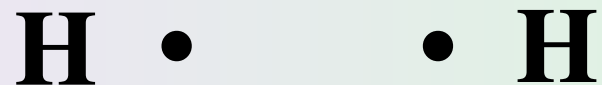


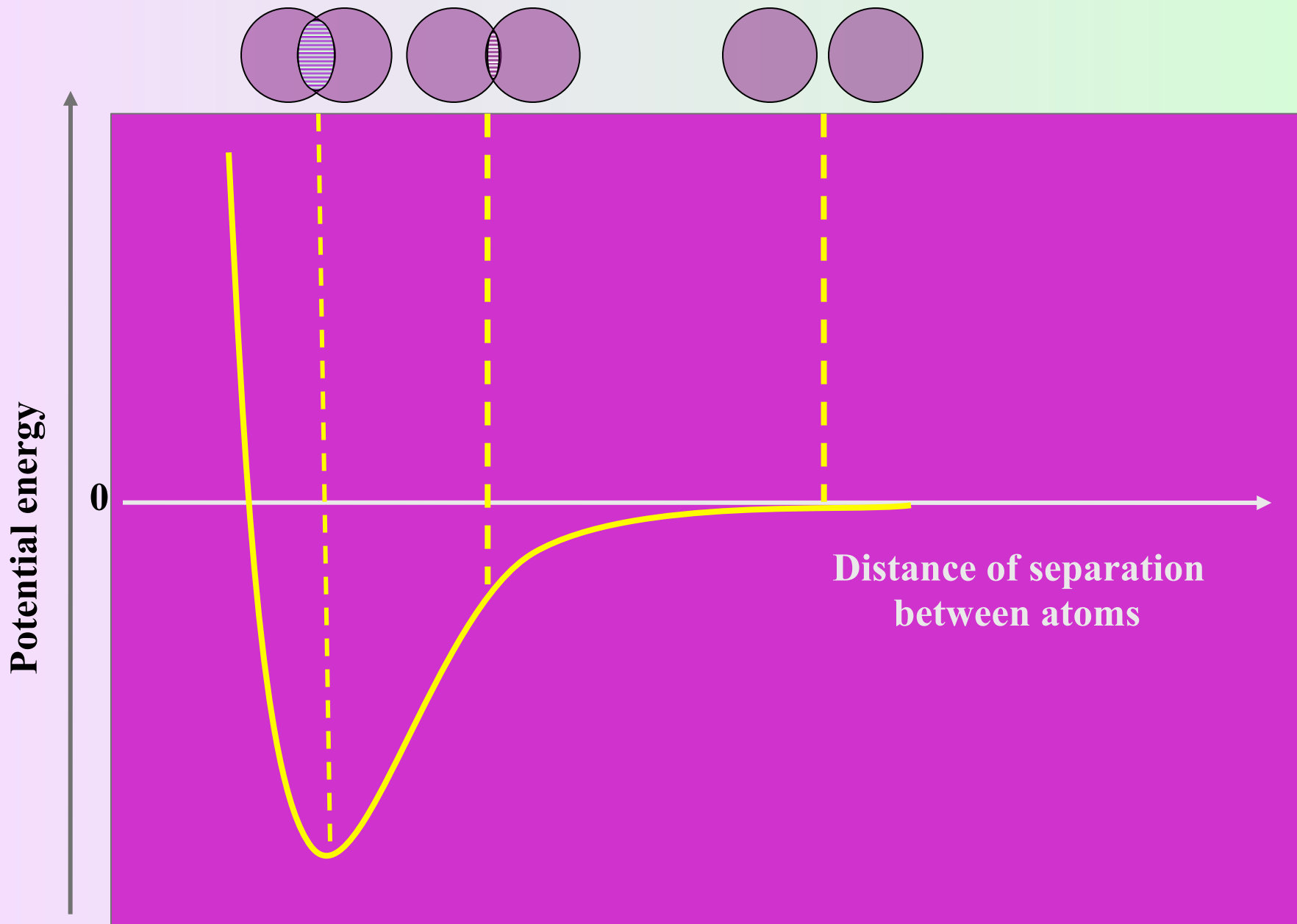
Forming Chemical Bonds

Why do atoms form chemical bonds ?

