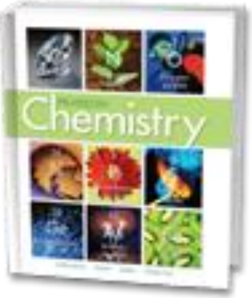


Chapter 7A

Ionic and Metallic Bonding

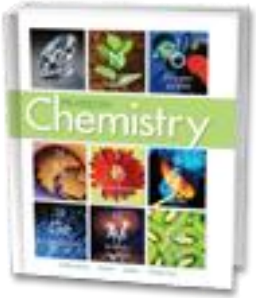
Ions

Ionic Bonds &

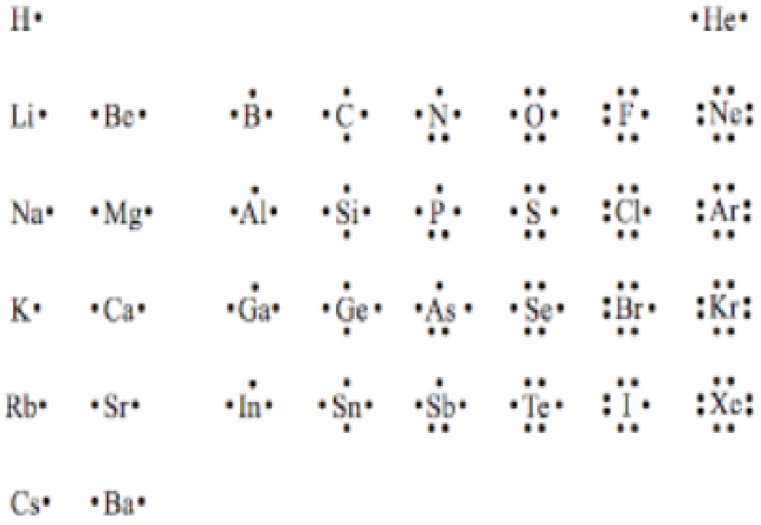
Forming Ionic Compounds

Properties of Ionic Compounds

Bonding in Metals



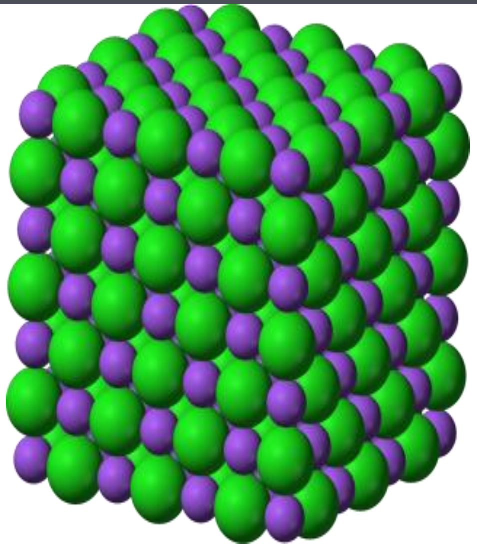
IONIC & METALLIC BONDING CHAPTER 7A



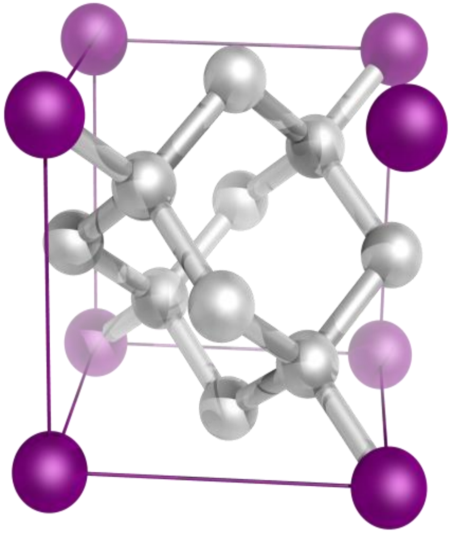
Topics:
1. Ionic and Metallic Bonding
2. Matter and Change

Objectives:
1. Understand the conditions of stability for atoms related to bonding.
2. Explain and show how elements become ions (cations and anions).
3. Explain the ionic compounds in terms of formation, electrical charge, structure and Electronegativity Difference.
4. Describe how the mass of the reactants and products of a chemical reaction is conserved

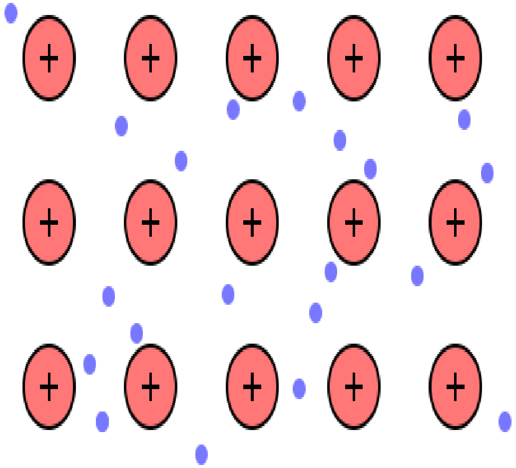
There are three main ways that elements can come together to form bonds.



Ionic

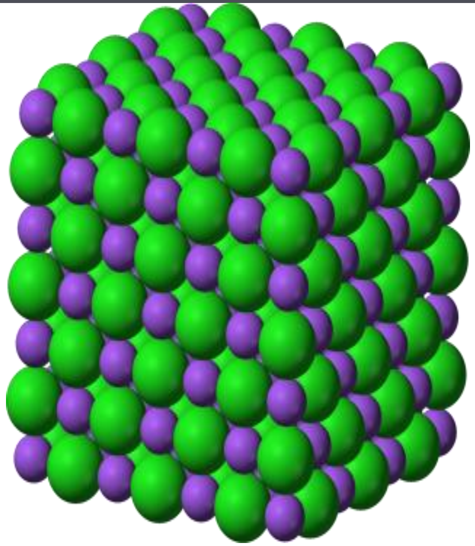


Covalent

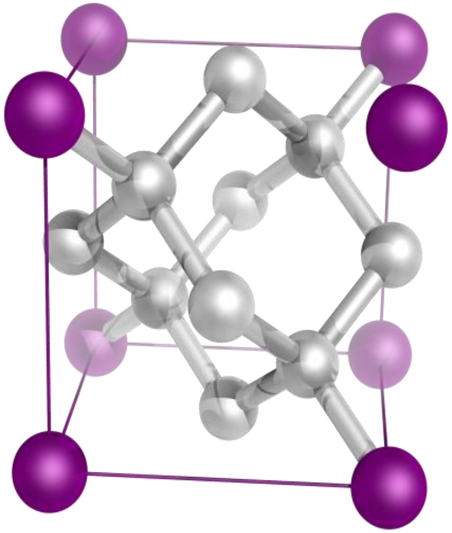


Metallic

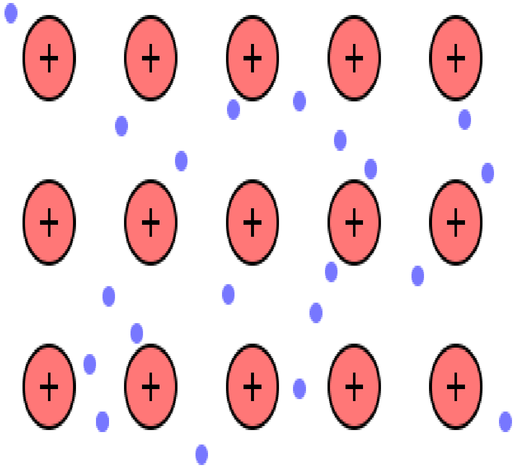
There are three main ways that elements can come together to form bonds.



Ionic



Covalent



Metallic

Why Do Atoms Bond?

Conditions for Atoms to Bond

?

?

LESSON QUESTION

Why Do Atoms Bond?

Conditions for Atoms to Bond

Electrical Neutrality

- Atoms are neutral before bonding.
- Ionic compounds are neutral because they have both cations and anions.

Complete Valence

- Atoms have incomplete valence prior to bonding.
- Atoms bond to complete their outer shell of electrons (8) (octet rule).

Valence Electrons & the Octet Rule

Valence electrons occupy the highest energy level of an atom and is indicated by the **GROUP A number (I-VIII)**.

The number of valence electrons largely determines the chemical properties of an element because valence electrons are usually the only electrons involved in chemical bonds.

The Octet Rule

Atoms desire to fill their valence (outermost energy level). This will cause them to achieve the electron configuration of a noble gas: ns^2np^6. This is to obtain a very stable, low-energy situation for the atoms.

An octet is a set of (8).

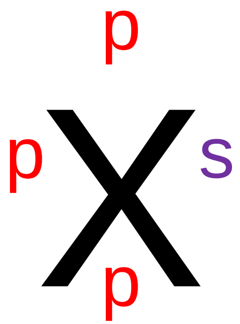
Electron Dot Diagrams

Also called Lewis structures

Show valence electrons in the atoms of an element (dots)

Usually only the **valence electrons** are shown in electron dot (Lewis) structures.

Valence electrons include the outermost "s" and "p" orbitals:



Remember, each orbital can contain up to 2 e-

Electron Dot Diagrams

Ctr notes (6:59)

https://screencast-o-matic.com/watch/cFQ3qbqSJ4

Lewis Structures (5 steps) (4:57)

https://screencast-o-matic.com/watch/cFQ3lKqS4e

Lewis Structures (Electron Dot Diagrams)

TRY IT

Give the nuclear symbol and e- dot diagrams:

Lithium

Gallium

Phosphorus

Fluorine

Magnesium

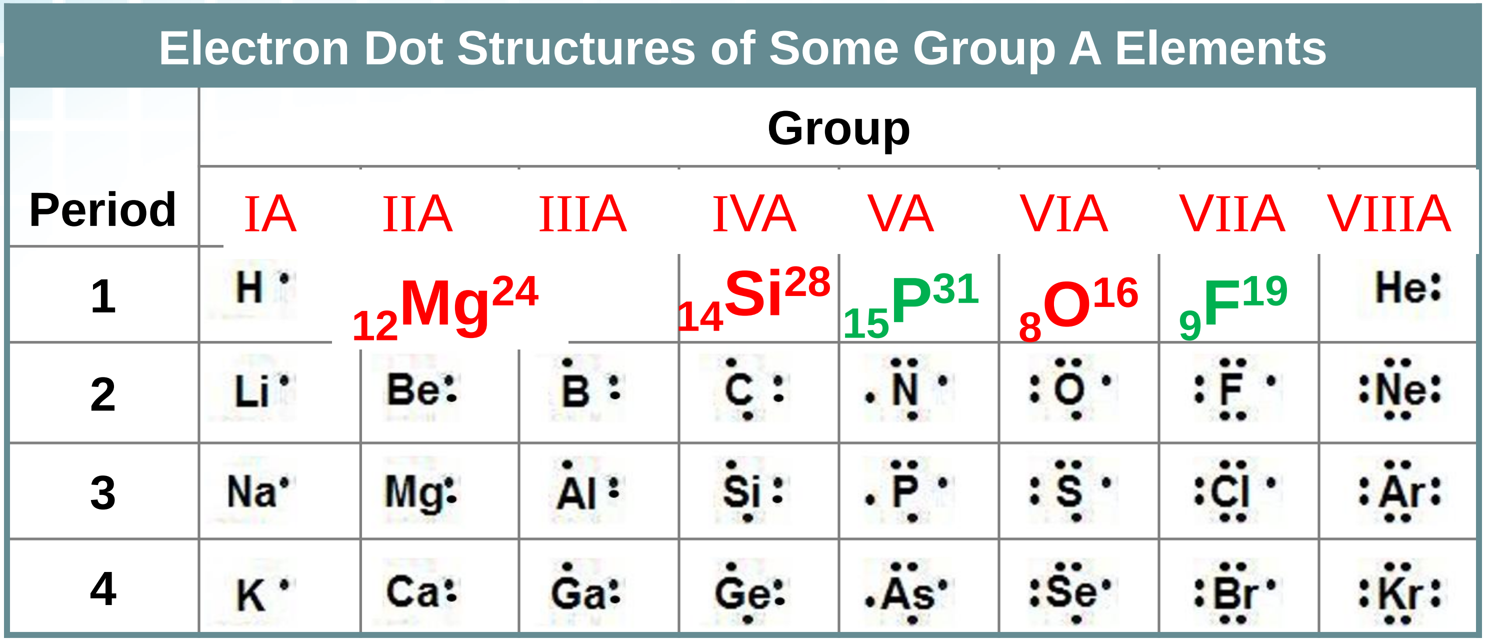
Silicon

Oxygen

Argon

7.1 Ions > Lewis (Electron dot) Structures

TRY IT



Electron Dot Structures of Some Group A Elements

Period	IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
	Group							
1	H	$_{12}Mg^{24}$		$_{14}Si^{28}$	$_{15}P^{31}$	$_{8}O^{16}$	$_{9}F^{19}$	He
2	Li	Be	B	C	N	O	F	Ne
3	Na	Mg	Al	Si	P	S	Cl	Ar
4	K	Ca	Ga	Ge	As	Se	Br	Kr

