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 Date: \_\_\_\_\_ Date (Due) \_\_\_\_\_

# Chemical Bonding

## A. Electronegativity

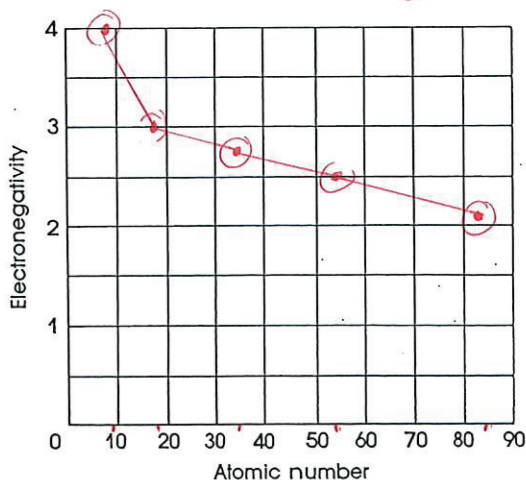
The ability of an atom to attract a shared pair of electrons in a covalent bond is called electronegativity. Answer the following questions about this concept, referring to the figure below, which shows the electronegativities of elements 1-88.

Period	Group 1												Group 18					
1	1 H 2.1	2											13 B 2.0	14 C 2.5	15 N 3.0	16 O 3.5	17 F 4.0	18 He -
2	3 Li 1.0	4 Be 1.5											5 Al 1.5	6 Si 1.8	7 P 2.1	8 S 2.5	9 Cl 3.0	10 Ne -
3	11 Na 0.9	12 Mg 1.2	3	4	5	6	7	8	9	10	11	12	13 Al 1.5	14 Si 1.8	15 P 2.1	16 S 2.5	17 Cl 3.0	18 Ar -
4	19 K 0.8	20 Ca 1.0	21 Sc 1.3	22 Ti 1.5	23 V 1.6	24 Cr 1.6	25 Mn 1.5	26 Fe 1.8	27 Co 1.8	28 Ni 1.8	29 Cu 1.9	30 Zn 1.6	31 Ga 1.6	32 Ge 1.8	33 As 2.0	34 Se 2.4	35 Br 2.8	36 Kr -
5	37 Rb 0.8	38 Sr 1.0	39 Y 1.2	40 Zr 1.4	41 Nb 1.6	42 Mo 1.8	43 Tc 1.9	44 Ru 2.2	45 Rh 2.2	46 Pd 2.2	47 Ag 1.9	48 Cd 1.7	49 In 1.7	50 Sn 1.8	51 Sb 1.9	52 Te 2.1	53 I 2.5	54 Xe -
6	55 Cs 0.7	56 Ba 0.9	57-71 1.1-1.2	72 Hf 1.3	73 Ta 1.5	74 W 1.7	75 Re 1.9	76 Os 2.2	77 Ir 2.2	78 Pt 2.2	79 Au 2.4	80 Hg 1.9	81 Tl 1.8	82 Pb 1.8	83 Bi 1.9	84 Po 2.0	85 At 2.2	86 Rn -
7	87 Fr 0.7	88 Ra 0.9																

1. Using the grid below, graph electronegativity versus atomic number for the elements in Group 17. How does electronegativity vary with the atomic number down a group?

*Electronegativity decreases with increasing atomic number. ↑ Halogens*

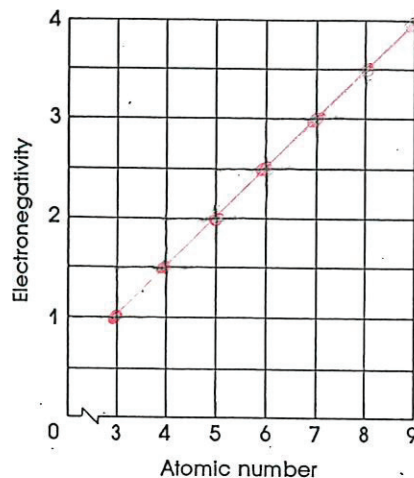
*Atoms near the top of a group (column) have smaller radii than those near the bottom. The nuclei of atoms with smaller radii are closer to the electrons and exert a greater attractive force on them.*



Li, Be, B, C, N, O, F, Ne

2. Using the grid below, graph electronegativity versus atomic number for the elements in Period 2. How does electronegativity vary with the atomic number across a period?

Electronegativity increases with increasing atomic # across a period.



