

Basic Concepts of Chemical Bonding

- 8.1 Chemical Bonds, Lewis Symbols, & the Octet Rule
- 8.2 Ionic Bonding (+7.3 ionic radius trends)
- 8.3 Covalent Bonding
- 8.4 Bond Polarity & Electronegativity



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Types of Chemical Bonds

Ionic Bond:

Due to electrostatic forces between opposite charges (metal + nonmetal)

Covalent Bond:

Sharing of electrons between two atoms (nonmetal + nonmetal)

Metallic Bond:

In metals where each atom bonded to several atoms and bonding electrons move freely around them



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Valence Electrons

The outer shell (valence shell) electrons of an atom

The electrons that participate in chemical bonding



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Valence Electrons

<u>Group</u>	<u>e⁻ configuration</u>	<u># of valence e⁻</u>
1A	ns ¹	1
2A	ns ²	2
3A	ns ² np ¹	3
4A	ns ² np ²	4
5A	ns ² np ³	5
6A	ns ² np ⁴	6
7A	ns ² np ⁵	7



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Lewis Symbols

Chemical symbol for the element plus a dot for each valence electron.

1 1A	2 2A																			18 8A		
•H	•Li •Be•																				•B• •C• •N• •O• •F• •Ne•	
•Na	•Mg•	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9	10	11 1B	12 2B										•Al• •Si• •P• •S• •Cl• •Ar•	
•K	•Ca•																					•Ga• •Ge• •As• •Se• •Br• •Kr•
•Rb	•Sr•																					•In• •Sn• •Sb• •Te• •I• •Xe•
•Cs	•Ba•																					•Tl• •Pb• •Bi• •Po• •At• •Rn•
•Fr	•Ra•																					



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Octet Rule:

Atoms tend to gain, lose, or share electrons until they are surrounded by eight valence electrons (noble gas configuration)

Na: [Ne] 3s¹ Na⁺: [Ne] lose

Cl: [Ne] 3s² 3p⁵ Cl⁻: [Ne] 3s² 3p⁶ gain

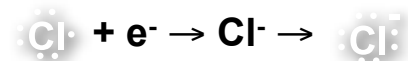
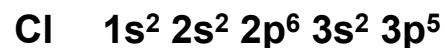
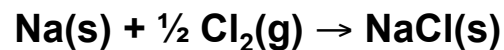
Cl₂: [Ne] 3s² 3p⁵  Share



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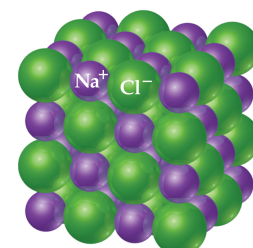
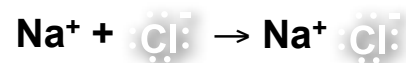
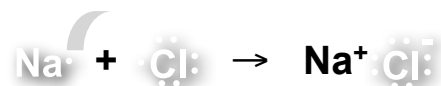
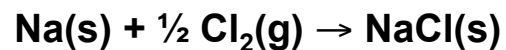
Ionic Bond



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Ionic Bond



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Ionic Bond: Electrostatic attraction between cations (positively charged ions) and anions (negatively charged ions)



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How Strong is the Ionic Bond?

Strength measured by the lattice energy of the ionic compound.

Lattice Energy (E_l):

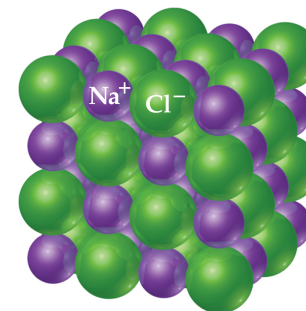
Energy required to completely separate one mole of a solid ionic compound into gaseous ions.



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Crystal Structure of NaCl



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Each Na^+ is surrounded by 6 Cl^-

Each Cl^- is surrounded by 6 Na^+



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<u>Compound</u>	<u>E_l (kJ/mol)</u>
-----------------	----------------------------------

LiF	1012
-----	------

MgCl ₂	2527
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MgO	3890
-----	------

ScN	7547
-----	------

$$E = \frac{kQ_1Q_2}{d}$$

Lattice energy increases with increasing ionic charge and with decreasing ionic size.