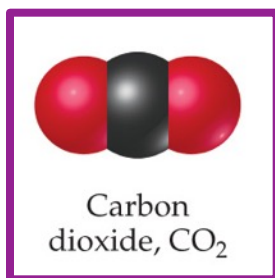
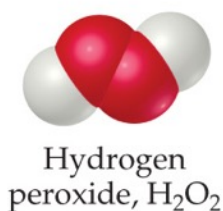
so that the system can achieve the lowest possible potential energy

Example covalent bonding in H_2

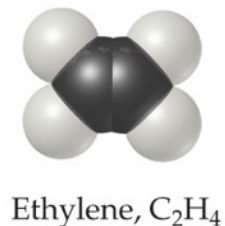




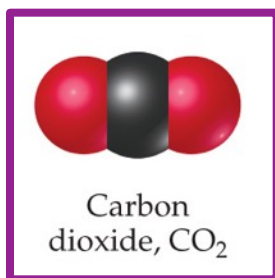
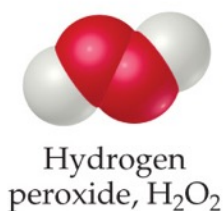
Chemical Formulas



The **subscript** to the right of the symbol of an element tells the number of atoms of that element in one molecule of the compound.



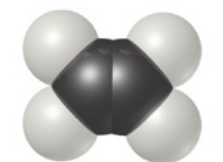
Chemical Formulas



The **subscript** to the right of the symbol of an element tells the number of atoms of that element in one molecule of the compound.



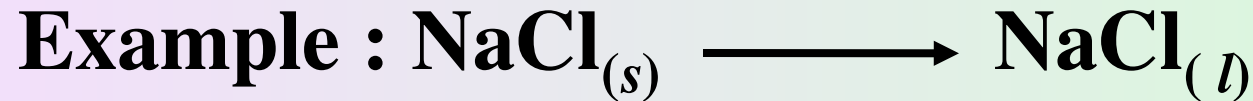
the number 1 is not used as a subscript



Ions and Ionic Compounds

Ionic compounds

Any compound when melted that conducts electricity is considered ionic



$\text{NaCl}_{(s)}$ is made up of Na^+ and Cl^- ions

Ions

When electrons are removed from or added to a neutral atom or molecule, a charged particle called an ion is formed.

Positively charged ions are called
cations

Negatively charged ions are called
anions

Ionic Bonds

especially prevalent in compounds formed between group 1A and 2A elements with group 6A and 7A elements.

between Elements with the biggest difference in electronegativity

Ionic Bonds

especially prevalent in compounds formed between group 1A and 2A elements with group 6A and 7A elements.

between Elements with the biggest difference in **electronegativity**

Electronegativity

**measure of an element to attract electrons
toward itself when bonded to another element**

Electronegativity

Increases from left to right in periodic table.

Decreases going down a group.

Fluorine is the most electronegative element.

Francium is the least electronegative element.

decreasing
electronegativity

increasing
electronegativity

1A 1												3A 13					4A 14	5A 15	6A 16	7A 17	8A 18
1 H																	2 He				
3 Li		4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne			
11 Na		12 Mg	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8 9 10			1B 11	2B 12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar			
19 K		20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr			
37 Rb		38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe			
55 Cs		56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn			
87 Fr		88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cp	113	114	115	116	117	118			

- Metals
- Metalloids
- Nonmetals

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

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Periodic
Properties
of the
Elements

