

SCIENCE 1105

CHEMICAL FORMULAS, BONDING, AND MOLECULAR ARCHITECTURE

CONTENTS

I. CHEMICAL FORMULAS	1
Ion Charge and Column Location	2
Formula Prediction	4
II. CHEMICAL BONDING	9
Electronegativity	10
Ionic Bonds	12
Covalent Bonds	13
Metallic Bonds	15
III. MOLECULAR SHAPE AND ELECTRON DISTRIBUTION	19
Hybridization	21
Polarity	30
GLOSSARY	43

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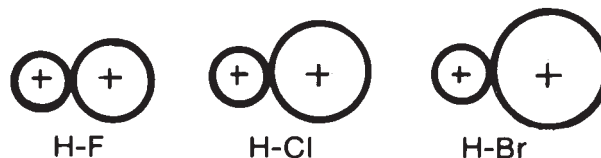
ELECTRONEGATIVIY

Scientists found that all atoms in the combined state show varying degrees of attraction for the electrons of the other member(s) of the compound. For example, the atom fluorine in HF has a very strong attraction for the electron of the hydrogen. In HCl is found a similar but weaker attraction, and in HBr an even weaker attraction is observed. Look at the Periodic Table of the Elements that you found as an insert to Science LightUnit 1103. Notice that the atomic size increases as you go down a vertical

column. This increase can be represented in this way:



The molecules of HF, HCl, and HBr could be represented in this way.



Do these activities.

- 2.1 Measure the distance between nuclei in each molecule.
 - a. HCl molecular distance between nuclei = _____
 - b. HF molecular distance between nuclei = _____
 - a. HBr molecular distance between nuclei = _____
- 2.2. Remember that each nucleus attracts the electrons of the other atom to hold the molecule together. Which atom has the greatest distance to overcome to attract the hydrogen electron (Circle the greatest one)?

fluorine	chlorine	bromine
----------	----------	---------
- 2.3 If two opposite charges get farther apart, does their attraction for each other increase, decrease, or remain the same? _____
- 2.4 Which element then has the least attraction for the hydrogen atom, fluorine, chlorine, or bromine? _____
- 2.5 Explain why HF is a more strongly bonded molecule than HBr.

Ionization energy. Review Science LightUnit 1104 (page 37) concerning ionization energy. Remember that ionization energy is the energy necessary to remove valence electrons from atoms. Look carefully at the Periodic Table. Notice that there is a general increase in ionization energy, E_1 , from left to right across a periodic row and a general increase in the ionization energy when going up a periodic column.

Increasing ionization energy means that generally *more energy* is required to remove an electron from the elements going *across a row*, and it takes progressively *more energy* to remove an electron when going *up a column*. This progression can be represented in general as in Figure 1.

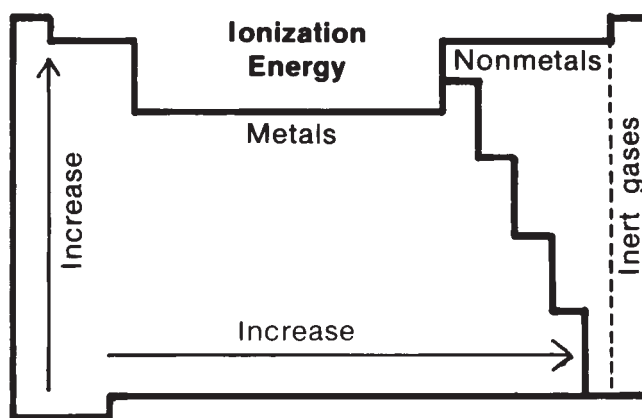


Figure 1

Another idea might be drawn from these observations. An atom that gives up an electron easily is less likely to take on another electron. This fact means that the atoms with less ability to hold any given electron (ones with low ionization energy) will not be very likely to want or to get another electron. Atoms with high ionization

potential will be able to hold another electron more easily. Therefore, in general, greater ionization energy indicates a greater ability to attract additional electrons; the lower the ionization energy, the less the desire for additional electrons.



Do this activity.

- 2.6 On the basis of the preceding reasoning, answer these questions.
- Do metals or nonmetals have the greatest chance to lose electrons and become positive ions? _____
 - Which group, metals or nonmetals, has the greatest chance to gain electrons and to become negative ions? _____
 - Which group of elements has very little desire to gain or to lose electrons?



Definition. Refer to the Periodic Table, which shows the atom's electron *attracting ability* for bonding electrons, or **electronegativity** as it is more commonly called. Pauling developed a scale of relative values with fluorine being

assigned a value of 4 and all other elements rated on that basis. Complete Figure 2 in 2.7 by putting in the corresponding electronegativities for each element listed.



Complete these activities.

- 2.7 Complete Figure 2 by putting the electronegativities of each element on the line in the box.

										Inert Gases							
H	Metals										Nonmetals					He	
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca													As		Br	Kr
Rb	Sr															I	Xe
Cs	Ba																

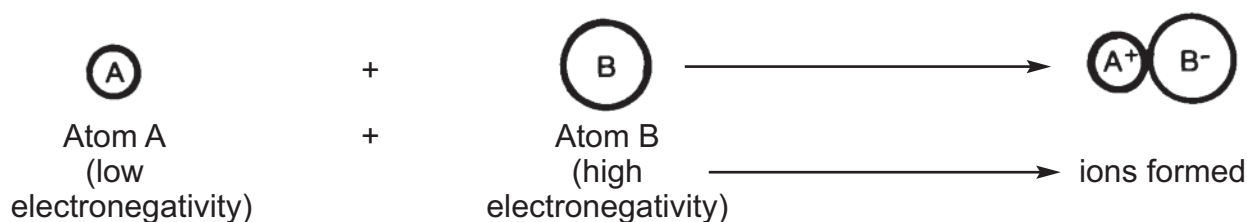
Figure 2

2.8 In relationship to Figure 1 for ionization energy, compare in general how ionization energy and electronegativity are related to the Periodic Table.

