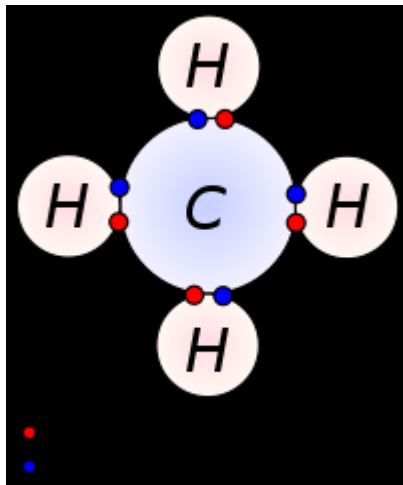
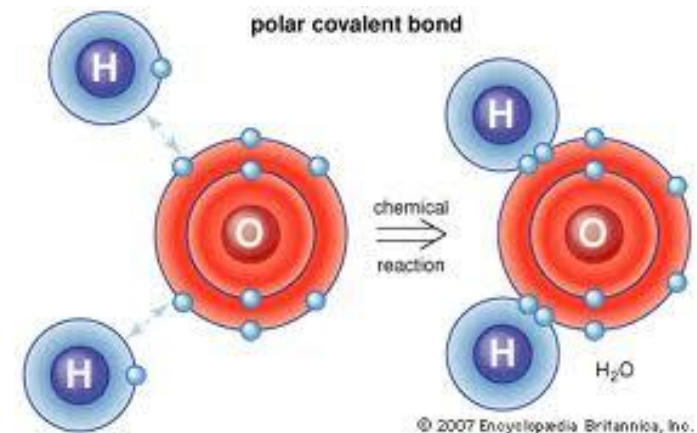


Ionic and Covalent Bonds



Section #2



Downloadable at: <http://tekim.undip.ac.id/staf/istadi>



I																		VII										VII										VIII									
1																		7										18										18									
H 1 1.00794 Hydrogen		Li 3 6.941 Lithium		Be 4 9.012182 Beryllium		Transition Metals																B 5 10.811 Boron		C 6 12.0107 Carbon		N 7 14.00674 Nitrogen		O 8 15.9994 Oxygen		F 9 18.9984032 Fluorine		Ne 10 20.1797 Neon															
Na 11 22.989770 Sodium		Mg 12 24.3050 Magnesium		Transition Metals																Al 13 26.981538 Aluminum		Si 14 28.0855 Silicon		P 15 30.973762 Phosphorus		S 16 32.066 Sulfur		Cl 17 35.4527 Chlorine		Ar 18 39.948 Argon																	
K 19 39.0983 Potassium		Ca 20 40.078 Calcium		Sc 21 44.955910 Scandium		Ti 22 47.867 Titanium		V 23 50.9415 Vanadium		Cr 24 51.9961 Chromium		Mn 25 54.938049 Manganese		Fe 26 55.845 Iron		Co 27 58.933200 Cobalt		Ni 28 58.6934 Nickel		Cu 29 63.546 Copper		Zn 30 65.39 Zinc		Ga 31 69.723 Gallium		Ge 32 72.61 Germanium		As 33 74.92160 Arsenic		Se 34 78.96 Selenium		Br 35 79.904 Bromine		Kr 36 83.80 Krypton													
Rb 37 85.4678 Rubidium		Sr 38 87.62 Strontium		Y 39 88.90585 Yttrium		Zr 40 91.224 Zirconium		Nb 41 92.90638 Niobium		Mo 42 95.94 Molybdenum		Tc 43 (98) Technetium		Ru 44 101.07 Ruthenium		Rh 45 102.90550 Rhodium		Pd 46 106.42 Palladium		Ag 47 107.8682 Silver		Cd 48 112.411 Cadmium		In 49 114.818 Indium		Sn 50 118.710 Tin		Sb 51 121.760 Antimony		Te 52 127.60 Tellurium		I 53 126.90447 Iodine		Xe 54 131.29 Xenon													
Cs 55 132.90545 Cesium		Ba 56 137.327 Barium		La 57 138.9055 Lanthanum		Hf 72 178.49 Hafnium		Ta 73 180.9479 Tantalum		W 74 183.84 Tungsten		Re 75 186.207 Rhenium		Os 76 190.23 Osmium		Ir 77 192.217 Iridium		Pt 78 195.078 Platinum		Au 79 196.96655 Gold		Hg 80 200.59 Mercury		Tl 81 204.3833 Thallium		Pb 82 207.2 Lead		Bi 83 208.98038 Bismuth		Po 84 (209) Polonium		At 85 (210) Astatine		Rn 86 (222) Radon													
Fr 87 (223) Francium		Ra 88 226.025 Radium		Ac 89 (227) Actinium		Rf 104 (261) Rutherfordium		Db 105 (262) Dubnium		Sg 106 (263) Seaborgium		Bh 107 (264) Bohrium		Hs 108 (265) Hassium		Mt 109 (268) Meitnerium		Uun 110 (269) Ununium		Uuu 111 (272) Unununium		Uub 112 (277) Unbibium		Uut 113 (285) Ununtrium		Uuq 114 (285) Ununquadium		Uup 115 (289) Ununpentium		Uuh 116 (289) Ununhexium		Uus 117 (293) Ununseptium		Uuo 118 (293) Ununoctium													
* Lanthanides				Ce 58 140.116 Cerium		Pr 59 140.90765 Praseodymium		Nd 60 144.24 Neodymium		Pm 61 (145) Promethium		Sm 62 150.36 Samarium		Eu 63 151.964 Europium		Gd 64 157.25 Gadolinium		Tb 65 158.92534 Terbium		Dy 66 162.50 Dysprosium		Ho 67 164.93032 Holmium		Er 68 167.26 Erbium		Tm 69 168.93421 Thulium		Yb 70 173.04 Ytterbium		Lu 71 174.967 Lutetium																	
* Actinides				Th 90 232.0381 Thorium		Pa 91 231.03588 Protactinium		U 92 238.0289 Uranium		Np 93 (237) Neptunium		Pu 94 (244) Plutonium		Am 95 (243) Americium		Cm 96 (247) Curium		Bk 97 (247) Berkelium		Cf 98 (251) Californium		Es 99 (252) Einsteinium		Fm 100 (257) Fermium		Md 101 (258) Mendelevium		No 102 (259) Nobelium		Lr 103 (262) Lawrencium																	
** Radioactive				Th 90 232.0381 Thorium		Pa 91 231.03588 Protactinium		U 92 238.0289 Uranium		Np 93 (237) Neptunium		Pu 94 (244) Plutonium		Am 95 (243) Americium		Cm 96 (247) Curium		Bk 97 (247) Berkelium		Cf 98 (251) Californium		Es 99 (252) Einsteinium		Fm 100 (257) Fermium		Md 101 (258) Mendelevium		No 102 (259) Nobelium		Lr 103 (262) Lawrencium																	