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most
electronegative

1A 1																	8A 18
1 H	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8 9 10			1B 11	2B 12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cp	113	114	115	116	117	118

least
electronegative

59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

Periodic
Properties
of the
Elements

Pauling Electronegativity Scale

		H 2.2				He	
Li 0.98	Be 1.57	B 2.04	C 2.55	N 3.04	O 3.44	F 3.98	Ne
Na 0.93	Mg 1.31	Al 1.61	Si 1.90	P 2.19	S 2.58	Cl 3.16	Ar
K 0.82	Ca 1.00	Ga 1.81	Ge 2.01	As 2.18	Se 2.55	Br 2.96	Kr 2.9
Rb 0.82	Sr 0.95	In 1.78	Sn 1.96	Sb 2.05	Te 2.1	I 2.66	Xe 2.6
Cs 0.79	Ba 0.89	Tl 2.04	Pb 2.33	Bi 2.02	Po 2.0	At 2.2	Rn

Group	1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	1A	2A		3B	4B	5B	6B	7B	8B			1B	2B	3A	4A	5A	6A	7A	8A
Period																			
1	1 H																		2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 Y	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
6	55 Cs	56 Ba	*	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	**	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo
lanthanides	*	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb				
actinides	**	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No				

← Metals
Metalloids
→ Nonmetals

In chemical reactions **metals** tend to lose electrons to **nonmetals**

metals

**good conductors of heat
and electricity**

malleable

ductile

lustrous

**tend to lose
electrons in
chemical reactions**

nonmetals

poor conductors

brittle

—

—

**tend to gain
electrons in
chemical reactions**

Specific Groups

Main groups

group numbers identified by suffix A

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	1A	2A											3A	4A	5A	6A	7A	8A
Period																		
1	1 <u>H</u>																	2 <u>He</u>
2	3 <u>Li</u>	4 <u>Be</u>											5 <u>B</u>	6 <u>C</u>	7 <u>N</u>	8 <u>O</u>	9 <u>F</u>	10 <u>Ne</u>
3	11 <u>Na</u>	12 <u>Mg</u>											13 <u>Al</u>	14 <u>Si</u>	15 <u>P</u>	16 <u>S</u>	17 <u>Cl</u>	18 <u>Ar</u>
4	19 <u>K</u>	20 <u>Ca</u>											31 <u>Ga</u>	32 <u>Ge</u>	33 <u>As</u>	34 <u>Se</u>	35 <u>Br</u>	36 <u>Kr</u>
5	37 <u>Rb</u>	38 <u>Sr</u>											49 <u>In</u>	50 <u>Sn</u>	51 <u>Sb</u>	52 <u>Te</u>	53 <u>I</u>	54 <u>Xe</u>
6	55 <u>Cs</u>	56 <u>Ba</u>											81 <u>Tl</u>	82 <u>Pb</u>	83 <u>Bi</u>	84 <u>Po</u>	85 <u>At</u>	86 <u>Rn</u>
7	87 <u>Fr</u>	88 <u>Ra</u>											113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo

Main group metals

Alkali metals



Alkaline earth metals



Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	1A	2A	3B	4B	5B	6B	7B	8B			1B	2B	3A	4A	5A	6A	7A	8A
Period																		
1																		
2	3 Li	4 Be																
3	11 Na	12 Mg																
4	19 K	20 Ca																
5	37 Rb	38 Sr																
6	55 Cs	56 Ba																
7	87 Fr	88 Ra																

13 Al			
31 Ga	32 Ge		
49 In	50 Sn	51 Sb	
81 Tl	82 Pb	83 Bi	84 Po

transition metals



Group	1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	1A	2A		3B	4B	5B	6B	7B		8B		1B	2B	3A	4A	5A	6A	7A	8A
Period																			
1	1 H																		2 He
2	3 Li	4 Be												5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg												13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca		21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr		39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	**	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo
lanthanides			*	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb		
actinides			**	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No		

Metals versus Nonmetals

- Metals tend to form cations.
- Nonmetals tend to form anions.