$_{3}Li^{7}$

$_{18}Ar^{40}$

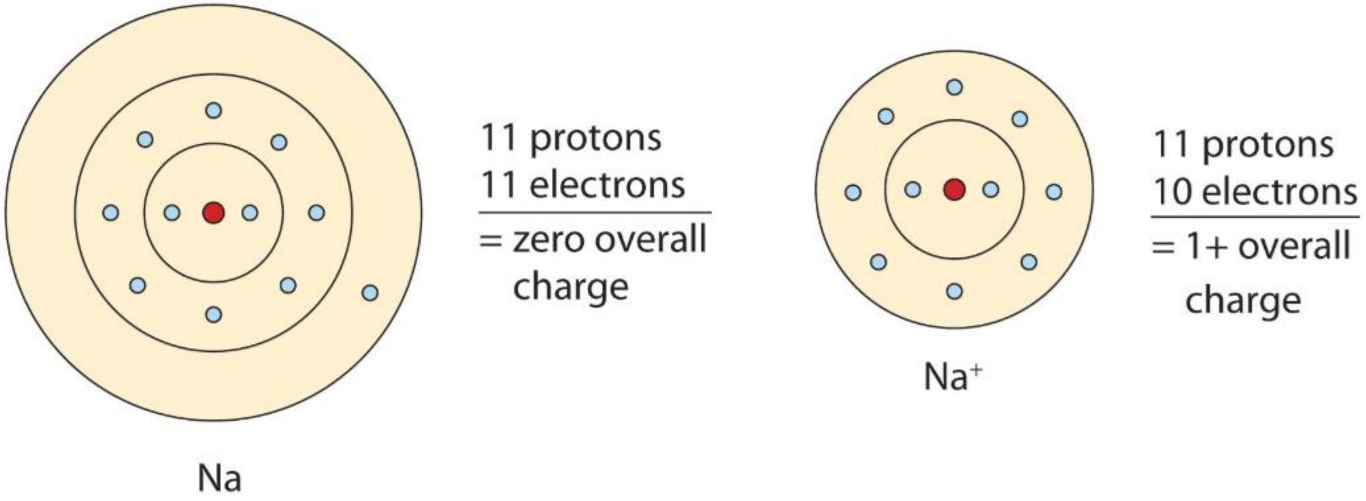
$_{31}Ga^{70}$

Notice that all the electrons within a given "A" group (*with the exception of helium*) have the same number of electron dots in their structures.

Formation of **Cations**

A **neutral** atom (*unbonded*) is electrically neutral because it has **equal numbers of protons and electrons**.

An **ion** forms when an atom or group of atoms loses or gains electrons. A positively charged ion, or cation, is produced when an atom loses one or more valence electrons.



Formation of **Cations**

Metals tend to **lose their valence electrons** (**Low Ionization Energy**), leaving a **complete octet or valence** in the next-lowest energy level.

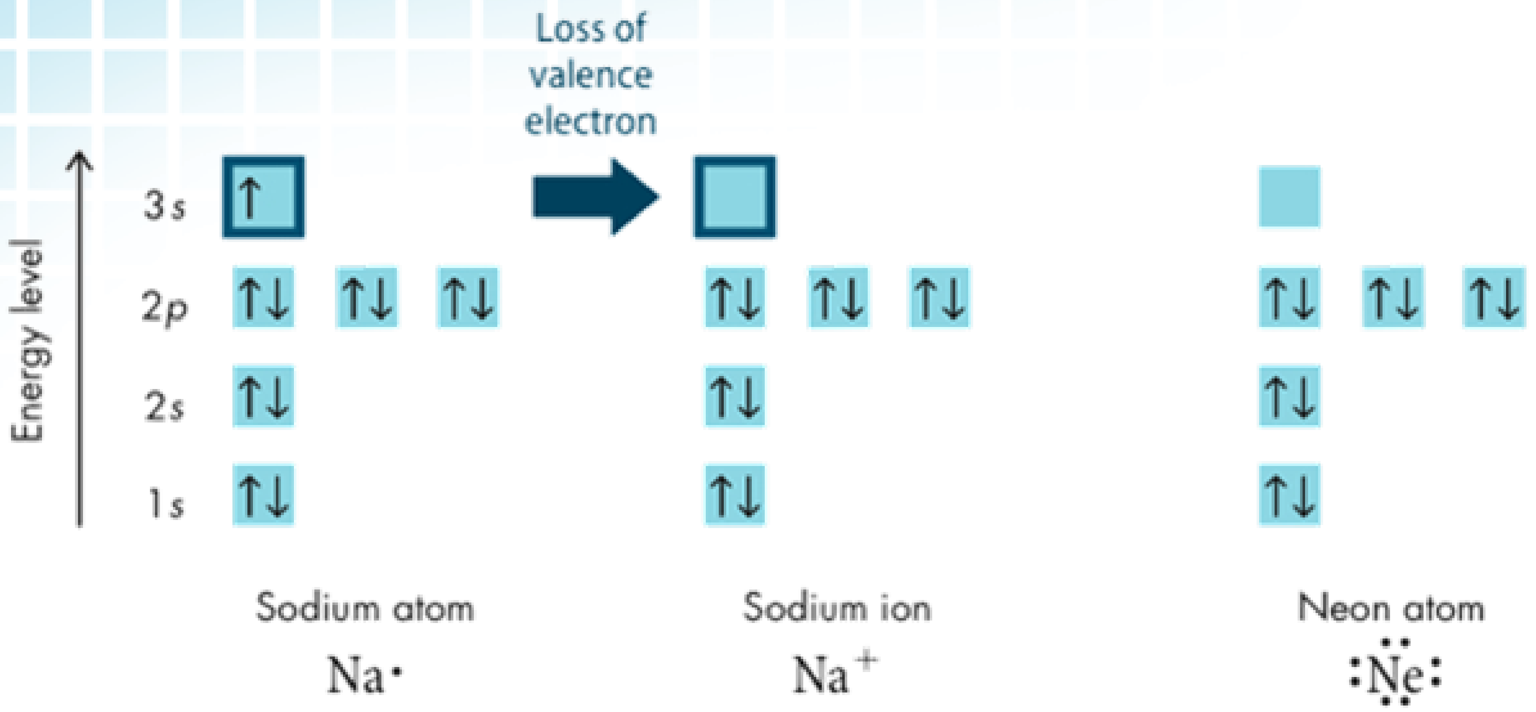
- A sodium atom (Na) forms a sodium cation (Na^+).

  +11 p 11 e- → +11 p 10 e- = +1 cation

- A calcium atom (Ca) forms a calcium cation (Ca^{2+}).

  +20 p 20 e- → +20 p 18 e- = +2 cation

Group IA Cations



$$\mathrm{Na}\ \ 1s^2 2s^2 2p^6 3s^1 \xrightarrow{-e^-} \mathrm{Na}^+\ \ 1s^2 \underbrace{2s^2 2p^6}_{\text{octet}}$$

Both the sodium ion and the neon atom have eight electrons in their valence shells (highest occupied energy levels).

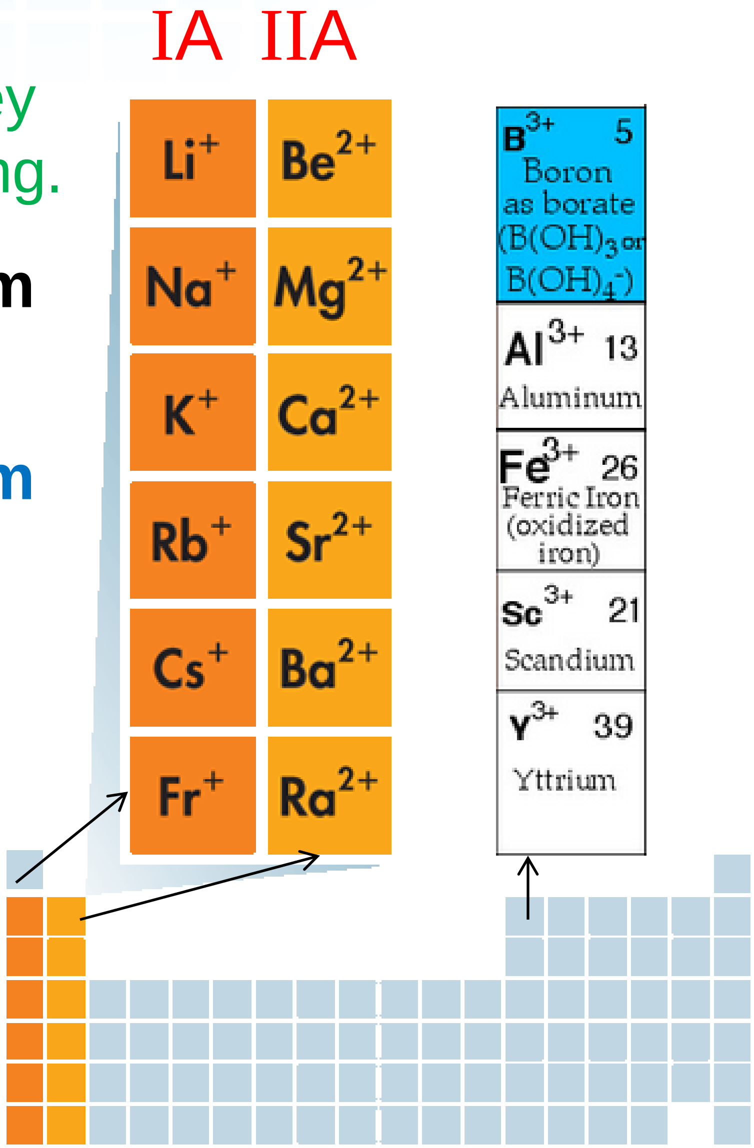
7.1 Ions > Formation of Cations

Remember that metals have a LOW Ionization Energy (I.E.), meaning they easily give up electrons when bonding.

Group 1A elements ALWAYS form 1+ cations.

Group 2A elements ALWAYS form 2+ cations.

Group 3A elements usually form +3 cations.



Practice Making Cations

Give the nuclear symbol, *p+*, *e-*, *charge*, *valence* of each element BEFORE bonding.

Aluminum

Magnesium

Potassium

Boron

Practice Making Cations

TRY IT

Give the nuclear symbol, *p+*, *e-*, *charge*, *valence* of each element BEFORE bonding.