Atomic weights are based on ¹²C = 12 and conform to the 1995 IUPAC reported values. Number in () indicates the isotope of longest half-life.



Compounds: Introduction to Bonding

- The noble gases - helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), and radon (Rn) – occur in air as separate atoms
- Other molecules: O₂, N₂, H₂, S₈, C, Cu, Ag, Pt, Au
- Elements combine to form a compound in 2 general ways:
 - **Transferring electrons** from the atoms of one element to those of another to form **ionic compounds**
 - **Sharing electrons** between atoms of different elements to form **covalent compounds**.
- These processes generate **chemical bonds**, the forces that hold the atoms of elements together in a compound.

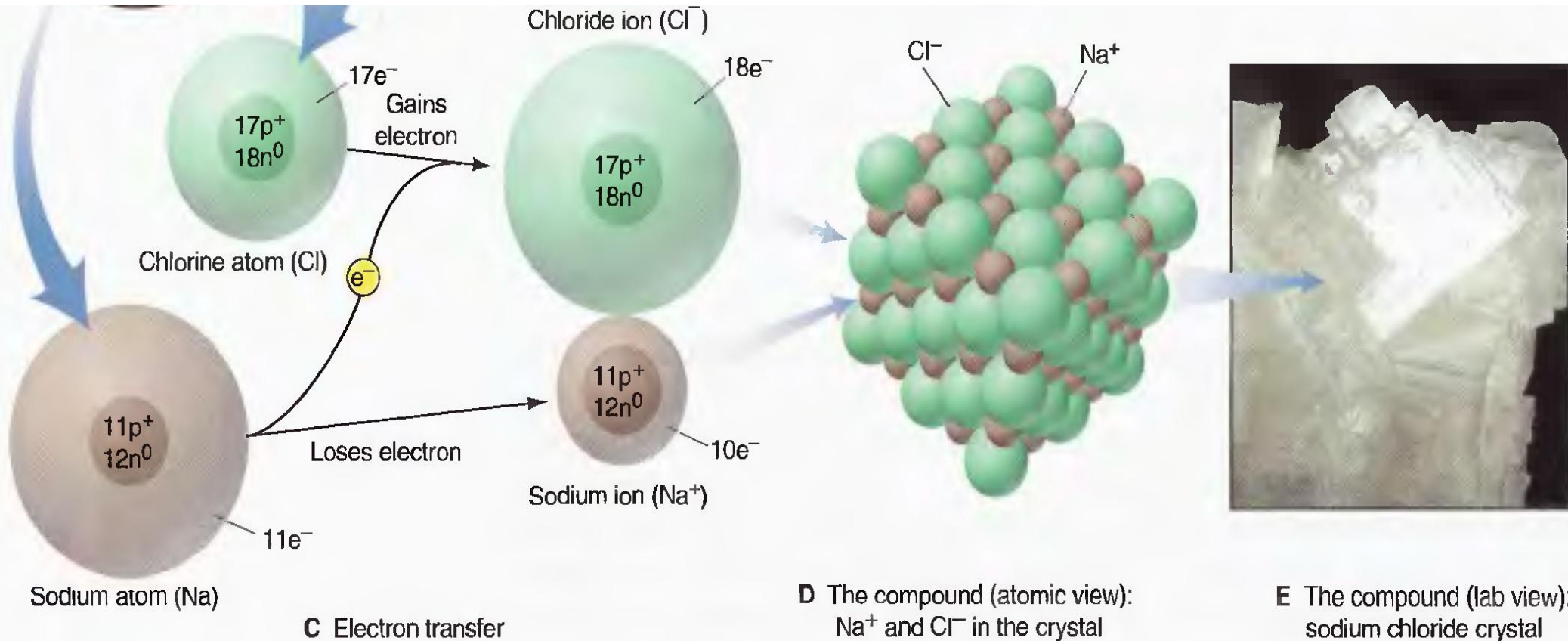


Formation of Ionic Compounds

- **Ionic compounds** are composed of ions – charged particles that form when an atom (or small group of atoms) gains or losses one or more electrons.
- **Binary ionic compound**: one composed of just two elements, typically forms when a metal reacts with a nonmetal.
- Each metal atom loses a certain number of its electrons and becomes a **CATION**, a positively charged ion.
- The non metal atoms gain the electron loss by the metal atoms and becomes **ANIONS**, negatively charged ion.
- The Cations and Anions attract each other through electrostatic forces and form the ionic compounds
- All binary ionic compounds are solid
- A cation or anion derived from a single atom is called a **MONATOMIC ION**



Example of the formation of ionic compound -- NaCl



IONIC BONDING
ANIMATION

IONIC & COVALENT
BONDING



- Sodium atom loses 1 electron and forms a sodium cation (Na^+).
- A Chlorine atom gains the electron and becomes a chloride anion (Cl^-).
- The oppositely charge ions (Na^+ and Cl^-) attract each other
- The resulting solid aggregation is a regular array of alternating Na^+ and Cl^- ions that extends in all three dimensions



STRENGTH OF IONIC BONDING

- depends on net strength of attractions and repulsions and is described by Coulomb's Law
- *The energy of attraction (or repulsion) between two particles is directly to the product of the charges and inversely proportional to the distance between them*
- *Ions with higher charges attract (or repel) each other more strongly than ions with lower charges*

$$\text{Energy} \propto \frac{\text{Charge 1} * \text{Charge 2}}{\text{Distance}}$$



- Smaller ion attract (or repel) each other more strongly than larger ions, because their charges are closer together.
- Ionic compounds are neutral, that is, they possess no net charge
- Figure 2.13

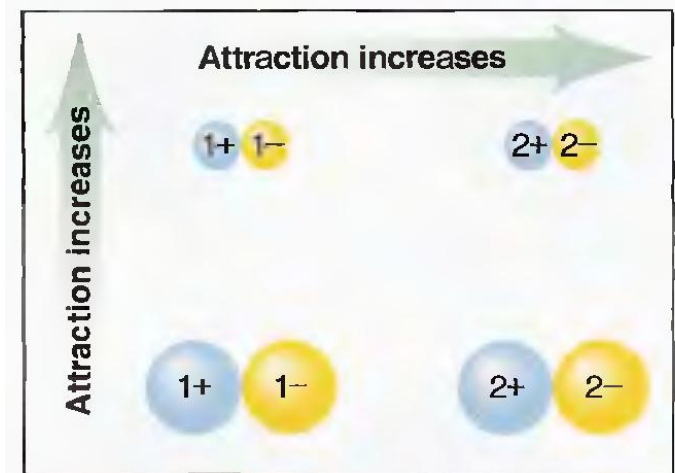


Figure 2.13 Factors that influence the strength of ionic bonding. For ions of a given size, strength of attraction (*arrows*) increases with higher ionic charge (*left to right*). For ions of a given charge, strength of attraction increases with smaller ionic size (*bottom to top*).

Why Why Why Why ???????

