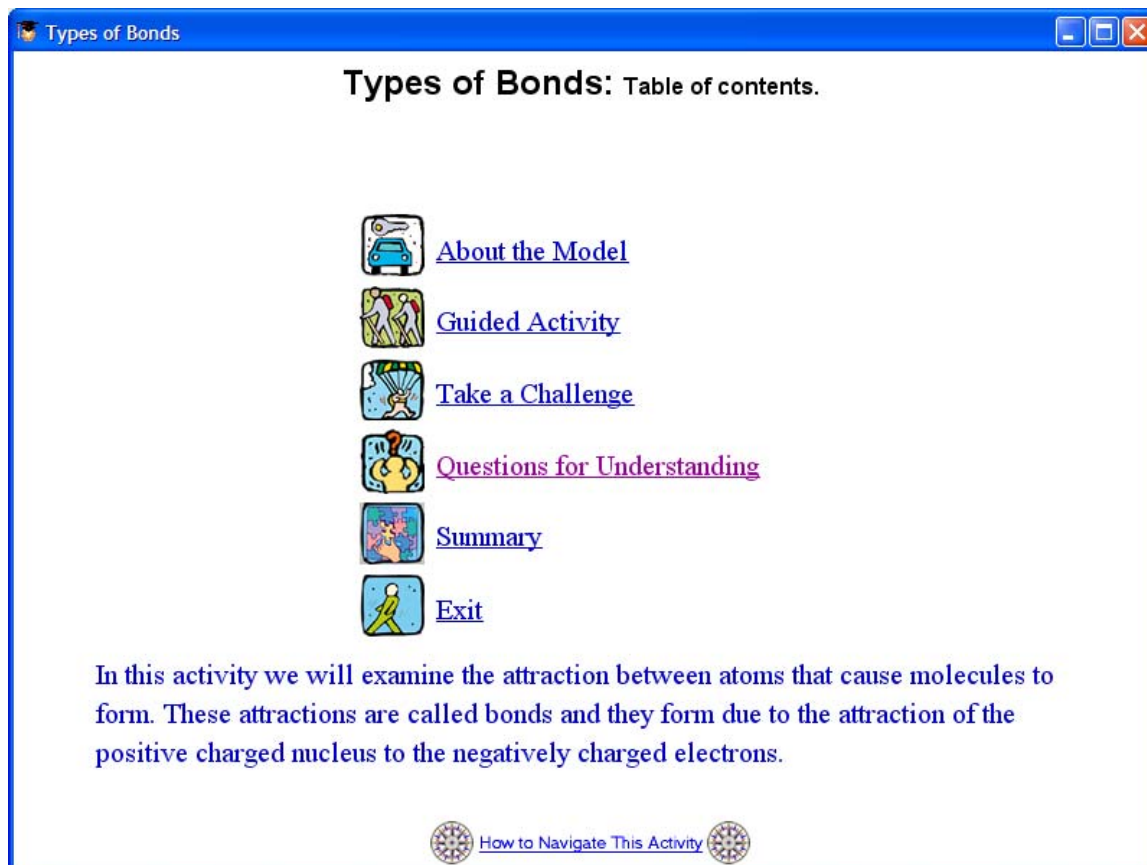
#### Alignment to National Math and Science Standards (NCTM or NSES)

Objective	Standards
<b>Students will understand how to classify different types of bonds.</b>	<ul style="list-style-type: none"><li data-bbox="678 369 922 394">• Varies by state.</li></ul>
<b>Students will understand what holds atoms together.</b>	<ul style="list-style-type: none"><li data-bbox="678 600 922 625">• Varies by state.</li></ul>
<b>Students will be able to link bond type to macroscopic properties.</b>	<ul style="list-style-type: none"><li data-bbox="678 779 922 804">• Varies by state.</li></ul>







## 4.0 Activity Sections

### 4.1 Table of Contents

This activity has 5 sections.



The screenshot shows a window titled "Types of Bonds" with a blue border. The title bar includes a small icon of a person and the text "Types of Bonds", along with standard window control buttons (minimize, maximize, close). The main content area has the title "Types of Bonds: Table of contents." centered at the top. Below the title is a vertical list of six items, each with a small icon to its left and a text label to its right:

-  [About the Model](#)
-  [Guided Activity](#)
-  [Take a Challenge](#)
-  [Questions for Understanding](#)
-  [Summary](#)
-  [Exit](#)

Below the list is a paragraph of text:

In this activity we will examine the attraction between atoms that cause molecules to form. These attractions are called bonds and they form due to the attraction of the positive charged nucleus to the negatively charged electrons.

At the bottom center of the window is a small globe icon followed by the text "How to Navigate This Activity" and another globe icon.


### 4.2 About the model

In this step students are first asked to review different views of bonded atoms. The students are then asked to compare these different views:

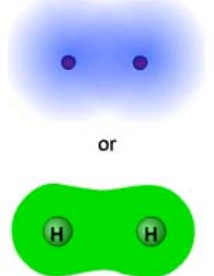
Types of Bonds

## Types of Bonds: About the model.


1. Each of these pictures show a representation of a molecule. How are the two pictures different from each other?



A Hydrogen Molecule



or



It is worth noting the different colors and the difference in shading between the two models. The shading represents the different electron densities around the nucleus.