Aluminum

${}_{13}\mathrm{Al}^{27}$

13p 13e- = 0

$[\mathrm{Ne}]3s^{2}3p^{1}$

Magnesium

${}_{12}\mathrm{Mg}^{24}$

12p + 12e- = 0

$[\mathrm{Ne}]3s^{2}$

Potassium

${}_{19}\mathrm{K}^{39}$

19p + 19e- = 0

$[\mathrm{Ar}]4s^{1}$

Boron

${}_{5}\mathrm{B}^{11}$

5 p + 5e- = 0

$[\mathrm{He}]2s^{2}2p^{1}$

Practice Making Cations

TRY IT

Give the cation of each element AFTER bonding (*include p*+, *e*-, *charge, valence*)

Aluminum

Magnesium

Potassium

Boron

7.1 Ions > Practice Making Cations

TRY IT

Give the cation of each element AFTER bonding (*include p+, e-, charge, valence*)

Aluminum

Al^{+3}

13p 10e-

[Ne] → $2s^2 2p^6$

Magnesium

Mg^{+2}

12p 10e-

[Ne] → $2s^2 2p^6$

Potassium

K^{+}

19p 18e-

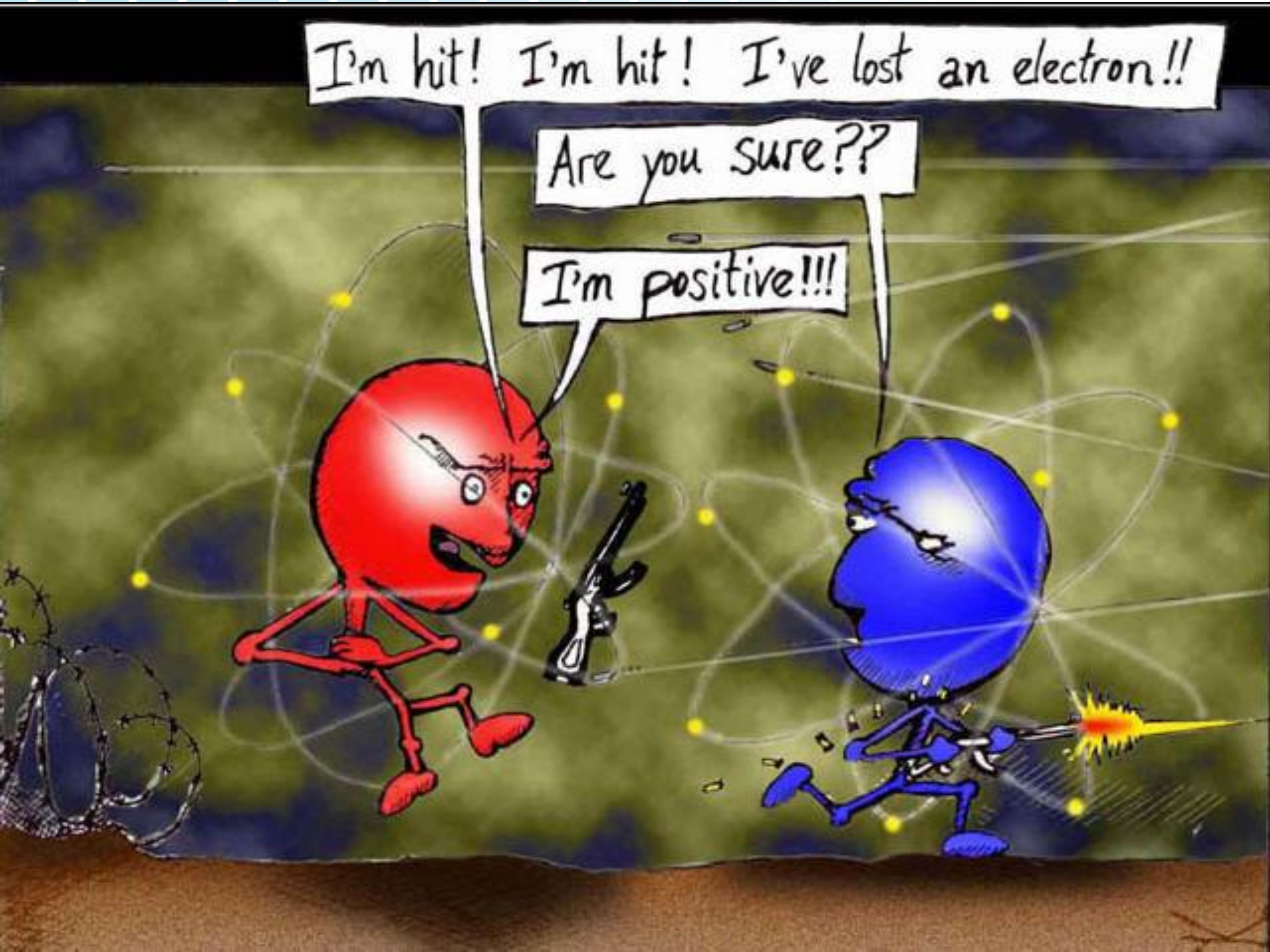
[Ar] → $3s^2 3p^6$

Boron

B^{+3}

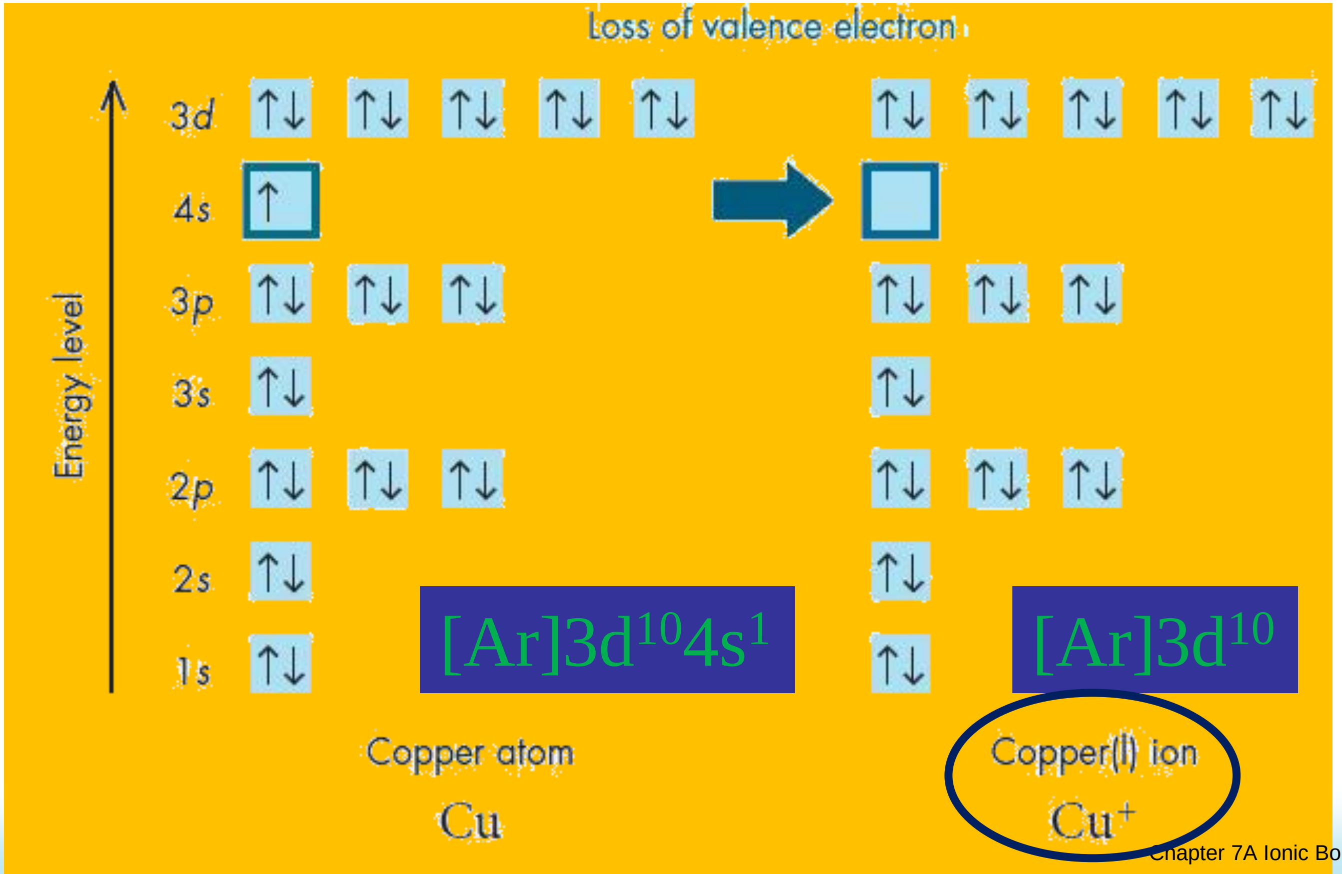
5 p 2e-

[He] → $1s^2$


I'm hit! I'm hit! I've lost an electron!!
Are you sure??
I'm positive!!!

Transition Metal Cations

The charges of transition metal cations vary due to the “**d**” sublevel. E.g. A copper atom loses its lone 4s electron to form a copper ion (Cu^+) with a pseudo noble-gas electron configuration:



$[Ar]3d^{10}4s^1$

$[Ar]3d^{10}$

Formation of Anions

An anion is produced when an atom **gains** or shares one or more **valence electrons**.

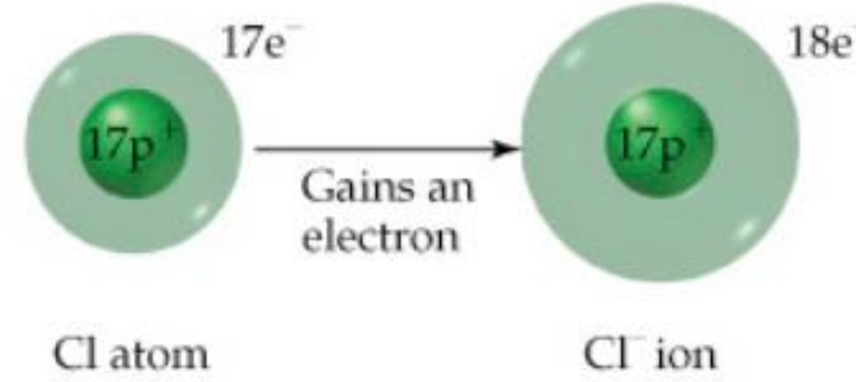
As with metals, atoms of nonmetals and metalloids form anions by filling their valence **to attain noble gas electron configuration**.

$$\mathrm{Cl}\quad 1s^22s^22p^63s^23p^5 \xrightarrow{+e^-} \mathrm{Cl}^- \quad 1s^22s^22p^6\underbrace{3s^23p^6}_{\text{octet}}$$

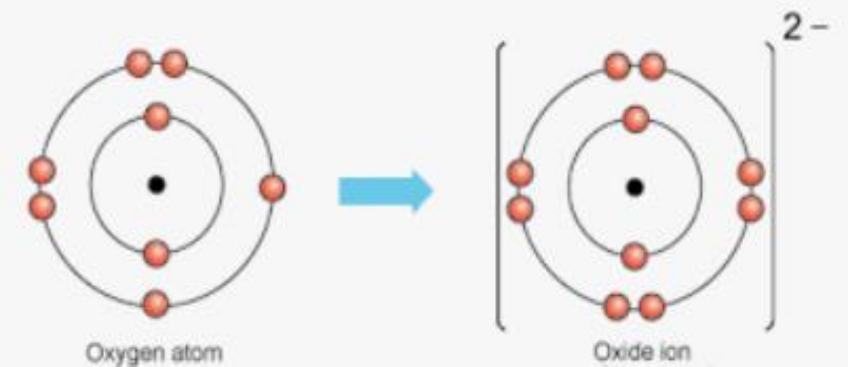
Formation of Anions

The name of an anion of a nonmetallic element is *not* the same as the element name. The name of the anion typically **ends in *-ide***.