- Why does each sodium atom give up only 1 of its 11 electrons?
- Why doesn't each chlorine atom gain two electrons, instead of just one?
- ==> ***PERIODIC TABLE will answer***
- In general, metals lose electrons and non metals gain electrons to form ions with the same number of electrons as in the nearest noble gas [GROUP 8A(18)]



- Noble gases have a stability (low reactivity) that is related to their number of electrons
- Sodium ion ($11e^-$) can attain the stability of neon ($10e^-$) by losing one electron
- By gaining one electron, a chlorine atom ($17e^-$) attains the stability of argon ($18e^-$).
- Thus, when an element located near a noble gas forms a monatomic ion, it gains or loses enough electrons to attain the same number as that noble gas

The image shows a 3D cylindrical representation of the periodic table. The noble gases are highlighted in yellow, and their corresponding ions are shown in blue. The noble gases are He, Ne, Ar, Kr, and Xe. The ions shown are H⁻, F⁻, Cl⁻, I⁻, Li⁺, Na⁺, K⁺, Rb⁺, Cs⁺, Mg²⁺, Ca²⁺, Sr²⁺, and Ba²⁺. The table is organized into columns labeled 5A (15), 6A (16), 7A (17), 8A (18), 1A (1), 2A (2), and 3A (13).

5A (15)	6A (16)	7A (17)	8A (18)	1A (1)	2A (2)	3A (13)
		H ⁻	He	Li ⁺		
N ³⁻	O ²⁻	F ⁻	Ne	Na ⁺	Mg ²⁺	Al ³⁺
	S ²⁻	Cl ⁻	Ar	K ⁺	Ca ²⁺	
		Br ⁻	Kr	Rb ⁺	Sr ²⁺	
		I ⁻	Xe	Cs ⁺	Ba ²⁺	