This section then goes on to show another way of viewing bonding electrons:

Types of Bonds

## Types of Bonds: About the model.

**Electrostatic Potential**

negative      neutral      positive

more positive      more negative      both neutral      more negative      more positive

**uneven sharing of electrons**      **equal sharing of electrons**      **uneven sharing of electrons**

The color of the orbital in each model shows the electron distribution in a chemical bond or molecule. As you can see from the color chart above:

- green represents a neutral charge
- blue represents a negative charge
- yellow represents a positive charge

Notice that sometimes electrons are equally shared and sometimes they are unequally shared.

This model is designed to show students that electrons do not evenly surround bonded atoms. This uneven electron distribution causes an uneven charge. The distribution is affected by the nuclear attraction for electrons. The attraction is measured by electronegativity.

## 4.3 Guided activity

This section introduces the student to the model that allows the formation of different types of bonds by changing electronegativity:

**Types of Bonds: Relating the size of electron clouds to electronegativity.**

**Nature of the Chemical Bond**

Non-polar Covalent      Polar Covalent      Ionic

Low      Medium      High

Difference in Electronegativity ( 0.00 )

Click on an Atom to Choose Electronegativity by Element

Electronegativity of Atom 1      Electronegativity of Atom 2

low      2.37      high      low      2.37      high

**Electrostatic Potential**

negative      neutral      positive

**2. Try setting one atom to have a slightly higher electronegativity than the other atom. Which electron cloud gets bigger:**

the one with higher electronegativity

the one with lower electronegativity

**3. Why does that make sense?**

[Text Input Box]

In the model students vary electronegativity of two different bonding atoms and observe the effects. It is worth noting that the side with higher EN is more negative and has a larger cloud.

In the next section students must play with the sliders to make:

- A covalent bond (equal EN)
- A polar bond (EN between 0.8 and 1.7)
- An ionic bond (EN greater than 1.7)

**Types of Bonds: Making the three types of bonds.**

Click on an Atom to Choose Electronegativity by Element

Electronegativity of Atom 1: low 4.00 high

Electronegativity of Atom 2: low 0.70 high

**Electrostatic Potential**

negative neutral positive

**Chemical bonds occur when electrons are shared:**

- Non-polar covalent bonds share electrons equally
- Polar covalent bonds have an unequal sharing of electrons
- Ionic bonds have an extremely unequal sharing of electrons

**Play with the slider controls and attempt to make a non-polar covalent bond, a polar covalent bond and an ionic bond. Think about the difference between each type of bond.**

**6. Describe the difference in the electron clouds between each of the three bond types.**

This screen will not allow the students to move on until they have made the three different types of bonds. To create the bonds, they must move the sliders to adjust the electronegativity of Atom 1 and Atom 2.

After the students have made all three different types of bonds, question 6 will appear. Students should then describe the differences in size, electron distribution (or uneven distribution) and charge on each side of the atom.

On the following screen, students are encouraged to numerically distinguish between the different types of bonds: covalent, polar and ionic.

**Types of Bonds: Determining numerical boundaries between bond types.**

Click on an Atom to Choose Electronegativity by Element

Electronegativity of Atom 1: low  high

Electronegativity of Atom 2: low  high

Electrostatic Potential: negative neutral positive

7. In order to classify a bond as a particular type, scientists look at the **DIFFERENCE** in electronegativity between the atoms. What value separates non-polar from polar covalent?

8. What value separates polar covalent from ionic?

[Hint](#)

Check hints for help!

It is important for students to experiment with the model so that they can determine these numbers on their own. The difference between non-polar (covalent) and polar is about 0.8. The difference between polar and ionic is about 1.7. The program will take a range of numbers.

The following screen focuses on covalent bonds. The student can make covalent bonds by setting similar EN's for each atom. This means that both EN's can be high, medium or low. Note that polar bonds are those bonds that have a charge.

On the next screen students examine polar covalent bonds. These bonds have uneven electron distribution as well as a larger negative electron cloud and a smaller, less negative electron cloud.



**Types of Bonds: Explaining the difference between polar and non-polar covalent bonds.**

There are two kinds of covalent bonds: non-polar covalent, and polar covalent. One type shares electrons approximately equally and one doesn't.

11. Which type of covalent bond has electrons shared quite unevenly?

non-polar covalent

polar covalent

12. Explain why that makes sense based on both the shape of the cloud and the charge distribution between the two atoms.

On the last screen of this section:

**Types of Bonds: Understanding molecular attractions.**

When two or more atoms are bonded together via covalent bonds, we call that bonded group of atoms a molecule. Set the molecule above to have a polar covalent bond.

13. Polar molecules tend to

Repel each other  Stick together  Get cold

14. Explain why:

Students construct a polar bond and are asked to consider the implications of these bonds. Since polar molecules have both a positive and a negative side these molecules tend to stick together.

