

# 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.

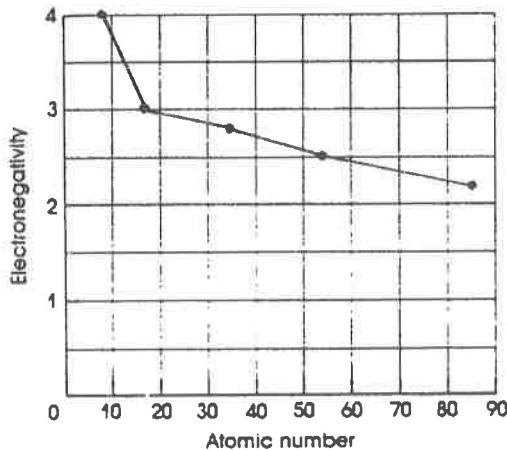
Period	Group 1										Group 18									
1	1	2											13	14	15	16	17	18		
2	3	4											5	6	7	8	9	10		
3	11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54		
6	55	56	57-71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86		
7	87	88																		

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 down a group.

Account for this fact.

The atoms near the top of a group have smaller radii than those near the bottom. The nuclei of atoms with smaller radii are closer to the shared, oppositely charged e<sup>-</sup>, and thus exert a greater attractive force on them.



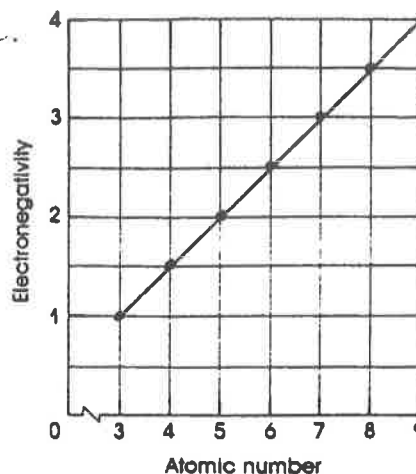


2. Using the grid below, graph electronegativity versus atomic number for the elements in Period 2. How does electronegativity vary with the atomic number across a period?

Electronegativity increases w.  
increasing atomic # across a period.

Account for this fact.

The nuclear charge of an atom  
increases across a period from  
left to right. Elements with  
greater nuclear charge attract  
a shared pair of e<sup>-</sup> more  
strongly. (Also atomic size -  
see Quer. 1)



Why is no electronegativity shown for element 10? = Ne

Neon is a noble gas that does  
not form bonds. Since electro-  
negativity can be measured  
only in terms of ability to  
attract shared e<sup>-</sup>, the value of  
this quantity cannot be determined  
for a non-bonding atom.

## B. Polarity of Bonds

Non-Polar      Polar      Ionic  
0.0 - 0.4      0.4 - 2.0      2.0 - 4.0

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 0.4 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 0.4 but less than 2.0, the bond is polar covalent, which means that the sharing is unequal. If the difference is greater than 2.0, 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>	$2.8 - 2.8 = 0$	non polar covalent	-
LiH	$2.1 - 1.0 = 1.1$	polar covalent	H
LiBr	$2.8 - 1.0 = 1.8$	polar covalent	Br
CuF	$4.0 - 1.9 = 2.1$	ionic	F
CO	$3.5 - 2.5 = 1.0$	polar covalent	O
HAt	$2.2 - 2.1 = 0.1$	nonpolar covalent	-



## 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.

N: 16  
A: 14  
S: 2



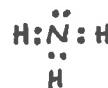
N: 24  
A: 20  
S: 4



N: 32  
A: 22  
S: 10



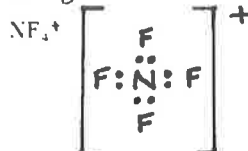
N: 14  
A: 8  
S: 6



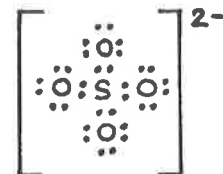
N: 24  
A: 16  
S: 8



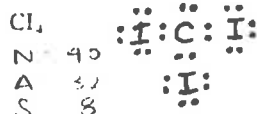
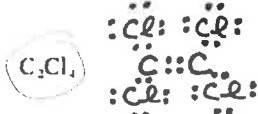
N: 40  
A: 33  
S: 8