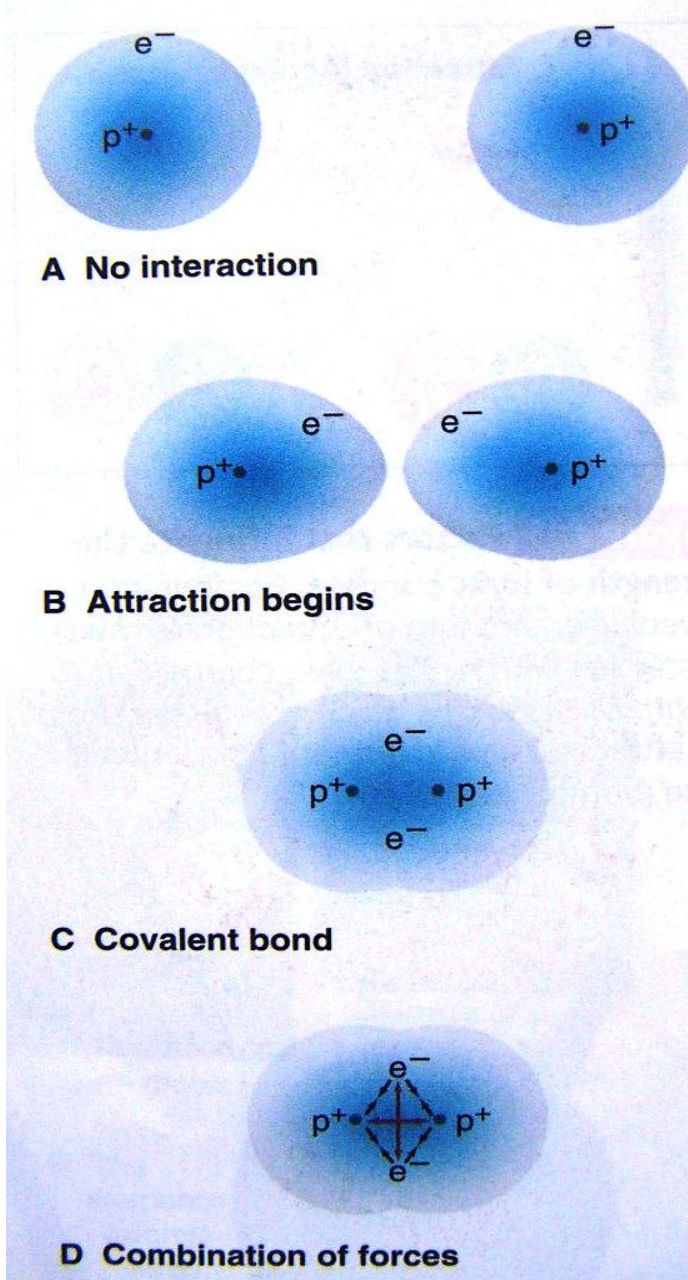


In Periodic Table

- The elements in Group 1A(1) lose one electron, those in Group 2A(2) lose two, and aluminum in Group 3A(13) loses three
- The elements in Group 7A(17) gain one electron, oxygen and sulfur in Group 6A(16) gain two, and nitrogen in Group 5A(15) gains three
- Fluorine (F, Z=9) has one electron fewer and sodium (Na, Z=10) has one electron more than the noble gas neon (Ne, Z=10), they form the F⁻ and Na⁺ ions
- Similarly, oxygen (O, Z=8) gains two electrons and magnesium (Mg, Z=12) loses two to form the O²⁻ and Mg²⁺ ions and attain the same number of electrons as neon



Formation of Covalent Compounds



- Covalent compound form when elements share electrons, which usually occurs between nonmetals
- Example: Two Hydrogen atoms (H, Z=1):
- The nucleus of each atom attracts the electron of the other atom more and more strongly
- The separated atoms begin to interpenetrate each other
- At some optimum distance between the nuclei, the atoms form a **COVALENT BOND, where a pair of electrons mutually attracted by the two nuclei**

COVALENT
BONDING

IONIC & COVALENT
BONDING

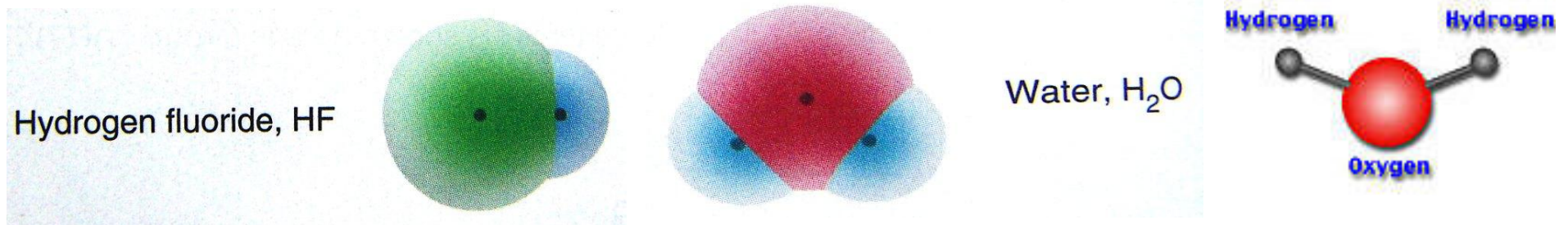


- The result is a hydrogen molecule, in which each electron no longer “belongs” to a particular H atom; the two electrons are shared by the two nuclei