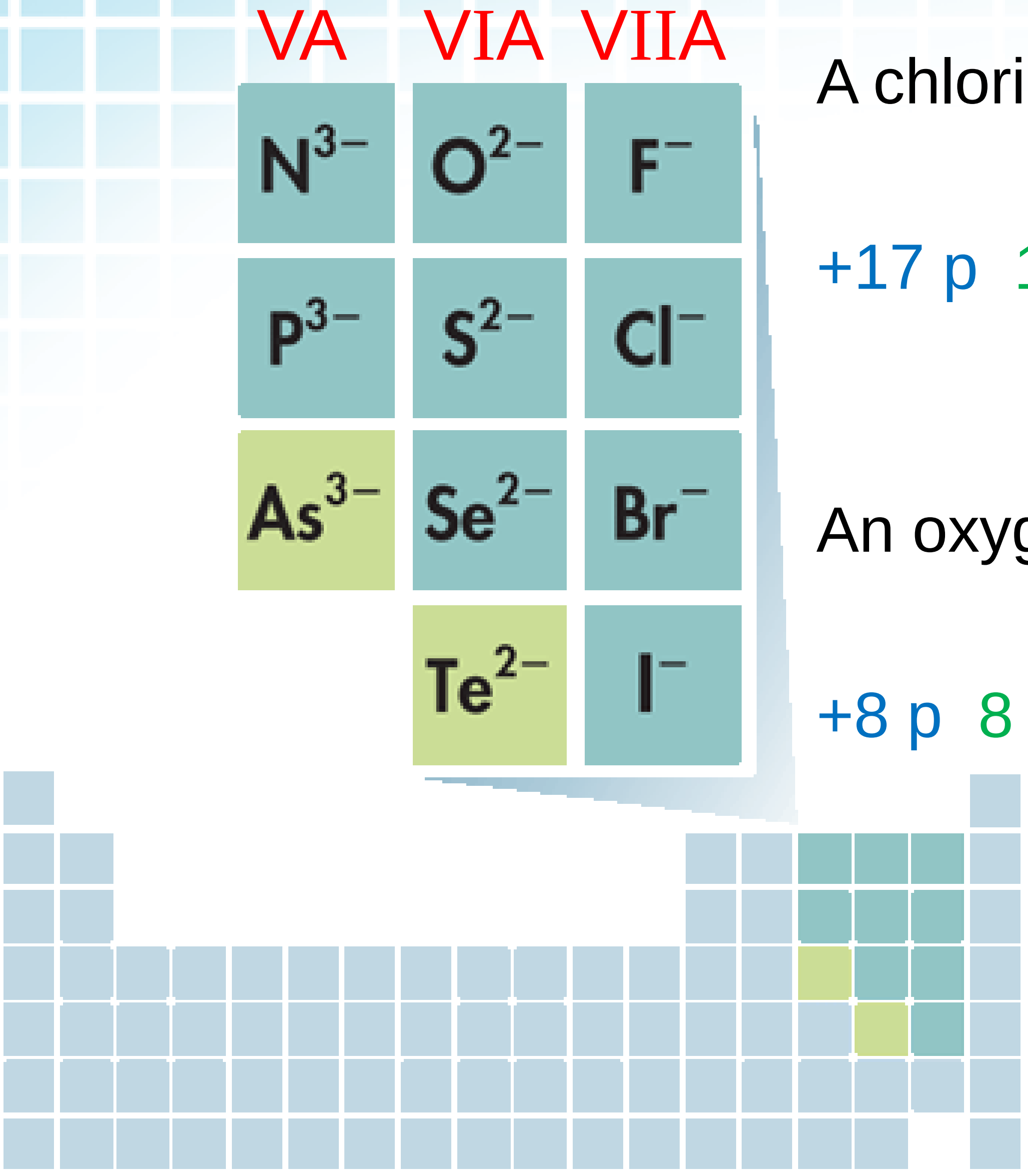
A chlorine atom (Cl) forms a chloride anion (Cl^-).



An oxygen atom (O) forms an oxide anion (O^{2-}).



7.1 Ions > Formation of Anions



A chlorine atom (Cl) forms a chloride anion (Cl-)

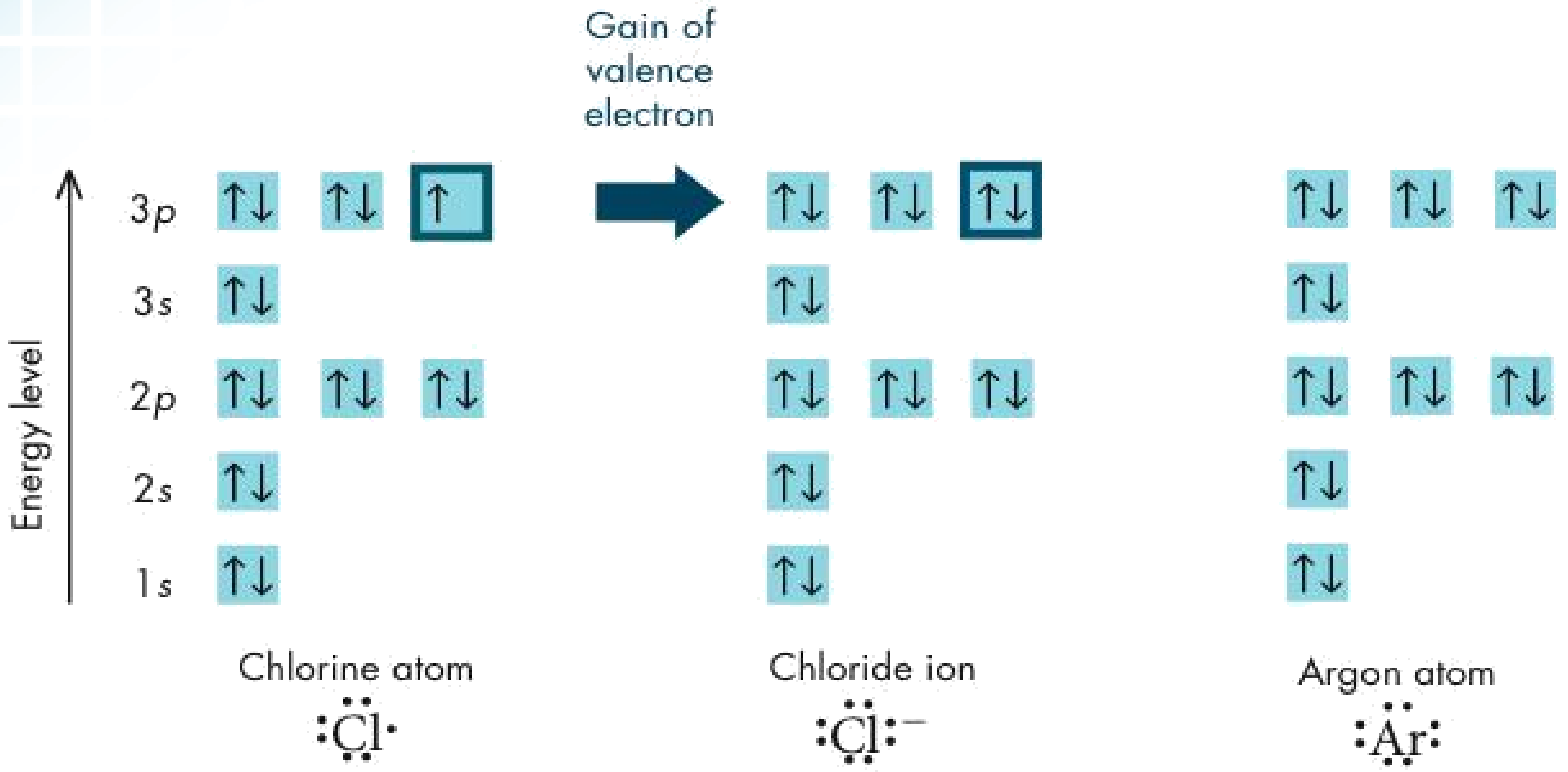
+17 p 17 e- → +17 p 18 e- = -1 anion

An oxygen atom (O) forms an oxide anion (O^{2-})

+8 p 8 e- → +8 p 10 e- = -2 anion

Formation of Anions

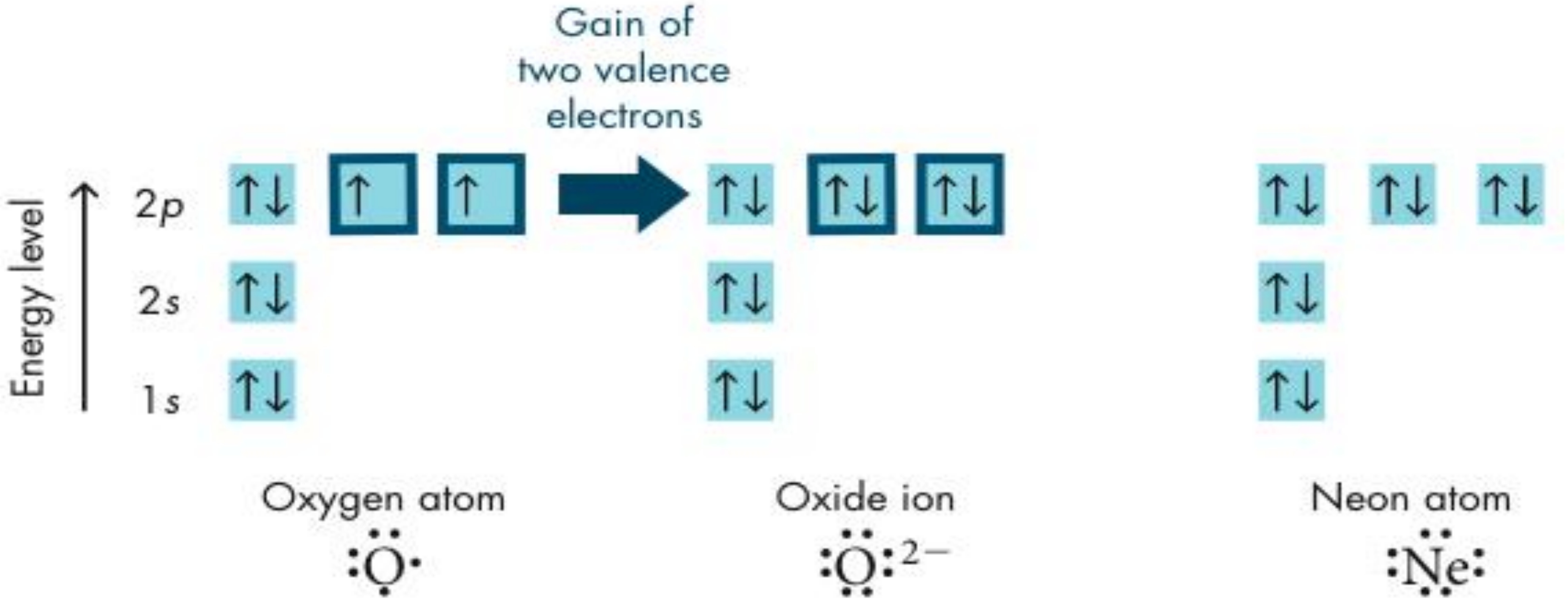
Chlorine atoms need one more valence electron to achieve the electron configuration of the nearest noble gas [Ar].



Formation of Anions

Oxygen is in Group VIA, and has six valence electrons.

An oxygen atom attains the electron configuration of neon by gaining two electrons (full valence).



QUICK CHECK

Show *e- dot diagram* of the following atoms & how they become ions (*p+, e-, charge, 'Kernel'*):

Potassium

Nitrogen

Sulfur

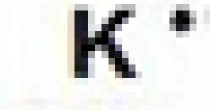
Beryllium

Aluminum

Bromine

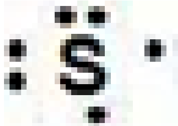
QUICK CHECK

Show *e- dot diagram* of the following atoms & how they become ions (*p+, e-, charge, 'Kernel'*):

Potassium


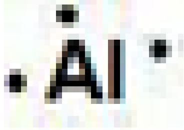
+19 p **18 e-**

+1 cation, [Ar]$^{+1}$

Sulfur


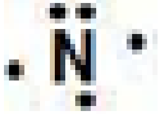
+16 p **18 e-**

-2 anion, [Ar]$^{-2}$

Aluminum


+13 p **10 e-**

+3 cation, [Ne]$^{+3}$

Nitrogen


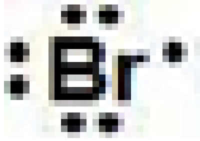
+7 p **10 e-**

-3 anion, [Ne]$^{-3}$

Beryllium


+4 p **2 e-**

+2 cation, [He]$^{+2}$

Bromine


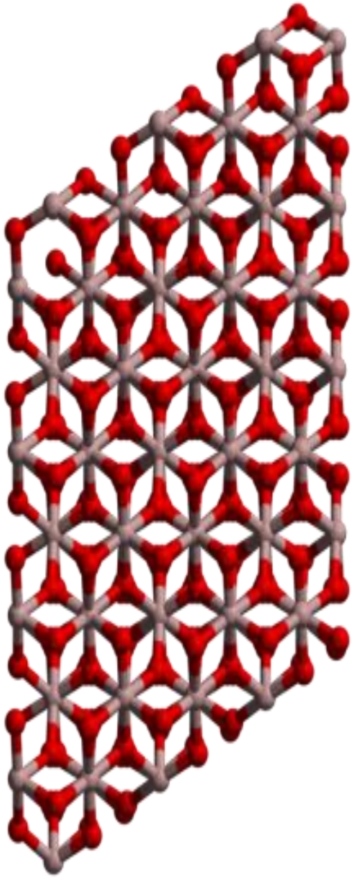
+35 p **36e-**

-1 anion, [Kr]$^{-1}$

How Do Ionic Bonds Form between Atoms?

LESSON QUESTION

How Ionic Compounds Form



Sodium chloride, or table salt, is an ionic compound consisting of sodium cations and chloride anions.

- An **ionic compound** is a compound composed of **cations** and **anions**.
- Although they are composed of ions, ionic compounds are electrically neutral overall. The total positive charge of the cations equals the total negative charge of the anions.