1A	2A	Transition metals										3A	4A	5A	6A	7A	8A		
H ⁺																	H ⁻		
Li ⁺														N ³⁻	O ²⁻		F ⁻	N O B L E	
Na ⁺	Mg ²⁺											Al ³⁺		P ³⁻	S ²⁻		Cl ⁻		
K ⁺	Ca ²⁺	Sc ³⁺	Ti ⁴⁺	V ⁵⁺ V ⁴⁺	Cr ³⁺	Mn ²⁺ Mn ⁴⁺	Fe ²⁺ Fe ³⁺	Co ²⁺ Co ³⁺	Ni ²⁺	Cu ⁺ Cu ²⁺	Zn ²⁺				Se ²⁻		Br ⁻	G A S E S	
Rb ⁺	Sr ²⁺									Pd ²⁺	Ag ⁺	Cd ²⁺		Sn ²⁺ Sn ⁴⁺	Sb ³⁺ Sb ⁵⁺	Te ²⁻			I ⁻
Cs ⁺	Ba ²⁺									Pt ²⁺	Au ⁺ Au ³⁺	Hg ₂ ²⁺ Hg ²⁺		Pb ²⁺ Pb ⁴⁺	Bi ³⁺ Bi ⁵⁺				

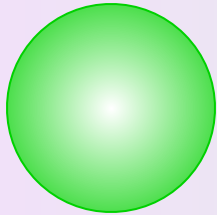
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Ionic and Molecular Compounds

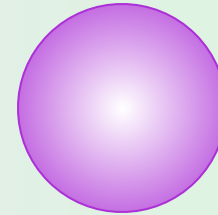
Ionic compounds are usually formed between metals and nonmetals.

Molecular compounds are usually formed between two nonmetals.