- Repulsions between the nuclei and between the electrons also occur, but the net attraction is greater than the net repulsion.
- Other nonmetals that exist as diatomic molecules at room temperature are nitrogen (N_2), oxygen (O_2), and the halogens (fluorine (F_2), chlorine (Cl_2), bromine (Br_2), and iodine (I_2)).
- Phosphorus exists as tetratomic molecules (P_4), and sulfur and selenium as octatomic molecules (S_8 and Se_8).
- At room temperature, covalent compounds may be gases, liquids, or solids

	1A (1)	2A (2)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)	
1	H ₂								<div style="display: flex; flex-direction: column; gap: 5px;"> <div> Diatomic molecules</div> <div> Tetratomic molecules</div> <div> Octatomic molecules</div> </div>
2					N ₂	O ₂	F ₂		
3					P ₄	S ₈	Cl ₂		
4						Se ₈	Br ₂		
5							I ₂		
6									
7									



- Atoms of different elements share electrons to form the molecules of a covalent bond
- Example: Hydrogen Fluoride (HF), Water (H₂O)



- **Most covalent substances consists of molecules** : a cup of water ==> consists of individual water molecules
- **No molecules exist in a sample of ionic compound**: ==> NaCl is a continuous array of oppositely charged sodium and chloride ions, not a collection of individual NaCl molecules

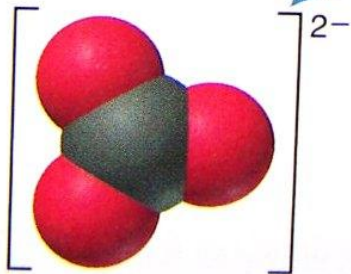
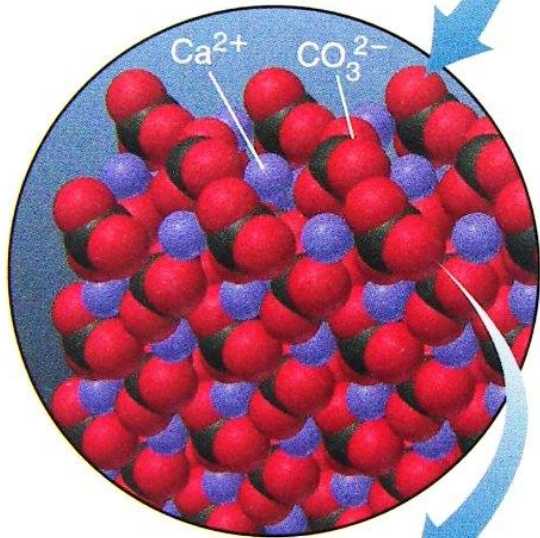