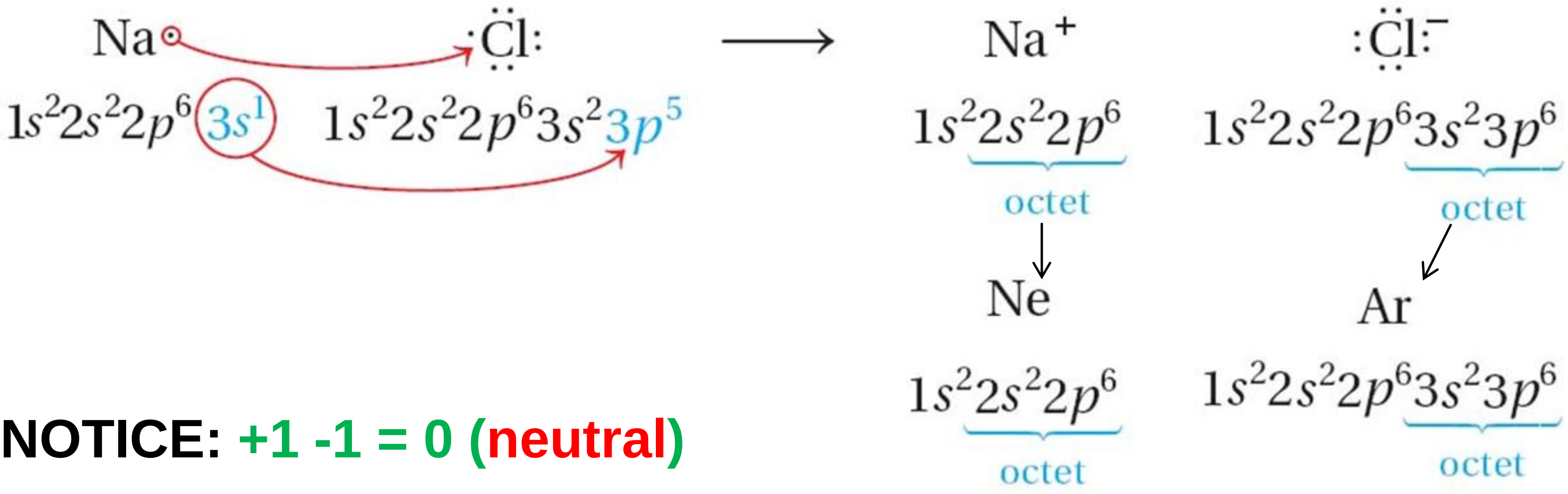
Ionic Bonds

Anions and cations have **opposite** charges and **attract** one another by means of electrostatic forces which are called **ionic bonds**.

When sodium and chlorine react to form a compound, the sodium atom **transfers** its one valence electron to the chlorine atom.

Ionic Bonds

To obtain electrical neutrality and stable octets, Sodium and chlorine atoms combine in a one-to-one ratio.

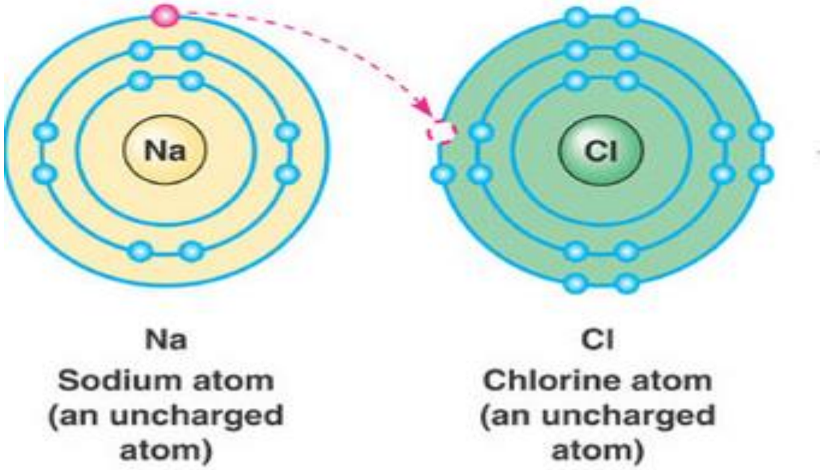


NOTICE: +1 -1 = 0 (neutral)

Ionic Bonds

An **ionic bond** is an attraction between two oppositely charged ions.

Atoms are most stable with electrical neutrality and full valence.



Ionic Bonds

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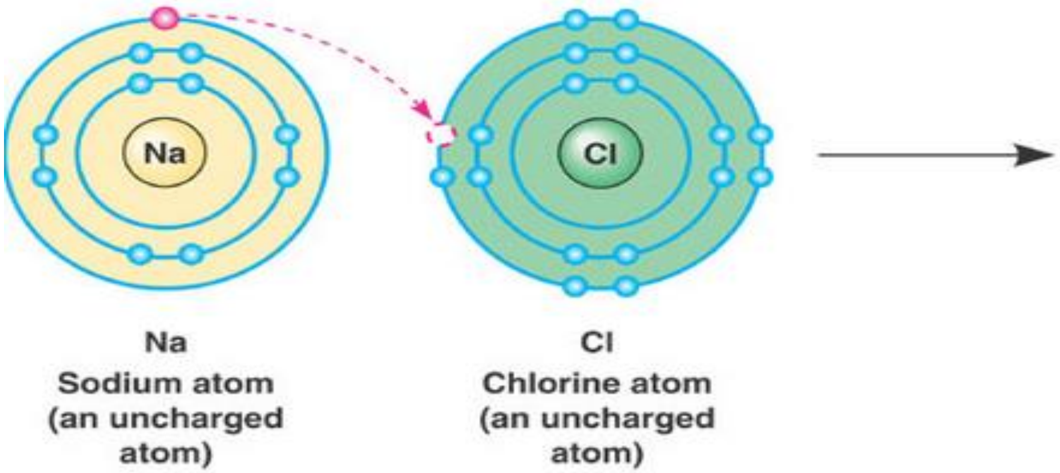


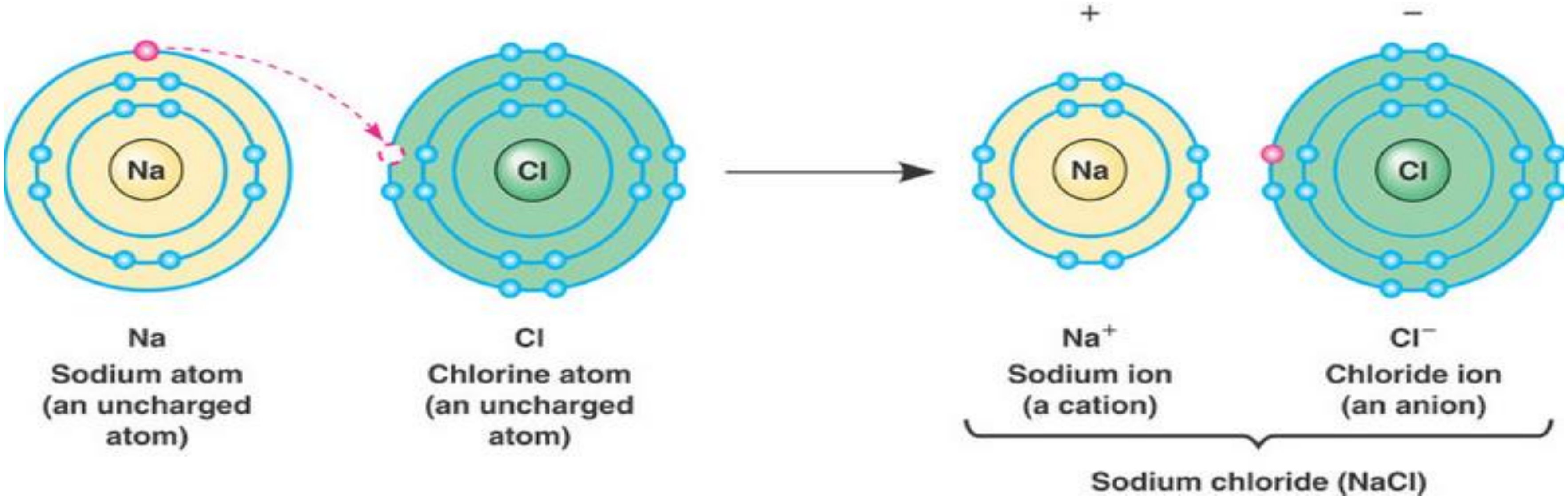
Na and Cl are electrically neutral, but their valence is NOT full

To become more stable, sodium transfers its electron to Chlorine

Ionic Bonds

An **ionic bond** is an attraction between two oppositely charged ions.

Atoms are most stable with electrical neutrality and full valence.