IONIC BONDS

When elements with different abilities to attract the electrons of another element are put together, a bond will result. If one element can completely take a valence electron away from some other atom, ions will form.

Definition. An ionic bond is any bond that is made from ions. This relationship is shown in this diagram.

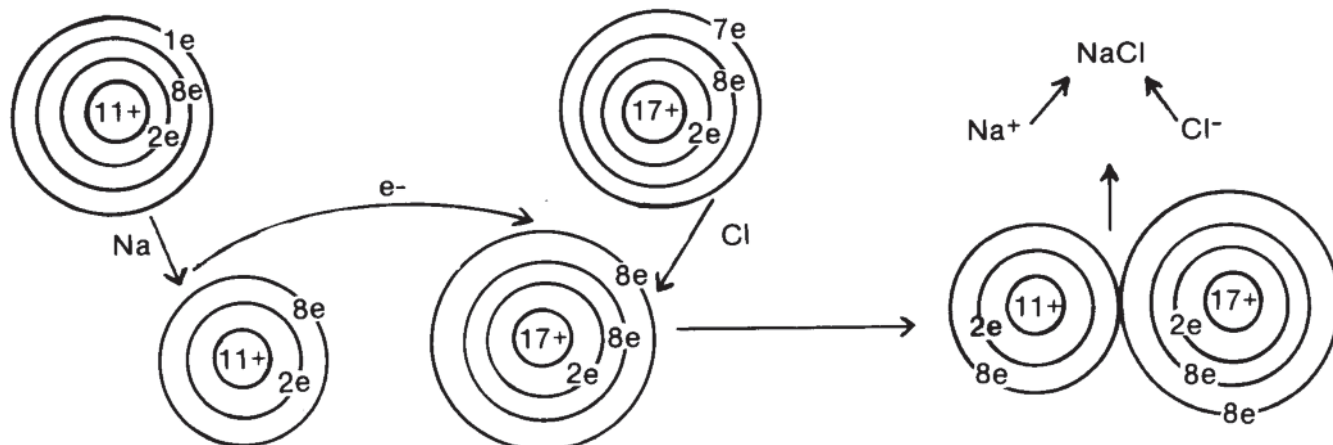


Complete this question.

2.9 Why does an ionic bond stay together? (Hint: Opposite electrical charges)

Characteristics. Ionic bonds are the most common bonds in the minerals of the earth. Most crystals are ionic in nature. Some common ionic compounds include table salt (NaCl),

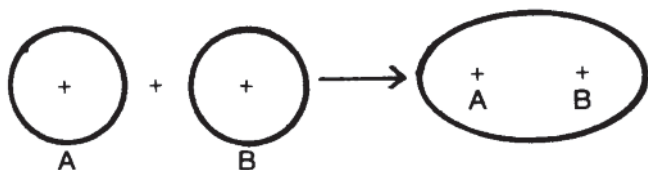
hydrochloric acid (HCl), and calcium chloride (CaCl₂). The ionic bond involves a transfer of a valence electron from one atom to another. This transfer is shown in this diagram.



COVALENT BONDS

Most ionic bonds occur between metals and nonmetals. Nearly all inorganic substances are ionic in nature. A few notable exceptions are water (H_2O), carbon dioxide (CO_2), and atmospheric gases like oxygen (O_2), hydrogen (H_2), and nitrogen (N_2). These exceptions are a part of a second class of bonds called **covalent bonds**.

Definition. Sometimes a bond will form between two or more atoms that have similar electronegativities. In this case, Atom A has no more attraction for the electrons of Atom B than Atom B has for the electrons of Atom A. Each has a mutual attraction for the other's valence electrons. When this sharing bond occurs, the resulting bond is called a *covalent bond*. This covalent bond is shown in this diagram.



Covalent bonding: the electron pair bond. Two or more electrons are located in the region between the nuclei. This bond is a highly directed bond because the bonding electrons are located only in specific places.

Percent ionic character. Chemists find that

	Element	Electronegativity
Step 1:	F	4.0
	H	<u>2.1</u>
	difference =	1.9

Step 2: Find 1.9 in the top row of the chart.

Step 3: Locate the percent directly below 1.9. The percent ionic character is equal to 59%.

The total percent ionic character and percent covalent character will equal 100% for each bond. The percent covalent character is deter-

mined by subtracting the percent ionic character from 100%.

most bonds are partly ionic and partly covalent. The amount of ionic and covalent character is determined by the difference in the electronegativities of the atoms making up the compound. The mathematics resulting in a prediction device for determining the degree of ionic character of any bond was studied by several men. We will use the chart as developed by Linus Pauling, a twice Nobel Prize winner. Refer to the Periodic Table used in this LightUnit. In the uppercenter of the Periodic Table is a chart that displays the *Difference in electronegativity* and the *Percent ionic character*. This chart is based on fluorine, which has the greatest attraction for electrons and is given a value of 4. All of the other elements have a value relative to the value for fluorine.

You can determine the percent of ionic character of a single bond by this method:

1. Calculate the numerical difference in the electronegativity values of the two atoms involved in the bond.
2. Locate this value in the top row of the chart labeled "Difference in electronegativity."
3. Read the value directly below this electronegativity difference. This second value is the percent of ionic character.

Example. Determine the ionic character of the bond between H and F in the molecule HF.



Do these activities. Use the Periodic Table as necessary.

2.10

As the electronegativity differences between two elements gets greater, what happens to the amount of ionic character? _____