Another Key Difference

- ***Covalent bonding***: involves the mutual attraction between two (positively charged) nuclei and the two (negatively charged) electrons that reside between them.
- ***Ionic bonding***: involves the mutual attraction between positive and negative ions



Polyatomic Ions



Carbonate ion
 CO_3^{2-}

- Many ionic compounds contain polyatomic ions, which consist of two or more atoms ***bonded Covalently*** and have a net positive or negative charge
- ***Calcium carbonate*** is a 3D array of monatomic calcium cations and polyatomic carbonate anions.
- As the bottom structure shows, each ***carbonate*** ion consists of four covalently bonded atoms



Three Types of Chemical Bonding

Key:

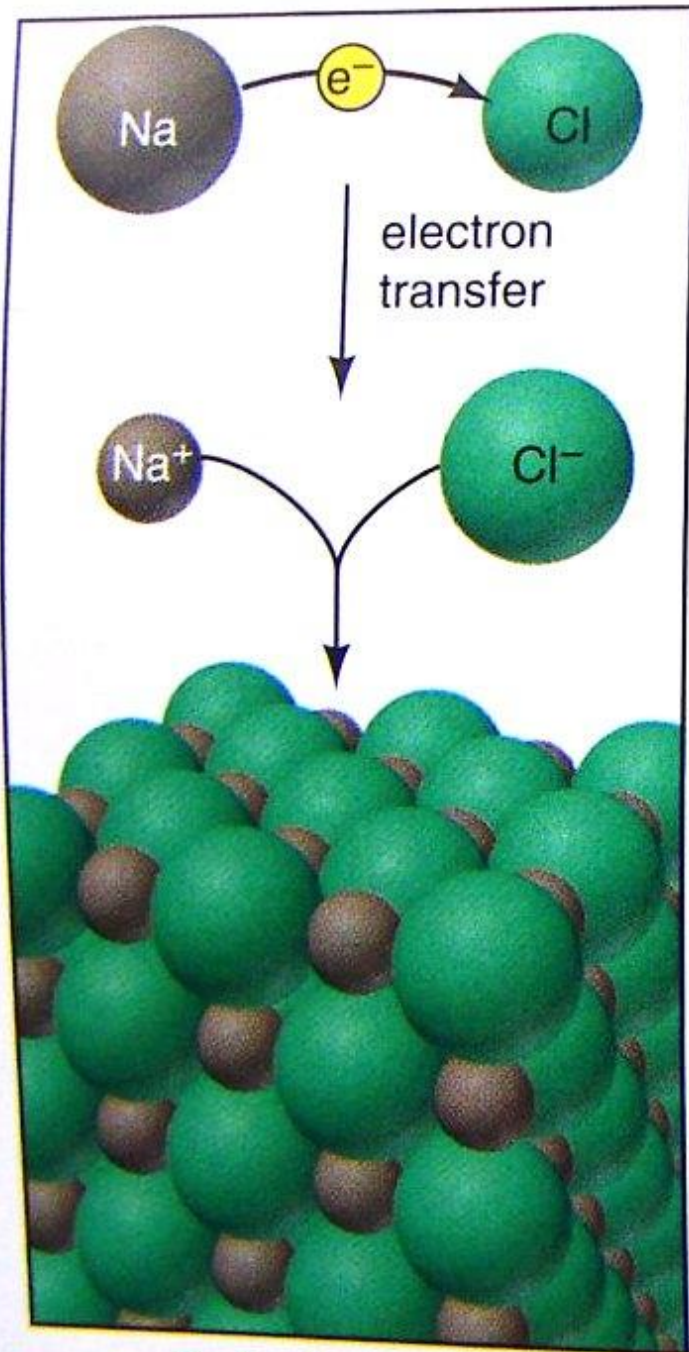
- Metals
- Nonmetals
- Metalloids

1A (1)		2A (2)												3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
Li	Be											B	C	N	O	F	Ne		
Na	Mg	3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	8B (8) (9) (10)			1B (11)	2B (12)	Al	Si	P	S	Cl	Ar		
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr		
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe		
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	112		114		116				
A		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu				
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr				

Why atoms bond at all ?