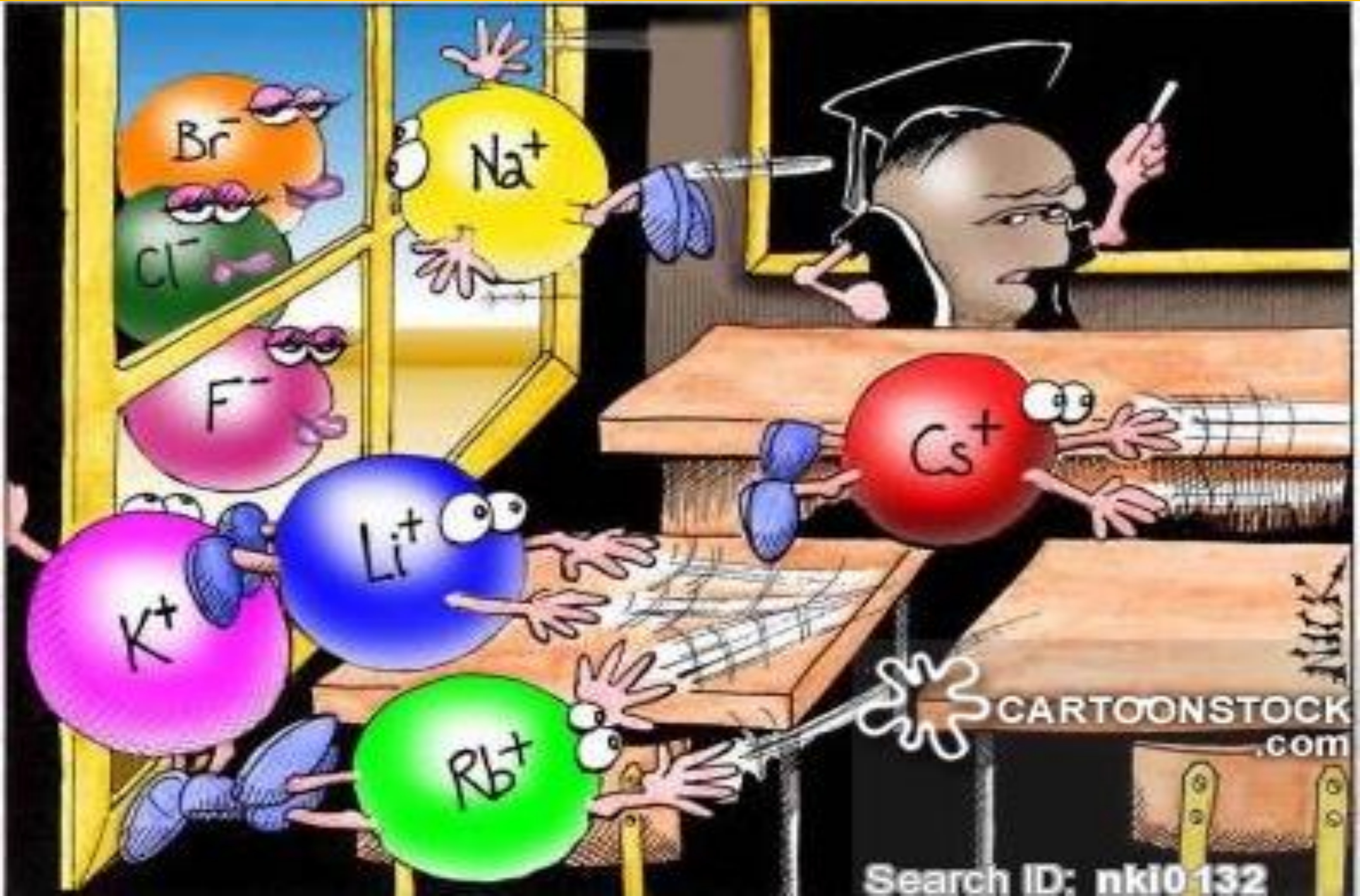


Na and Cl are electrically neutral, but their valence is NOT full

To become more stable, sodium transfers its electron to Chlorine

Electrostatic attraction between ions

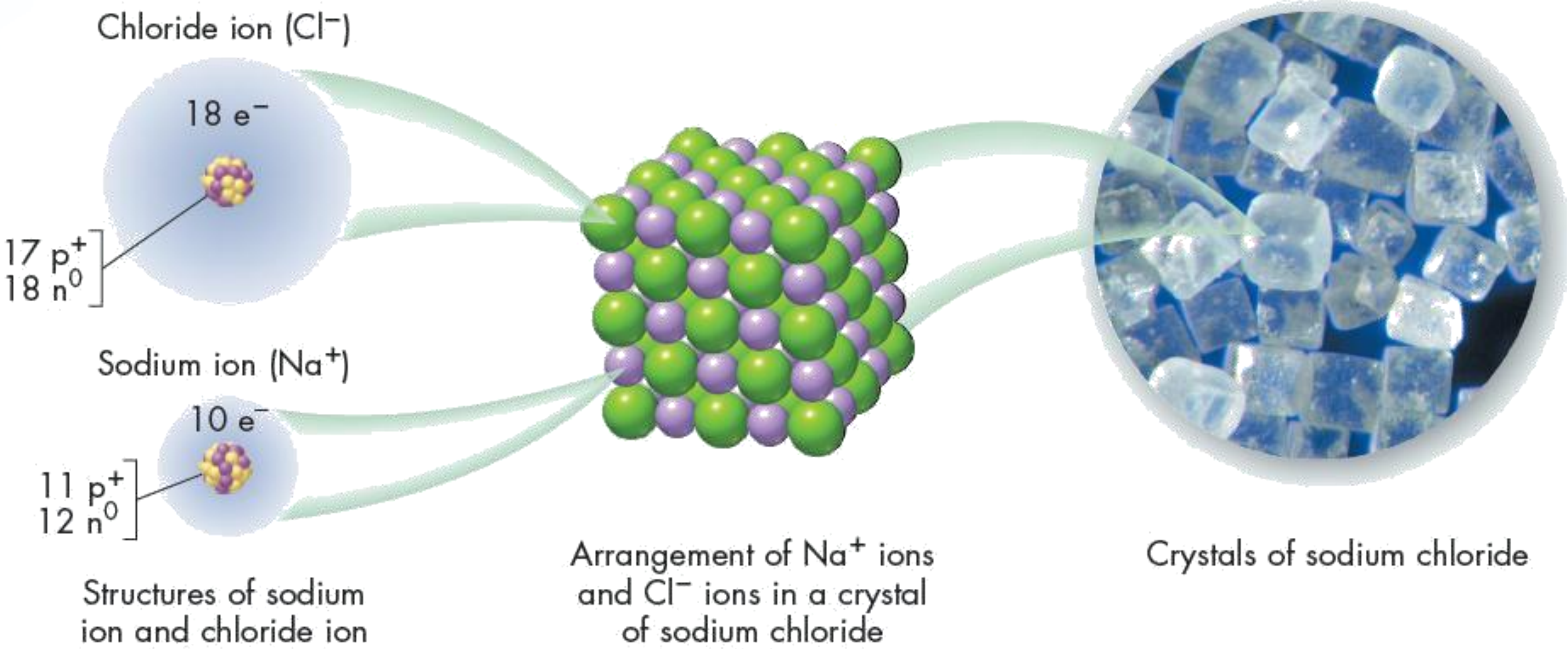
Perhaps one of you gentlemen would mind telling me just what it is outside the window that you find so attractive?



7.1 Ions > Formation of Ionic Compounds

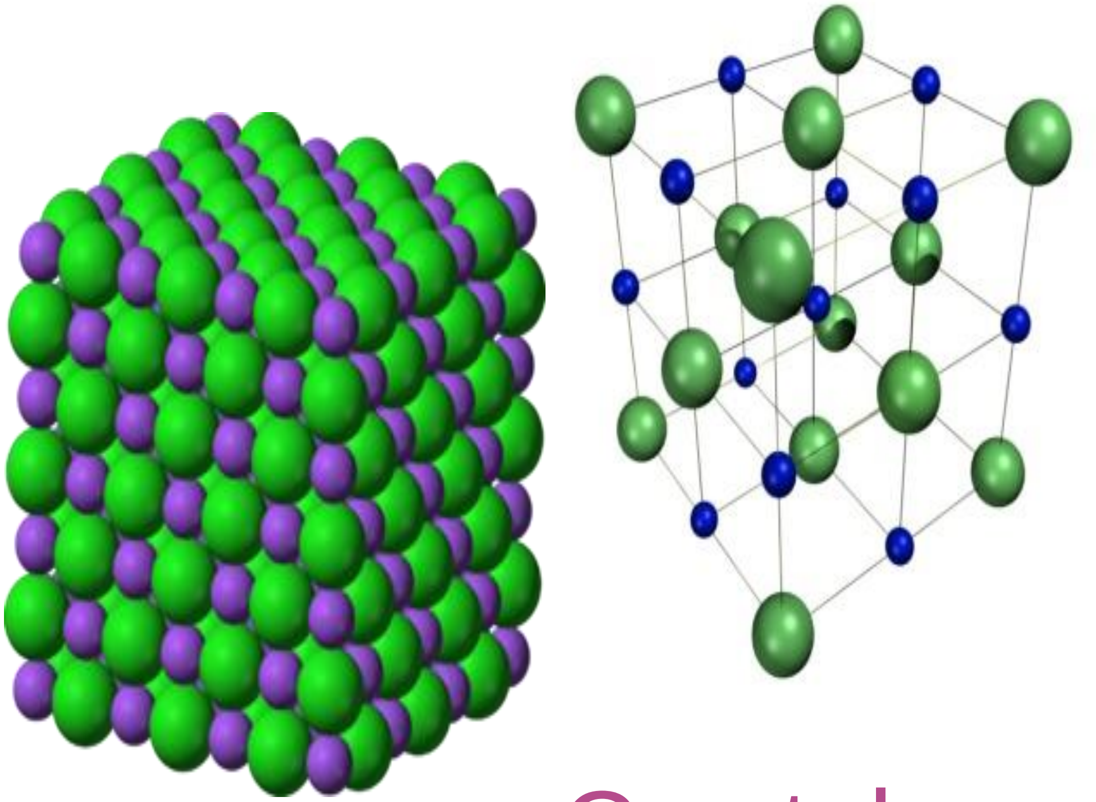
We represent compounds (Ionic or Covalent) with a **chemical formula** showing the number of atoms of each element in a substance.

NaCl is the chemical formula for sodium chloride.



Formula Units or “Compounds”

- *Technically, ionic compounds are not called molecules, because they do not exist as discrete units, but as collections of positively and negatively charged ions arranged in repeating patterns.*
- **Formula unit:** the smallest repeating unit of an ionic compound.



Crystal Lattices

Ionic compounds do not form molecules.

Formula Units

The chemical formula of an ionic compound refers to a ratio known as a formula unit. A **formula unit** is the lowest whole-number ratio of ions in an ionic compound.

Determine the formula unit of the following elements when they bond ionically (show the cation, anion and correct formula):

Sodium + Fluorine

Calcium + Chlorine

Aluminum + Oxygen

Formula Units

Sodium + Fluorine

$1\ Na^{+}\ 1\ F^{-} \rightarrow NaF$

Calcium + Chlorine

$1\ Ca^{2+}\ 2\ Cl^{-} \rightarrow CaCl_2$

Aluminum + Oxygen

$2\ Al^{3+}, 3\ O^{2-} \rightarrow Al_2O_3$

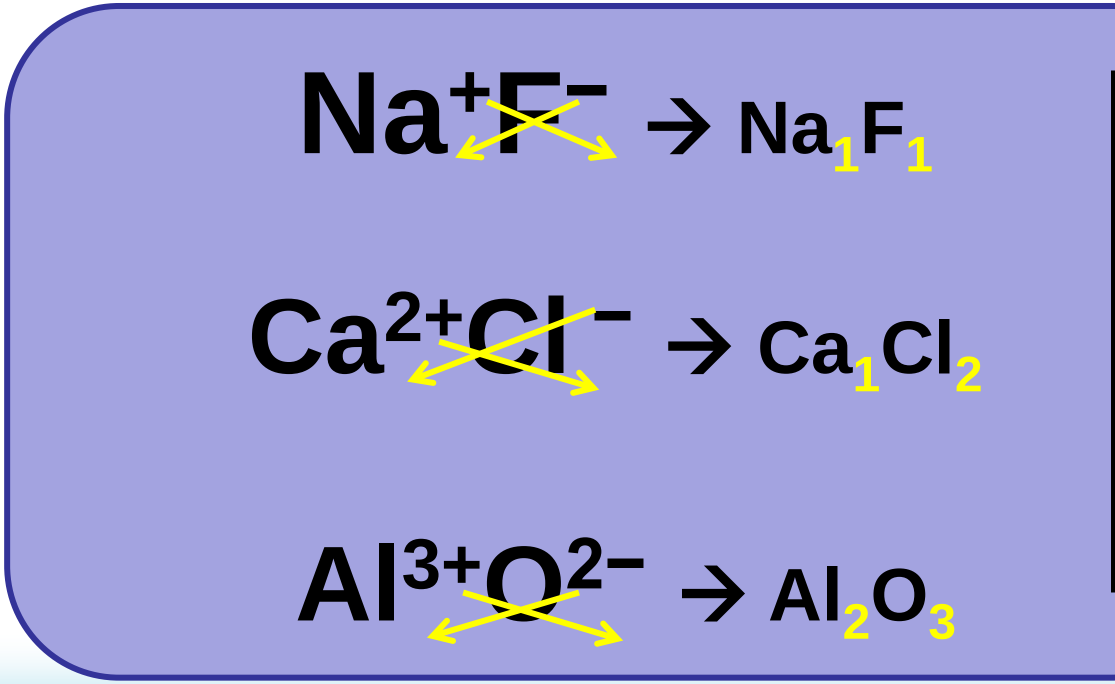
- **Remember that non-metals form anions that end in "-ide" … Name the compounds:**

Sodium Fluoride
Calcium Chloride
Aluminum Oxide

Criss-Cross Method

Making Formulas easy:

- Place the cation 1st with its charge as a superscript
- Place the anion 2nd with its charge as a superscript
- Criss-Cross the superscripts without the + or -



$Na^{+}F^{-} \rightarrow Na_{1}F_{1}$

$Ca^{2+}Cl^{-} \rightarrow Ca_{1}Cl_{2}$

$Al^{3+}O^{2-} \rightarrow Al_{2}O_{3}$

You do NOT have to write subscripts of "1"

Lewis Structures (Electron Dot Diagrams)

Ionic Bonds & Ionic Compounds Notes (4:30)

https://screencast-o-matic.com/watch/cFQZ21Ycvy

Ionic Bonding & Electron Configuration of H + F (4:23)

https://screencast-o-matic.com/watch/cFQqo9q8GK

Ionic Bonding & Electron Configuration of Na + S (3:19)

https://screencast-o-matic.com/watch/cFQTlGYV8n

Predicting Formulas of Ionic Compounds

Use electron dot structures to predict the formulas of the ionic compounds formed from the following elements:

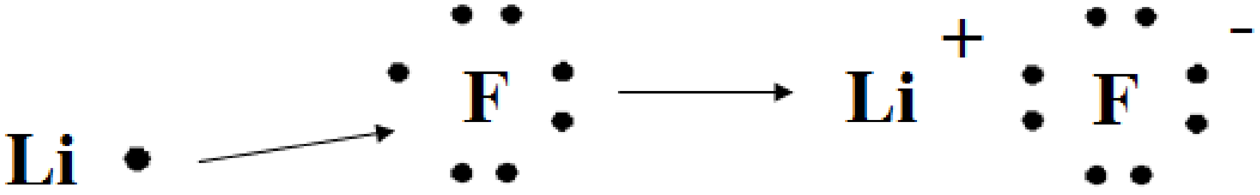
Lithium and Fluorine

Predicting Formulas of Ionic Compounds

Use electron dot structures to predict the formulas of the ionic compounds formed from the following elements:

Lithium and Fluorine

In order to have a completely filled valence shell, the fluorine atom must gain one electron. These electrons come from one lithium atom, which loses one electron.



The formula of the compound formed is LiF which is electrically neutral and the atoms have full valence.