Charge effect more than size.



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Atomic Radius

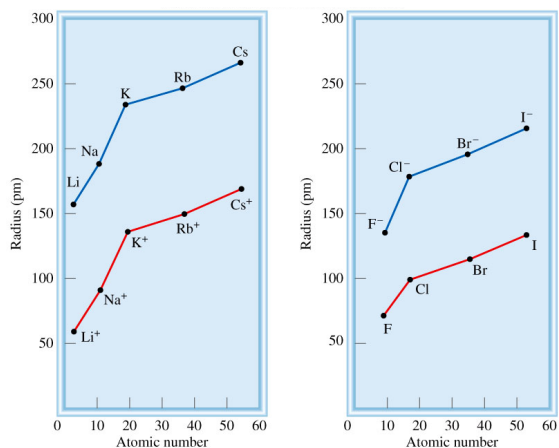


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Ionic Radius

Follow the same trend as atomic radius



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TABLE 9.1 Lattice Energies and Melting Points of Some Alkali Metal and Alkaline Earth Metal Halides and Oxides

Compound	Lattice Energy (kJ/mol)	Melting Point (°C)
LiF	1017	845
LiCl	828	610
LiBr	787	550
LiI	732	450
NaCl	788	801
NaBr	736	750
NaI	686	662
KCl	699	772
KBr	689	735
KI	632	680
MgCl ₂	2527	714
Na ₂ O	2570	Sub*
MgO	3890	2800

*Na₂O sublimates at 1275°C.

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Arrange in order of increasing lattice energy

LiF, LiI, and LiCl

LiI < LiCl < LiF

MgF₂, ScF₃, and LiF

LiF < MgF₂ < ScF₃

MgO, SrO and CaO

SrO < CaO < MgO

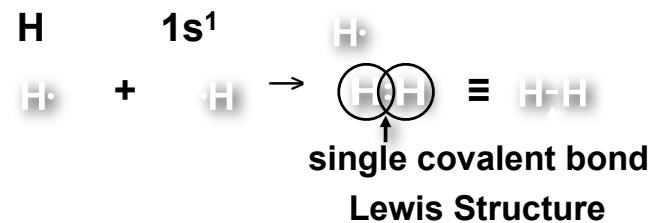
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Covalent Bond

Forms when two atoms in a molecule share a pair of e⁻, one e⁻ from each atom.

H₂ molecule:

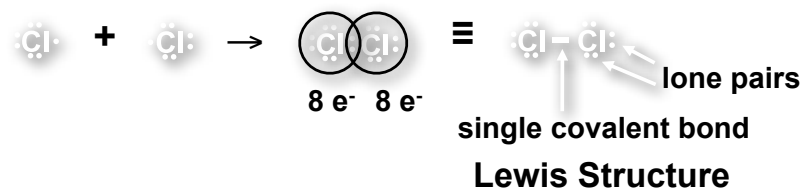


Every covalent bond is made from 2 electrons shared by both atoms.

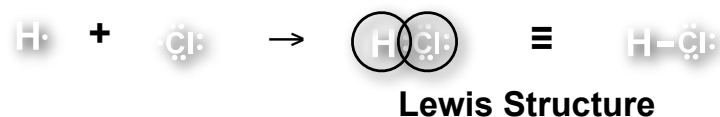
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Cl₂ molecule:



HCl molecule:



H₂O molecule:



NF₃ molecule:



Multiple Bonds

CO₂ molecule:



N₂ molecule:



Bond Strength:

N≡N	N=N	N-N	
941	418	163	kJ/mol
triple	> double	> single	

Bond Length

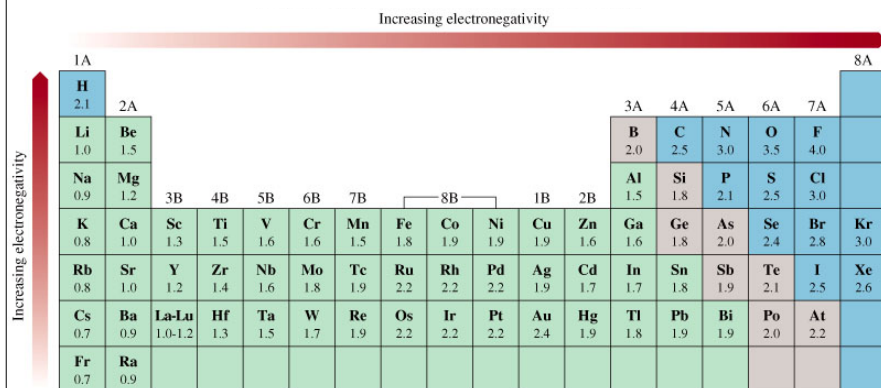
N≡N	N=N	N-N	
1.10	1.24	1.47	Å
triple	< double	< single	

As the number of shared e⁻ between the two atoms increases bond strength increases and length decreases.



Electronegativity

Ability of an atom in a molecule to attract bonded electrons to itself.



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Bond Polarity & Electronegativity



In H₂ and Cl₂ molecules electrons of the covalent bond are shared equally by the two atoms

Result: Nonpolar (pure) covalent bond



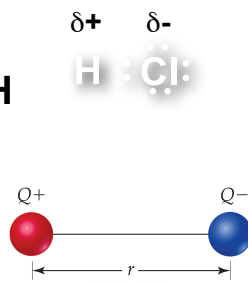
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In HCl molecule, electrons are not equally shared between H and Cl atoms due difference in electronegativity

Electrons spend more time closer to Cl because it has higher electronegativity than H atom.

Bond has a dipole (two poles)
dipole moment $\mu = Qr$



Result: Polar covalent bond



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Covlaent/polar covalent/or ionic

Parameter:

Difference in electronegativity, ΔEN

$\Delta EN \geq 2$ ionic bond NaCl

$\Delta EN < 2$ polar covalent bond CO

$\Delta EN = 0$ pure covalent bond F₂



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The Electronegativities of Common Elements

Increasing electronegativity

1A																				8A											
H																															
2.1																															
2A																															
Li	Be																														
1.0	1.5																														
3A		4A		5A		6A		7A																							
Na	Mg	B	C	N	O	F																									
0.9	1.2	2.0	2.5	3.0	3.5	4.0																									
3B		4B		5B		6B		7B		8B		1B		2B																	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr														
0.8	1.0	1.3	1.5	1.6	1.6	1.5	1.8	1.9	1.9	1.9	1.6	1.6	1.8	2.0	2.4	2.8	3.0														
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe														
0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.2	2.2	2.2	1.9	1.7	1.7	1.8	1.9	2.1	2.5	2.6														
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At															
0.7	0.9	1.0-1.2	1.3	1.5	1.7	1.9	2.2	2.2	2.2	2.4	1.9	1.8	1.9	1.9	2.0	2.2															
Fr	Ra																														
0.7	0.9																														

Increasing difference in electronegativity

Covalent Share e⁻ → Polar Covalent partial transfer of e⁻ → Ionic transfer e⁻



Which is the most polar bond?
S – Cl, S – Br, Se – Cl, Se – Br

Se – Cl

					8A				
14		15		16		17		2	
4A		5A		6A		7A		He	
6	7	8	9						
C	N	O	F						
1.4	1.5	1.6	1.7						
14	15	16	17						
Si	P	S	Cl						
1.8	2.1	2.5	3.0						
32	33	34	35						
Ge	As	Se	Br						
2.0	2.0	2.4	2.8						
					8A				
A		4A		5A		6A		7A	
B	C	N	O	F					
2.0	2.5	3.0	3.5	4.0					
Al	Si	P	S	Cl					
1.5	1.8	2.1	2.5	3.0					
Ga	Ge	As	Se	Br					
1.6	1.8	2.0	2.4	2.8					
In	Sn	Sb	Te	I					
1.7	1.8	1.9	2.1	2.5					