- *Bonding lowers the potential energy between positive and negative particles.*
- Just as the electron configuration and the strength of the nucleus-electron attraction determine the properties of an atom,
- the type and strength of chemical bonds determine the properties of a substance





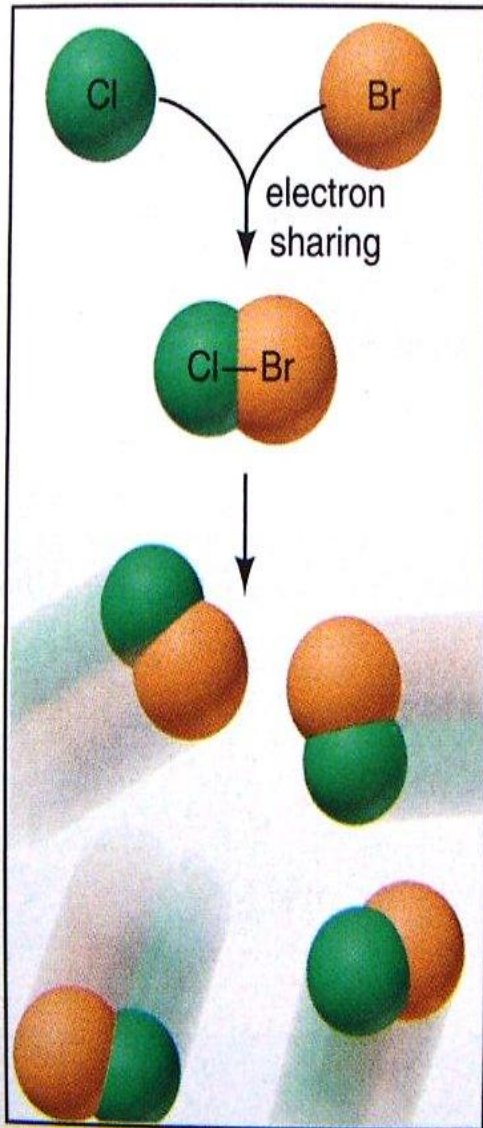
A Ionic bonding

- **(1). Metal with nonmetal:** electron transfer and ionic bonding
- Typically as IONIC, BONDING
- Such difference occur between reactive metals (1A(1) and 2A(2)) and nonmetals (7A(17)) and the top of Group 6A (16).
- The metal atom loses its one or two valence electrons, whereas the nonmetal atom gains the electron(s).
- Electron transfer from metal to nonmetal occurs, and each atom forms an ion with a noble gas electron configuration



- The electrostatic attraction between these positive and negative ions draws them into the 3D array of an ionic solid
- whose chemical formula represents the cation-to-anion ratio (empirical formula)