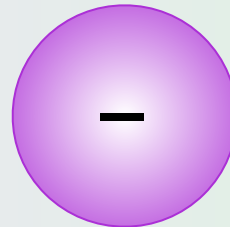
Atoms vs Ions



Na: 11 protons;
11 electrons



Cl: 17 protons;
17 electrons



Na⁺: 11 protons;
10 electrons

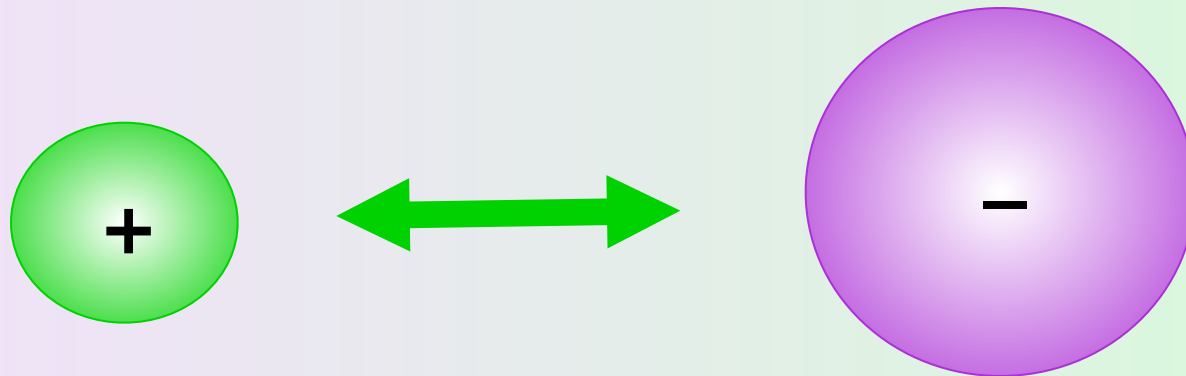
Cl⁻: 17 protons;
18 electrons

Atomic Ions
Dominant form on top

1A	2A											3A	4A	5A	6A		0	
H⁺																H ⁻	He	
Li ⁺	Be ²⁺											B	C	N ³⁻	O ²⁻	F ⁻	Ne	
Na ⁺	Mg ²⁺	3B	4B	5B	6B	7B	8B				1B	2B	Al ³⁺	Si	P ³⁻	S ²⁻	Cl ⁻	Ar
K ⁺	Ca ²⁺	Sc ³⁺	Ti ³⁺ Ti ⁴⁺	V ³⁺ V ⁵⁺	Cr ³⁺ Cr ²⁺	Mn ²⁺ Mn ⁴⁺	Fe ²⁺ Fe ³⁺	Co ²⁺ Co ³⁺	Ni ²⁺ Ni ³⁺	Cu ²⁺ Cu ⁺	Zn ²⁺	Ga ³⁺	Ge ⁴⁺	As ³⁻	Se ²⁻	Br ⁻	Kr	
Rb ⁺	Sr ²⁺	Y ³⁺	Zr ⁴⁺	Nb ⁵⁺ Nb ³⁺	Mo ⁶⁺	Tc ⁷⁺	Ru ³⁺ Ru ⁴⁺	Rh ³⁺	Pd ²⁺ Pd ⁴⁺	Ag ⁺	Cd ²⁺	In ³⁺	Sn ⁴⁺ Sn ²⁺	Sb ³⁺ Sb ⁵⁺	Te ²⁻	I ⁻	Xe	
Cs ⁺	Ba ²⁺	La ³⁺	Hf ⁴⁺	Ta ⁵⁺	W ⁶⁺	Re ⁷⁺	Os ⁴⁺	Ir ⁴⁺	Pt ⁴⁺ Pt ²⁺	Au ³⁺ Au ⁺	Hg ²⁺ Hg ⁺	Tl ⁺ Tl ³⁺	Pb ²⁺ Pb ⁴⁺	Bi ³⁺ Bi ⁵⁺	Po ²⁺ Po ⁴⁺	At ⁻	Rn	
Fr ⁺	Ra ²⁺	Ac ³⁺																