Why is no electronegativity shown for element 10?

Ne is a noble gas & does not form bonds.

Electronegativity is determined when a bond forms - Noble Gases do not form bonds so its electronegativity cannot be determined.

## B. Polarity of Bonds

Differences in electronegativity can be used to determine how polar a bond is between two atoms. If the difference in the electronegativities of the atoms is 0.2 or less, the bond is considered to be nonpolar covalent, and the electron sharing is more or less equal. If the difference is more than 0.2 but less than 1.7, the bond is polar covalent, which means that the sharing is unequal. If the difference is greater than 1.7, the bond is considered to be ionic, and the bonding electrons are essentially transferred to one of the atoms.

Using the table of electronegativities from Part A, calculate the electronegativity difference for the atoms that are bonded in the following diatomic molecules. Then tell whether the bond is nonpolar covalent, polar covalent, or ionic. Also, tell which atom has the greater share of the bonding electrons.

FORMULA	ELECTRONEGATIVITY DIFFERENCE	TYPE OF BOND	ATOM WITH GREATER ELECTRON SHARE
NO	$3.5 - 3.0 = 0.5$	polar covalent	O
MgO	$3.5 - 1.2 = 2.3$	ionic	O
Br <sub>2</sub>	$2.8 - 2.8 = 0$	nonpolar	-
LiH	$2.1 - 1.0 = 1.1$	polar	H
LiBr	$2.8 - 1.0 = 1.8$	ionic	Br
CuF	$4.0 - 1.9 = 2.1$	ionic	F
CO	$3.5 - 2.5 = 1.0$	polar	O
HAt	$2.2 - 2.1 = 0.1$	nonpolar	-

\*0.2 or less

nonpolar covalent

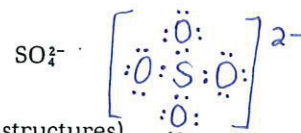
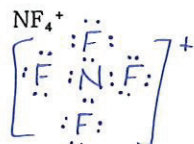
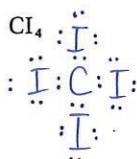
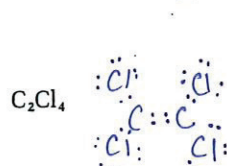
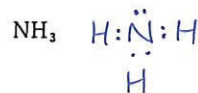
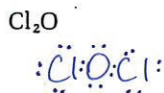
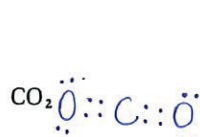
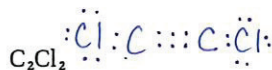
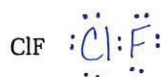
\*more than 0.2

but less than 1.7  
polar covalent

\*greater than 1.7  
ionic

## C. Electron Dot Structures

Bonding can be represented by means of diagrams in which valence electrons are shown as dots around the chemical symbols of the atoms. Draw electron dot structures for each of the following.



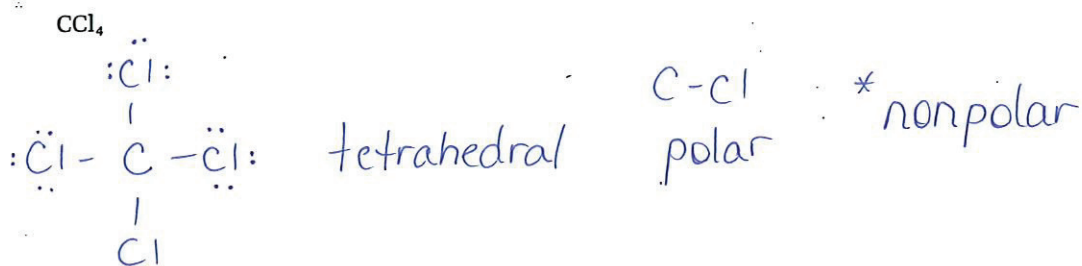
$\text{O}_3$  (indicate resonance structures)



## D. Molecular Shape and Polarity

The shape of a molecule depends upon the bonds within it and upon nonbonding electron pairs. The shape, once determined, together with the electronegativities of the atoms involved, allows determination of the overall polarity of the molecule. Draw each of the following, using lines to represent bonds, and indicate next to each molecule whether it is linear, trigonal planar, trigonal pyramidal, or tetrahedral. Then, referring to the electronegativities of the atoms involved, determine whether each bond is polar. If it is polar, add to the lines representing the bond an arrowhead pointing toward the more electronegative atom. Finally, decide whether the molecule as a whole is polar. If so, draw a large arrow near it, indicating the direction of polarity. The first substance has been done as an example.