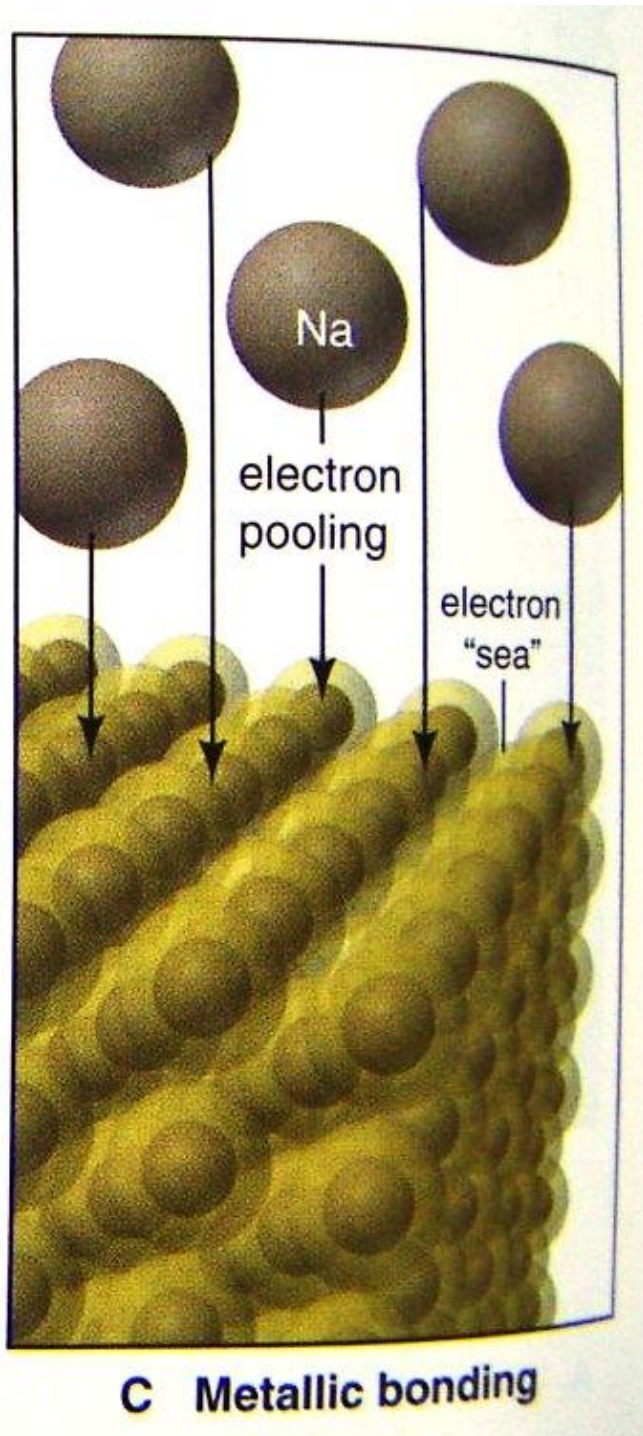




B Covalent bonding

- ***Nonmetal with nonmetal***: electron sharing and covalent bonding.
- when two atoms have a small difference in their tendencies to lose or gain electrons, we observe *electron sharing* and *covalent bonding*
- This type of bonding most commonly occurs between nonmetal atom, Although a pair of metal atoms can sometimes form a covalent bond also
- The attraction of each nucleus for the valence electrons of the other draws the atoms together.
- A shared electron pair is considered to be “localized” between the atoms because it spends most of its time there, linking them in a covalent bond of a particular length and strength.





- (3). ***Metal with metal: electron pooling and metallic bonding***
- In general, metal atoms are relatively large, and their view outer electrons are well shielded by filled inner levels
- Thus, they lose outer electrons comparatively easily but do not gain them very readily.
- These properties lead large numbers of metal atoms to share their valence electrons, but in a way that differs from covalent bonding



- All the metal atoms in a sample **pool** their valence electrons into an evenly distributed **“sea” of electrons** that “flows” between and around the metal-ion cores (nucleus plus inner electrons) and attracts them, thereby holding them together
- Unlike the localized electrons in covalent bonding, electrons in metallic bonding are **“delocalized”**, **moving freely throughout the piece of metal**.
- In other word: Metallic bonding occurs when many metal atoms pool their valence electrons in a delocalized electron sea that holds all the atoms together.



Notes

- You cannot always predict the bond type solely from the elements' positions in the periodic table
- All binary compounds contain a metal and a nonmetal, but all metals do not form binary ionic compounds with all nonmetals
- Example: metal beryllium (Group 2A(2)) combines with the nonmetal chlorine (Group 7A(17)), the bonding fits the covalent model better than the ionic model.



LEWIS ELECTRON-DOT SYMBOLS

		1A(1)	2A(2)
		ns^1	ns^2
Period	2	• Li	• Be •
	3	• Na	• Mg •

3A(13)	4A(14)	5A(15)	6A(16)	7A(17)	8A(18)
ns^2np^1	ns^2np^2	ns^2np^3	ns^2np^4	ns^2np^5	ns^2np^6
• B •	• C •	• N •	• O •	• F •	• Ne •
• Al •	• Si •	• P •	• S •	• Cl •	• Ar •

- The element symbol represents the nucleus and the inner electrons
- The dots around it represent valence electrons, either paired or unpaired
- The number of unpaired dots indicates the number of electrons a metal atom loses, or the number of nonmetal atom gains, or the number of covalent bonds a nonmetal atom usually forms



Lewis Symbol

- Note its A-group number (1A to 8A), which gives the number of valence electrons
- Place one dot at a time on the four sides (top, right, bottom, left) of the element symbol
- Keep adding dots, pairing the dots until all are used up
- The placement of dots is not important
- The number and pairing of dots provide information about an element's bonding behavior:
 - For a metal, the total number of dots is the maximum number of electrons an atom loses to form a cation
 - For a nonmetal, the number of unpaired dots is the number of electrons that become paired either through electron gain or through electron sharing.
 - Thus the number of unpaired dots equals either the number of electrons a nonmetal atom gains in becoming an anion or the number of covalent bonds it usually forms



Lewis : ==> OCTET RULE

- when atoms bond, they lose, gain, or share electrons to attain a filled outer level of eight (or two) electrons
- The octet rule holds for nearly all of the compounds of Period 2 elements and a large number of others as well