Ionic Bonding

electrostatic attraction between oppositely charged ions

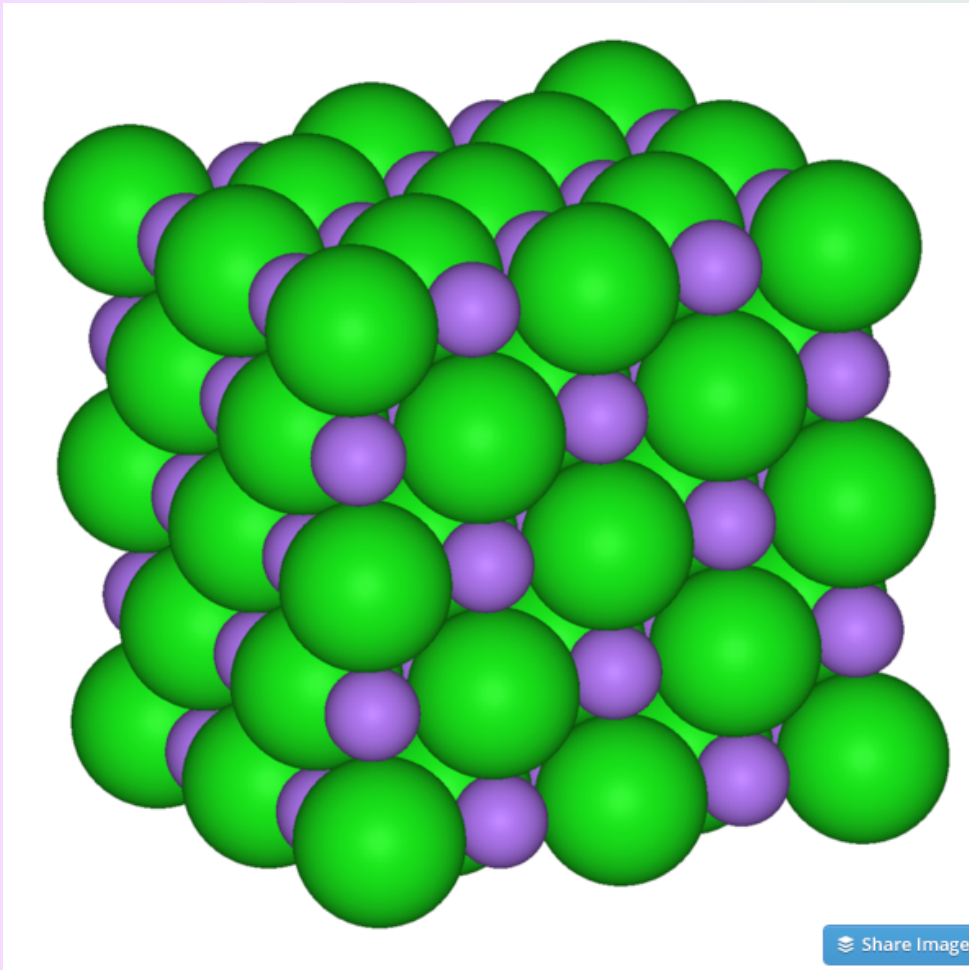


Ionic Compounds

discrete molecules are not present, so ionic compounds are represented by their **empirical formulas**

some times referred to as **formula units**

Empirical formula tells us which elements are present and the simplest whole-number ratio of their atoms.



**Solid
structure
of LiF**

**Crystal
lattice**

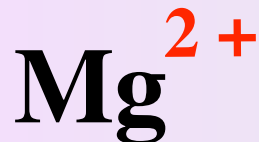
**the ions are packed together to maximize (+) (-)
attractions and minimize (+) (+) and (-) (-)
repulsions**

Writing Formulas

- compounds are electrically neutral
- The sum of the positive charges of the cations must equal the sum of the negative charges on the anions.
- The subscripts in the chemical formula must be in smallest whole numbers

Writing Formulas

group II A

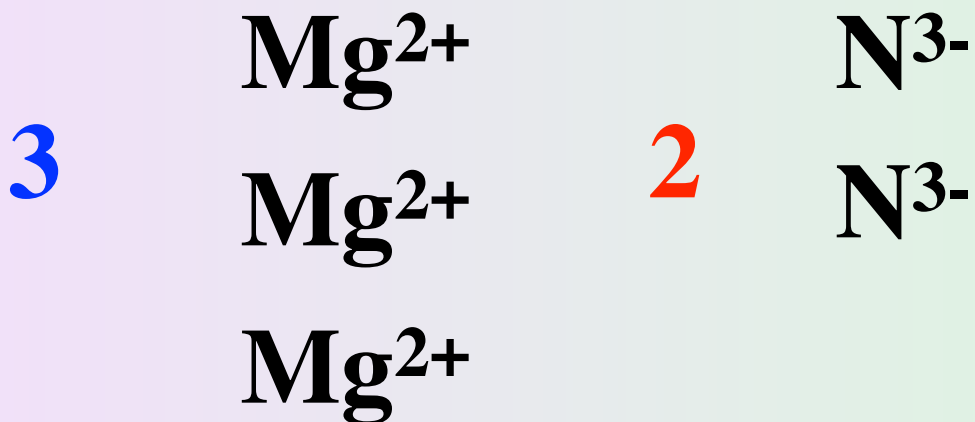
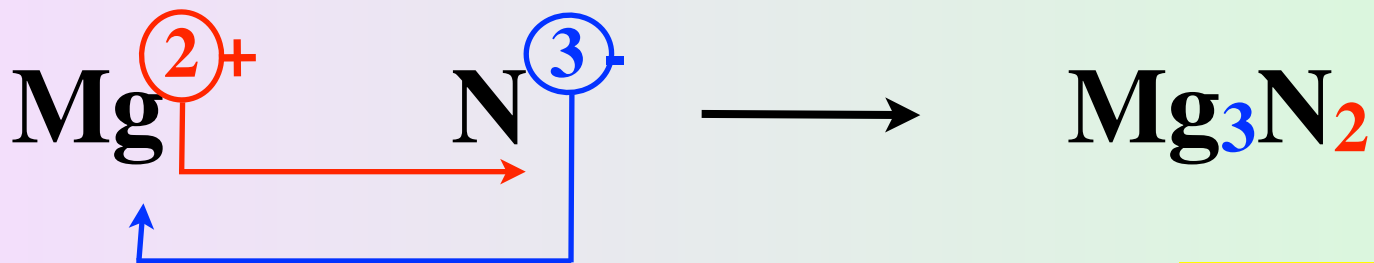