Lewis Structures (Electron Dot Diagrams)

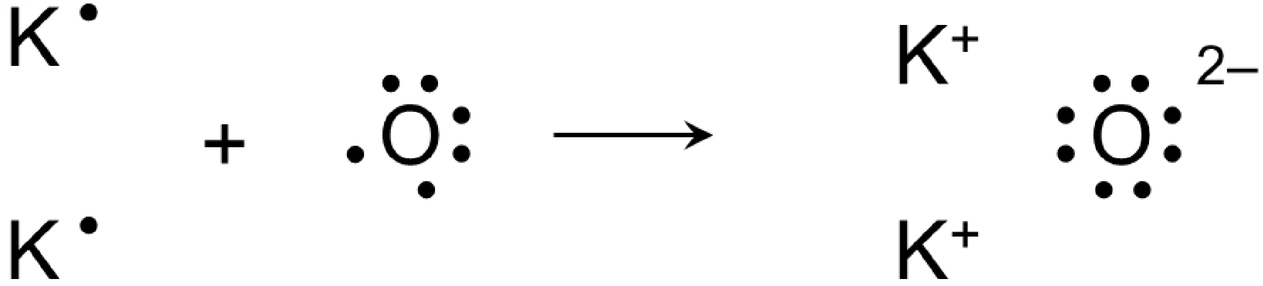
	Valence	Example	e dot	Oxidation State	Group Name
Group IA	$3s^1$	$_{11}\mathbf{Na}^{23}$	$\mathbf{Na}\cdot$	+1	*Alkali metals*
Group IIA	$3s^2$	$_{12}\mathbf{Mg}^{24}$	$\mathbf{Mg}\ :$	+2	*Alkaline earth metals*
Transition Metals (filling the 3 d sublevel)					
Group IIIA	$3s^2 3p^1$	$_{13}\mathbf{Al}^{27}$	$\overset{\cdot}{\mathbf{Al}}\ :$	+3	
Group IVA	$3s^2 3p^2$	$_{14}\mathbf{Si}^{28}$	$\cdot\ \overset{\cdot}{\mathbf{Si}}\ :$	+/-4	
Group VA	$3s^2 3p^3$	$_{15}\mathbf{P}^{31}$	$\cdot\ \overset{\cdot}{\underset{\cdot}{\mathbf{P}}}\ :$	-5	
Group VIA	$3s^2 3p^4$	$_{16}\mathbf{S}^{32}$	$:\overset{\cdot}{\underset{\cdot}{\mathbf{S}}}\ :$	-6	*Chalcogens*
Group VIIA	$3s^2 3p^5$	$_{17}\mathbf{Cl}^{35}$	$:\overset{\cdot}{\underset{\cdot\cdot}{\mathbf{Cl}}}\ :$	-7	*Halogens*
Group VIIIA	$3s^2 3p^6$	$_{18}\mathbf{Ar}^{40}$	$:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\mathbf{Ar}}}:$	0	*Noble / Inert Gases*

QUICK CHECK

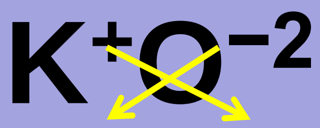
Use Lewis structures to determine the formula of the ionic compound formed when potassium reacts with oxygen. Show the overall charge on the formula unit.

QUICK CHECK

Use Lewis structures to determine the formula of the ionic compound formed when potassium reacts with oxygen. Show the overall charge on the formula unit



Criss-Cross:



$$K_2O$$

Overall Charge = 2(+1) -2 = **0**

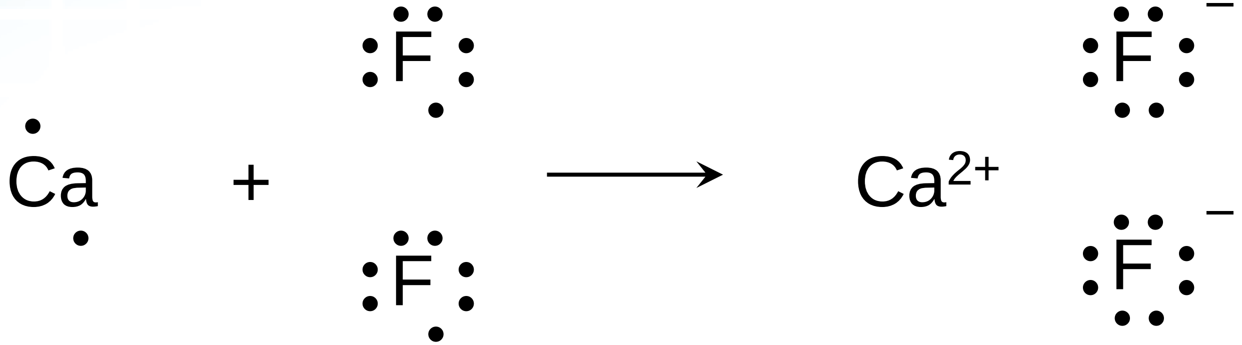
All the atoms have a full valence.

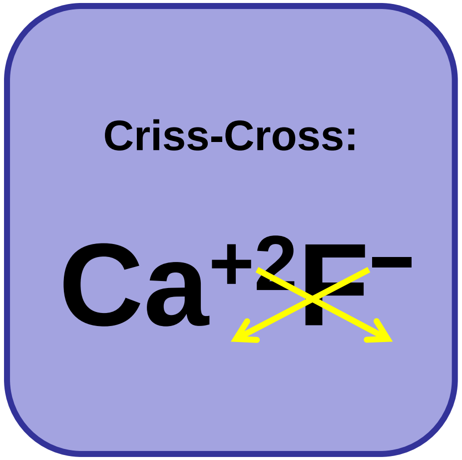
QUICK CHECK

Use Lewis structures to determine the formula of the ionic compound formed when calcium reacts with fluorine. Show the overall charge on the formula unit.

QUICK CHECK

Use Lewis structures to determine the formula of the ionic compound formed when calcium reacts with fluorine. Show the overall charge on the formula unit.





Criss-Cross:

$Ca^{+2}F^{-}$

$$CaF_2$$

Overall Charge = +2 + 2(-1) = **0**

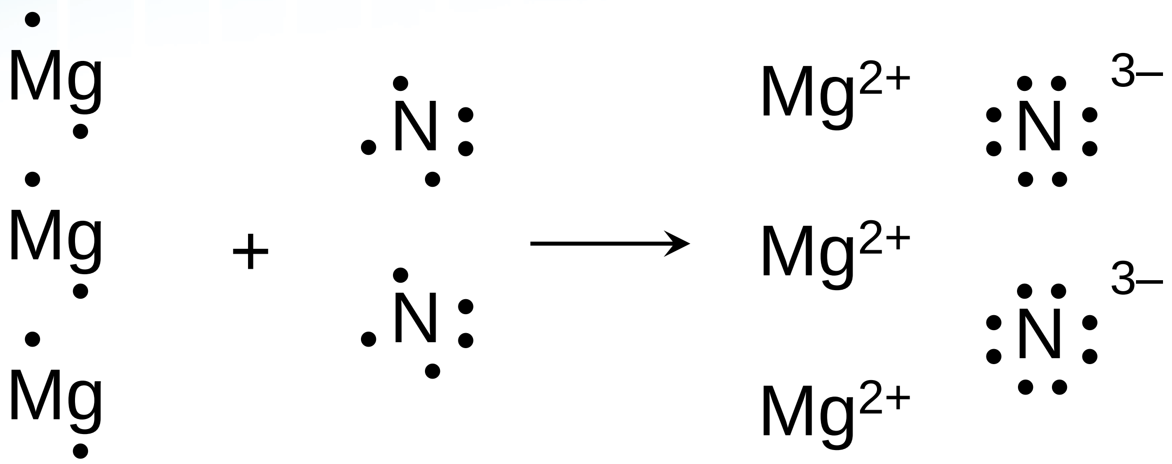
All the atoms have a full valence.

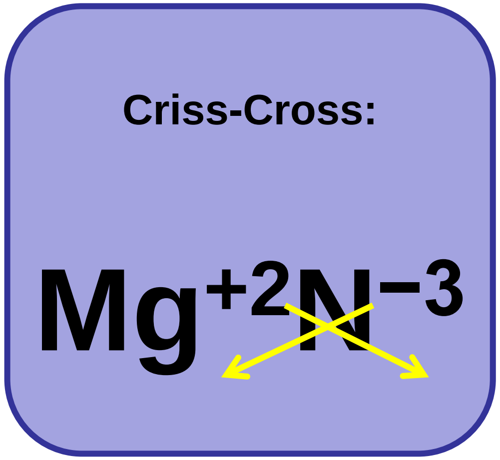
QUICK CHECK

Use Lewis structures to determine the formula of the ionic compound formed when magnesium reacts with nitrogen. Show the overall charge on the formula unit.

QUICK CHECK

Use Lewis structures to determine the formula of the ionic compound formed when magnesium reacts with nitrogen. Show the overall charge on the formula unit.




Criss-Cross:

$Mg^{+2}N^{-3}$

$$Mg_3N_2$$

Overall Charge = 3(+2) + 2(-3) = **0**

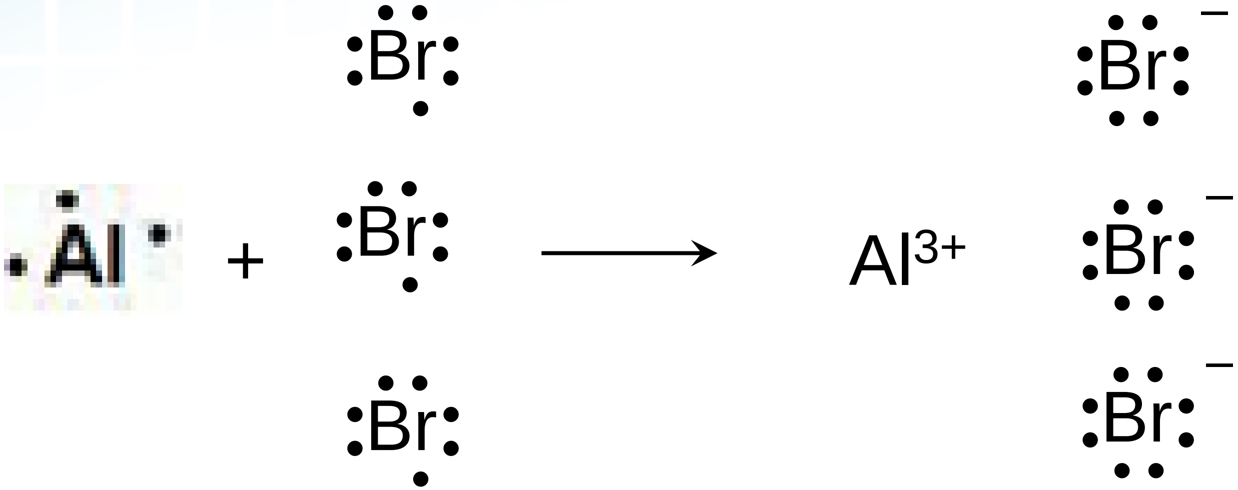
All the atoms have a full valence.

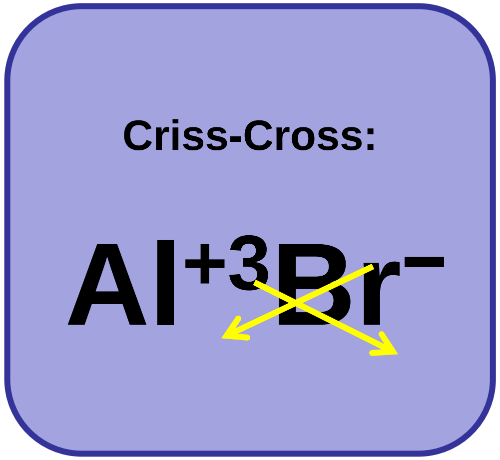
QUICK CHECK

Use Lewis structures to determine the formula of the ionic compound formed when aluminum reacts with Bromine. Show the overall charge on the formula unit.

QUICK CHECK

Use Lewis structures to determine the formula of the ionic compound formed when aluminum reacts with Bromine. Show the overall charge on the formula unit.





Criss-Cross:

$Al^{+3}Br^{-}$

$$AlBr_3$$

Overall Charge = +3 + 3(-1) = **0**

All the atoms have a full valence.

Identify Ionic Compounds (END)

When elements that make up compounds or molecules have an **END** (**E**lectro**N**egativity **D**ifference) **greater than 1.7**, we say they are **ionic**. Which of the following compounds are ionic compounds?