FORMULA	REPRESENTATION	SHAPE	POLARITY OF BONDS	POLARITY OF MOLECULE
$\text{NI}_3$	$\begin{array}{c} \cdot\ddot{\text{N}}\cdot \quad \delta^+ \\   \\ \delta^- \cdot\ddot{\text{I}}\cdot \quad   \quad \cdot\ddot{\text{I}}\cdot \delta^- \\   \\ \cdot\ddot{\text{I}}\cdot \delta^- \end{array}$	trigonal pyramidal	N-I polar	polar
$\text{NCl}_3$	$\begin{array}{c} \cdot\ddot{\text{N}}\cdot \\   \\ \cdot\ddot{\text{Cl}}\cdot \quad   \quad \cdot\ddot{\text{Cl}}\cdot \\   \\ \cdot\ddot{\text{Cl}}\cdot \end{array}$	trigonal pyramidal	N-Cl non-polar	nonpolar
$\text{BCl}_3$	$\begin{array}{c} \cdot\ddot{\text{Cl}}\cdot \quad \cdot\ddot{\text{Cl}}\cdot \\   \quad   \\ \text{B} \\   \\ \cdot\ddot{\text{Cl}}\cdot \end{array}$	trigonal planar	B-Cl polar	nonpolar
$\text{Cl}_2\text{O}$	$\cdot\ddot{\text{Cl}}-\ddot{\text{O}}-\ddot{\text{Cl}}\cdot$	bent	O-Cl polar	polar
$\text{OF}_2$	$\cdot\ddot{\text{F}}\cdot \quad \cdot\ddot{\text{O}}\cdot \quad \cdot\ddot{\text{F}}\cdot$	bent	OF polar	polar



tetrahedral

C-Cl  
polar

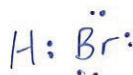
\* nonpolar



linear

Be-H  
polar

\* nonpolar



linear

H-Br  
polar

polar

## E. Intermolecular Forces

The forces between molecules include dipole-dipole forces (for polar molecules), London forces (for nonpolar molecules), and hydrogen bonding (for molecules in which hydrogen is attached to fluorine, oxygen, or nitrogen). Indicate, for each of the following substances, the intermolecular forces involved.

- |                             |                      |
|-----------------------------|----------------------|
| 1. $\text{H}_2$             | <u>London</u>        |
| 2. Ne                       | <u>London</u>        |
| 3. $\text{CH}_2\text{Cl}_2$ | <u>dipole-dipole</u> |
| 4. $\text{NH}_3$            | <u>hydrogen</u>      |
| 5. HCl                      | <u>dipole-dipole</u> |
| 6. $\text{H}_2\text{O}$     | <u>hydrogen</u>      |
| 7. $\text{NF}_3$            | <u>dipole-dipole</u> |

## F. Bonding Crossword

The following clues relate to topics covered in Chapter 12. Use the clues to fill in the crossword grid.

### ACROSS

- |   |   |
|---|---|
| 3. A subatomic particle                             | 23. Another word for "angular"                        |
| 8. Same as 6 DOWN                                   | 24. Is used to represent an electron in a diagram     |
| 10. Number of electron dots around a magnesium atom | 26. Shape of HCl molecule                             |
| 12. London and dipole-dipole forces                 | 28. Region in which an electron is likely to be found |
| 14. Bonding in which electrons are transferred      | 29. Describes any force between molecules             |
| 17. Ability of an atom to attract shared electrons  | 31. Smallest particle of an element                   |
| 22. Number of electron dots around a hydrogen atom  |   |

**DOWN**

1. Number of electron dots around a chlorine atom
2. Formula for carbon monoxide
4. Covalent bond in which one atom supplies both electrons
5. Formula for table salt
6. Bond with a positive and a negative end
7. Bond in which electrons are shared
9. Symbol for lanthanum
10. Atomic number of neon
11. Symbol for oxygen
13. Properties of atoms in the same group are \_\_\_\_\_.
15. Regular lattice arrangement
16. Symbol for silver
19. Symbol for cerium
20. Element in Group 2
21. Same as 14 ACROSS
25. Symbols for two atoms that, when attached to hydrogen, result in hydrogen bonding
27. Formula for rubidium chloride
30. Symbol for 20 DOWN