group VA



- find the charge on the ions

Writing Formulas

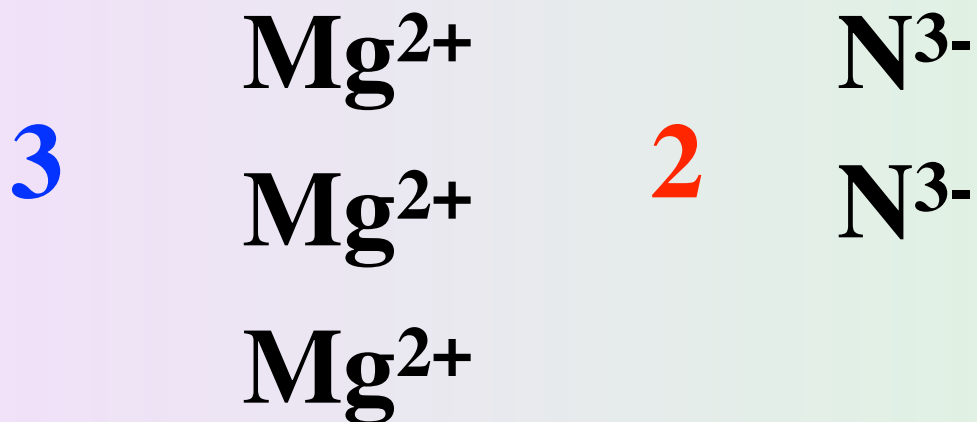
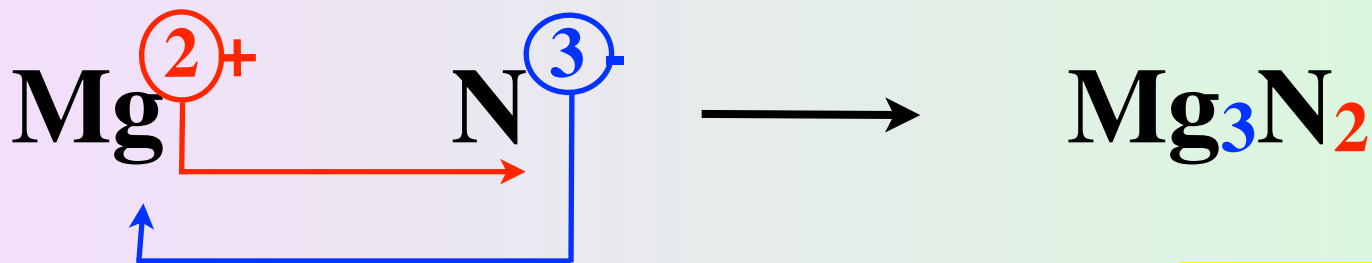


$$3(2+) = +6$$

$$-6 = 2(3-)$$

- *compounds are electrically neutral*

Writing Formulas



- *subscripts in smallest whole numbers*

$$3(2+) = +6$$

$$-6 = 2(3-)$$

**Molecules:
Atoms in Combination**

Definition

Molecule —is an aggregate of at least **two** atoms in a definite arrangement held together by chemical forces.

bonds



structure



Chemical Formulas

Express the composition of molecules and ionic compounds in terms of the symbols for the elements they contain.

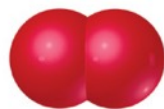
Empirical formula tells us which elements are present and the simplest whole-number ratio of their atoms.

Molecular formula gives the exact number of atoms each element in the compound

Chemical Formulas



Hydrogen, H₂



Oxygen, O₂



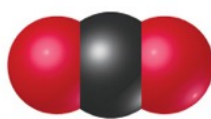
Water, H₂O



Hydrogen peroxide, H₂O₂



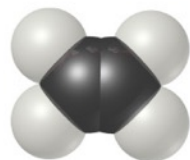
Carbon monoxide, CO



Carbon dioxide, CO₂



Methane, CH₄



Ethylene, C₂H₄

Molecular compounds are composed of molecules and almost always contain only nonmetals.

A molecule is not necessarily a compound.

Example



A compound is not necessarily molecular.

ionic compounds