Element	Electronegativity
C	2.5
Ca	1.0
Cl	3.2
H	2.2
O	3.4
Mg	1.3
Na	0.9
Si	1.9

[ ] $MgCl_2$

[ ] $C_6H_{12}O_6$

[ ] MgO

[ ] Na_2O

[ ] SiO_2

[ ] H_2O

[ ] $NaCl$

[ ] $CaCl_2$

[ ] O_2

[ ] CH_4

TRY IT

Identify Ionic Compounds

END greater than 1.7 → **ionic**.

[1.9] $MgCl_2$	[1.2] H_2O
[*] $C_6H_{12}O_6$	[2.3] NaCl
[2.1] MgO	[2.2] $CaCl_2$
[2.5] Na_2O	[0] O_2
[1.5] SiO_2	[0.3] CH_4

- *Simply subtract the Electronegativity of each element (do not multiply by subscripts)*

**Find END of each element*

(C-H = 0.3 … H-O = 1.2 … C-O = 0.9)

Element	Electronegativity
C	2.5
Ca	1.0
Cl	3.2
H	2.2
O	3.4
Mg	1.3
Na	0.9
Si	1.9

QUICK CHECK

Identify the Ions of Elements

What is the charge of each ion?

A lithium ion has a charge of ____.

A calcium ion has a charge of ____.

An aluminum ion has a charge of ____.

A fluorine ion has a charge of ____.

An oxygen ion has a charge of ____.

A phosphorus ion has a charge of ____.

A Selenium ion has a charge of ____.

An krypton ion has a charge of ____.

A Gallium ion has a charge of ____.

Which elements form an ionic compound? Check all that apply.

[ ] aluminum and oxygen

[ ] calcium and aluminum

[ ] fluorine and oxygen

[ ] lithium and fluorine

[ ] carbon and oxygen

[ ] sodium and fluorine

Identify the Ions of Elements

What is the charge of each ion?

A lithium ion has a charge of +1.

A calcium ion has a charge of +2.

An aluminum ion has a charge of +3.

A fluorine ion has a charge of -1.

An oxygen ion has a charge of -2.

A phosphorus ion has a charge of -3.

A Selenium ion has a charge of -2.

An krypton ion has a charge of 0.

A Gallium ion has a charge of +3.

Which elements form an ionic compound? Check all that apply.

[X] aluminum and oxygen
END = 3.5 - 1.5 = 2.0

[ ] calcium and aluminum
END = 1.5 - 1.0 = 0.5

[ ] fluorine and oxygen
END = 4.0 – 3.5 = 0.5

[X] lithium and fluorine
END = 4.0 - 1.0 = 3.0

[ ] carbon and oxygen
END = 3.5 – 2.6 = 0.9

[X] sodium and fluorine
END = 4.0 – 0.9 = 3.1

QUICK CHECK

Explain How Ionic Bonds Form

How and why do ionic bonds form? Check all that apply.

[ ] Ionic bonds form between metal atoms and other metal atoms.
[ ] Ionic bonds form between metal atoms and nonmetal atoms.

[ ] The more electronegative atoms transfer one or more electrons to the less electronegative atom.
[ ] The less electronegative atoms transfers one or more electrons to the more electronegative atom.

[ ] The metal atom forms a cation and the nonmetal atom forms an anion.
[ ] The metal atom forms a anion and the nonmetal atom forms an cation.

[ ] The attraction between ions with the same charge forms an ionic bond.
[ ] The attraction between ions with an opposite charge forms an ionic bond.

[ ] Positive ions are called cations and negative ions are called anions.
[ ] Negative ions are called cations and positive ions are called anions.

Explain How Ionic Bonds Form

How and why do ionic bonds form? Check all that apply.

[x] Ionic bonds form between metal atoms and nonmetal atoms.

[x] The less electronegative atoms transfers one or more electrons to the more electronegative atom.

[x] The metal atom forms a cation and the nonmetal atom forms an anion.

[x] The attraction between ions with an opposite charge forms an ionic bond.

[x] Positive ions are called cations and negative ions are called anions.

Period	*s*-block 1 IA
1	1.00794 +1 −1 **H** 1 $1s^1$

KEY

Atomic Mass →	12.0111	−4 +2 +4 ← **Selected Oxidation States**
Symbol →	**C**	
Atomic Number →	6	
Electron Configuration →	$1s^22s^22p^2$	

Relative atomic masses are based on ^{12}C = 12.00000

s-block

GROUP

2 ← **New Designation**

IIA ← **Former Designation**
(prior to 1984 IUPAC decision)

d-block

Transition Elements

GROUP

Period	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9	10	
2	6.941 +1 **Li** 3 $1s^22s^1$	9.01218 +2 **Be** 4 $1s^22s^2$									
3	22.98977 +1 **Na** 11 $[Ne]3s^1$	24.305 +2 **Mg** 12 $[Ne]3s^2$									
4	39.0983 +1 **K** 19 $[Ar]4s^1$	40.08 +2 **Ca** 20 $[Ar]4s^2$	44.9559 +3 **Sc** 21 $[Ar]3d^14s^2$	47.88 +2 +3 +4 **Ti** 22 $[Ar]3d^24s^2$	50.9415 +2 +3 +4 +5 **V** 23 $[Ar]3d^34s^2$	51.996 +2 +3 +6 **Cr** 24 $[Ar]3d^54s^1$	54.9380 +2 +3 +4 +7 **Mn** 25 $[Ar]3d^54s^2$	55.847 +2 +3 **Fe** 26 $[Ar]3d^64s^2$	58.9332 +2 +3 **Co** 27 $[Ar]3d^74s^2$	58.69 +2 +3 **Ni** 28 $[Ar]3d^84s^2$	63.54 29 [Ar]3d
5	85.4678 +1 **Rb** 37 $[Kr]5s^1$	87.62 +2 **Sr** 38 $[Kr]5s^2$	88.9059 +3 **Y** 39 $[Kr]4d^15s^2$	91.224 +4 **Zr** 40 $[Kr]4d^25s^2$	92.9064 +3 +5 **Nb** 41 $[Kr]4d^45s^1$	95.94 +3 +6 **Mo** 42 $[Kr]4d^55s^1$	(98) +4 +6 +7 **Tc** 43 $[Kr]4d^65s^1$	101.07 +3 **Ru** 44 $[Kr]4d^75s^1$	102.906 +3 **Rh** 45 $[Kr]4d^85s^1$	106.42 +2 +4 **Pd** 46 $[Kr]4d^{10}5s^0$	107.86 47 [Kr]4d
6	132.905 +1 **Cs** 55 $[Xe]6s^1$	137.33 +2 **Ba** 56 $[Xe]6s^2$	**La-Lu** 57 71	178.49 +4 **Hf** 72 $[Xe]4f^{14}5d^26s^2$	180.948 +5 **Ta** 73 $[Xe]4f^{14}5d^36s^2$	183.85 +6 **W** 74 $[Xe]4f^{14}5d^46s^2$	186.207 +4 +6 +7 **Re** 75 $[Xe]4f^{14}5d^56s^2$	190.2 +3 +4 **Os** 76 $[Xe]4f^{14}5d^66s^2$	192.22 +3 +4 **Ir** 77 $[Xe]4f^{14}5d^76s^2$	195.08 +2 +4 **Pt** 78 $[Xe]4f^{14}5d^96s^1$	196.96 79 [Xe]4f
7	(223) +1 **Fr** 87 $[Rn]7s^1$	226.025 +2 **Ra** 88 $[Rn]7s^2$	**Ac-Lr** 89 103	(261) **Unq*** 104	(262) **Unp** 105	(263) **Unh** 106	(262) **Uns** 107	**Uno** 108	**Une** 109		

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s-block

p-block

GROUP

10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 O
								4.00260 0 **He** 2 $1s^2$
			10.81 +3 **B** 5 $1s^22s^22p^1$	12.0111 −4 +2 +4 **C** 6 $1s^22s^22p^2$	14.0067 −3 −2 −1 +1 +2 +3 +4 +5 **N** 7 $1s^22s^22p^3$	15.9994 −2 **O** 8 $1s^22s^22p^4$	18.998403 −1 **F** 9 $1s^22s^22p^5$	20.179 0 **Ne** 10 $1s^22s^22p^6$
			26.98154 +3 **Al** 13 $[Ne]3s^23p^1$	28.0855 −4 +2 +4 **Si** 14 $[Ne]3s^23p^2$	30.97376 −3 +3 +5 **P** 15 $[Ne]3s^23p^3$	32.06 −2 +4 +6 **S** 16 $[Ne]3s^23p^4$	35.453 −1 +1 +3 +5 +7 **Cl** 17 $[Ne]3s^23p^5$	39.948 0 **Ar** 18 $[Ne]3s^23p^6$
58.69 +2 +3 **Ni** 28 $[Ar]3d^84s^2$	63.546 +1 +2 **Cu** 29 $[Ar]3d^{10}4s^1$	65.39 +2 **Zn** 30 $[Ar]3d^{10}4s^2$	69.72 +3 **Ga** 31 $[Ar]3d^{10}4s^24p^1$	72.59 −4 +2 +4 **Ge** 32 $[Ar]3d^{10}4s^24p^2$	74.9216 −3 +3 +5 **As** 33 $[Ar]3d^{10}4s^24p^3$	78.96 −2 +4 +6 **Se** 34 $[Ar]3d^{10}4s^24p^4$	79.904 −1 +1 +5 **Br** 35 $[Ar]3d^{10}4s^24p^5$	83.80 0 +2 **Kr** 36 $[Ar]3d^{10}4s^24p^6$
106.42 +2 +4 **Pd** 46 $[Kr]4d^{10}5s^0$	107.868 +1 **Ag** 47 $[Kr]4d^{10}5s^1$	112.41 +2 **Cd** 48 $[Kr]4d^{10}5s^2$	114.82 +3 **In** 49 $[Kr]4d^{10}5s^25p^1$	118.71 +2 +4 **Sn** 50 $[Kr]4d^{10}5s^25p^2$	121.75 −3 +3 +5 **Sb** 51 $[Kr]4d^{10}5s^25p^3$	127.60 −2 +4 +6 **Te** 52 $[Kr]4d^{10}5s^25p^4$	126.905 −1 +1 +5 +7 **I** 53 $[Kr]4d^{10}5s^25p^5$	131.29 0 +2 +4 +6 **Xe** 54 $[Kr]4d^{10}5s^25p^6$
195.08 +2 +4 **Pt** 78 $[Xe]4f^{14}5d^96s^1$	196.967 +1 +3 **Au** 79 $[Xe]4f^{14}5d^{10}6s^1$	200.59 +1 +2 **Hg** 80 $[Xe]4f^{14}5d^{10}6s^2$	204.383 +1 +3 **Tl** 81 $[Xe]4f^{14}5d^{10}6s^26p^1$	207.2 +2 +4 **Pb** 82 $[Xe]4f^{14}5d^{10}6s^26p^2$	208.980 +3 +5 **Bi** 83 $[Xe]4f^{14}5d^{10}6s^26p^3$	(209) +2 +4 **Po** 84 $[Xe]4f^{14}5d^{10}6s^26p^4$	(210) **At** 85 $[Xe]4f^{14}5d^{10}6s^26p^5$	(222) 0 **Rn** 86 $[Xe]4f^{14}5d^{10}6s^26p^6$

IONIZATION ENERGIES AND ELECTRONEGATIVITIES

First Ionization Energy (kcal/mol of atoms)
Electronegativity*

1	2	13	14	15	16	17	18
313 H 2.2							567 He
125 Li 1.0	215 Be 1.5	191 B 2.0	260 C 2.6	336 N 3.1	314 O 3.5	402 F 4.0	497 Ne
119 Na 0.9	176 Mg 1.2	138 Al 1.5	188 Si 1.9	242 P 2.2	239 S 2.6	300 Cl 3.2	363 Ar
100 K 0.8	141 Ca 1.0	138 Ga 1.6	182 Ge 1.9	226 As 2.0	225 Se 2.5	273 Br 2.9	323 Kr
96 Rb 0.8	131 Sr 1.0	133 In 1.7	169 Sn 1.8	199 Sb 2.1	208 Te 2.3	241 I 2.7	280 Xe
90 Cs 0.7	120 Ba 0.9	141 Tl 1.8	171 Pb 1.8	168 Bi 1.9	194 Po 2.0	At 2.2	248 Rn
Fr 0.7	122 Ra 0.9						

* Arbitrary scale based on fluorine = 4.0