N: 40  
A: 30+2  
S: 8



N: 48  
A: 36  
S: 12



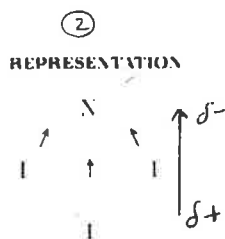
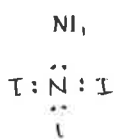
$\text{O}_3$  (indicate resonance structures)



## 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.

N: 32  
A: 20  
S: 2

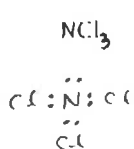


① SHAPE  
trigonal pyramidal

③ POLARITY OF BONDS  
N-I polar

④ POLARITY OF MOLECULE  
polar

N: 32  
A: 26  
S: 6

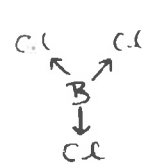
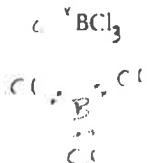


trigonal pyramidal

N-Cl non-polar  
(3.0; 3.0)

non-polar

N: 30  
A: 24  
S: 6

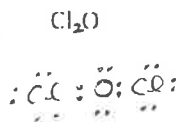


trigonal planar

B-Cl polar  
(2.0; 3.0)

non-polar

N: 22  
A: 20  
S: 4

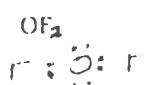


angular

Cl-O polar  
(3.0; 3.5)

polar

N: 24  
A: 22  
S: 4

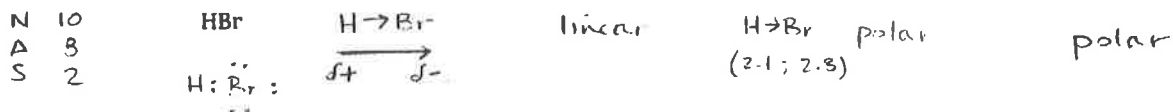
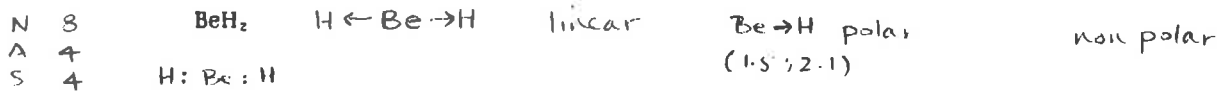
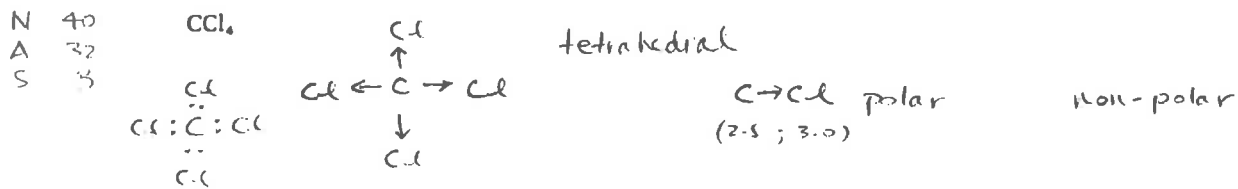


angular

O-F polar  
(3.5; 4.0)

polar

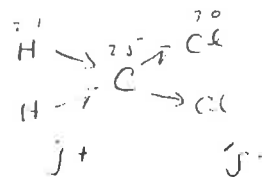




## E. Intermolecular Forces

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. H <sub>2</sub>                  | <u>London forces</u>        |
| 2. Ne                              | <u>London forces</u>        |
| 3. CH <sub>2</sub> Cl <sub>2</sub> | <u>dipole-dipole</u>        |
| 4. NH <sub>3</sub>                 | <u>hydrogen bonding</u>     |
| 5. HCl                             | <u>dipole-dipole forces</u> |
| 6. H <sub>2</sub> O                | <u>hydrogen bonding</u>     |
| 7. NF <sub>3</sub>                 | <u>dipole-dipole forces</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  |   |