#### 4.4 Take a challenge

In this section, students model ionic and covalent bonds. Ionic bonds come from opposite sides of the periodic table while covalent bonds occur between molecules that are both on the right side of the table.

In this challenge, students click on the nuclei of the atoms.

**Types of Bonds: Making an ionic bond.**

**Nature of the Chemical Bond**

Non-polar Covalent      Polar Covalent      Ionic

Low      Medium      High

**Difference in Electronegativity ( 0.00 )**

Click on an Atom to Choose Electronegativity by Element

Electronegativity of Atom 1      Electronegativity of Atom 2

low      3.16      high      low      3.16      high

**Electrostatic Potential**

negative      neutral      positive

**Check**

Every element has its own electronegativity (EN). Click on the nucleus of each of the atoms above. A periodic table will open. Choose two atoms from the periodic table. Notice the type of bond that those two atoms have. Use the periodic table to select two atoms that have an ionic bond. Click the "Check" button to see if you have created an ionic bond. If you need help, use the hints.

**Hint**

Check Hints for help!

The following Periodic Table window will open.

Types of Bonds

## Types of Bonds: Making an ionic bond.

**Nature of the Chemical Bond**

Non-polar Covalent      Polar Covalent      Ionic

Choose an Element

Table of Pauling Electronegativity

H																	High	Ne
Li	Be											B	C	N	O	F	Noble Gases	
0.98	1.57											2.04	2.55	3.04	3.44	3.98		
Na	Mg											Al	Si	P	S	Cl		
0.93	1.31											1.61	1.9	2.19	2.58	3.16		
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br		
0.82	1.0	1.36	1.54	1.63	1.66	1.55	1.83	1.88	1.91	1.9	1.65	1.81	2.01	2.18	2.55	2.96		
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I		
0.82	0.95	1.22	1.33	1.6	2.16	1.9	2.2	2.28	2.2	1.93	1.69	1.78	1.96	2.05	2.1	2.66		
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At		
0.79	0.89	1.1	1.3	1.5	2.36	1.9	2.2	2.2	2.28	2.54	2.0	2.04	2.33	2.02	2.0	2.2		
Fr	Ra	Ac																
0.7	0.89	1.1																

negative      neutral      positive

Check

Every element has its own electronegativity (EN). Click on the nucleus of each of the atoms above. A periodic table will open. Choose two atoms from the periodic table. Notice the type of bond that those two atoms have. Use the periodic table to select two atoms that have an ionic bond. Click the "Check" button to see if you have created an ionic bond. If you need help, use the hints.

Hint

Students click on an element to set that atom in the model. The periodic table is intended to give students a feel for how different regions of the table have different EN's. Please note that EN is highest in the upper right and lowest in the lower left. This is because non-metals want to gain electrons and metals want to lose electrons.

When a student believes that s/he has an ionic bond, s/he should click the "Check" button. This will test the hypothesis. If the bond is correct, the student can continue to the next screen.

**Types of Bonds: Making an ionic bond.**

**Nature of the Chemical Bond**

Non-polar Covalent      Polar Covalent      Ionic

Low      Medium      High

Difference in Electronegativity ( 2.23 )

Click on an Atom to Choose Electronegativity by Element

Electronegativity of Atom 1: low 0.93 high

Electronegativity of Atom 2: low 3.16 high

**Electrostatic Potential**

negative      neutral      positive

15. Where would you look on the periodic table to make up an ionic bond?

- Opposite sides
- Left side and left side
- Middle and right sides
- Right side and right side

16. Explain how the location of the elements on the periodic table relate to this bond.

The next screens are similar except for the fact that the student must construct a covalent (non-polar) bond. To do this, s/he must select two identical or close non-metals from the right side of the table. These non-metals share electrons to form a chemical bond.

#### 4.5 Questions for understanding

Question 14 asks students to begin to think about the affect of polarity on molecules. Water, which is a polar molecule, has surface tension, cohesion and adhesion. The molecular attraction between these molecules accounts for these properties.

Questions 20 and 21 ask students to compare the boiling point of carbon monoxide to that of hydrogen chloride. Students should be encouraged to use the model to determine which of these molecules has more polarity. The more polar molecule is going to have more attraction for other molecules and therefore will have a higher boiling point. Hydrogen chloride has a higher difference.

Questions 22 and 23 ask students to determine which of these substances has the lowest boiling point: hydrogen gas, chlorine gas, water or steel. Steel is the correct answer because it is the only solid.

## 4.6 Summary

This section shows the answers to all the questions in the activity. There is an icon on the lower left that will print each student's answers. After the students click the icon, s/he will be asked to type in her/his name. This is only for the printout; student names are not saved in our database. Then, a web page is generated with the answers. This process may take a few moments. The standard print dialog box will open and the student can select the appropriate printer.

## 5.0 Student Reports

Your students' work with the "Types of Bonds" activity is logged and viewable on the MAC Project Web Portal at <http://mac.concord.org>. For each student, you can view a report containing questions and answers.

The next activity in the Chemical sequence is "States of Matter."