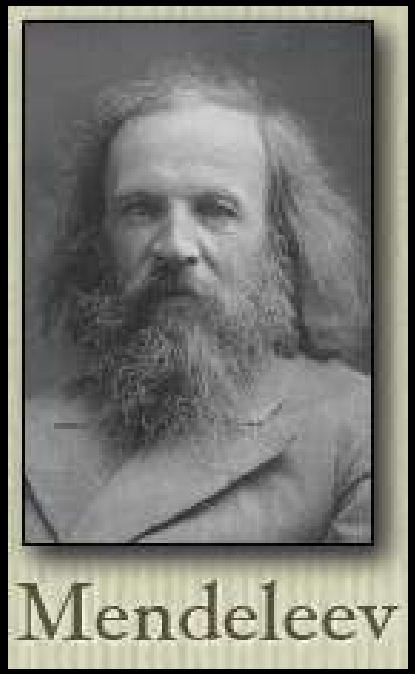
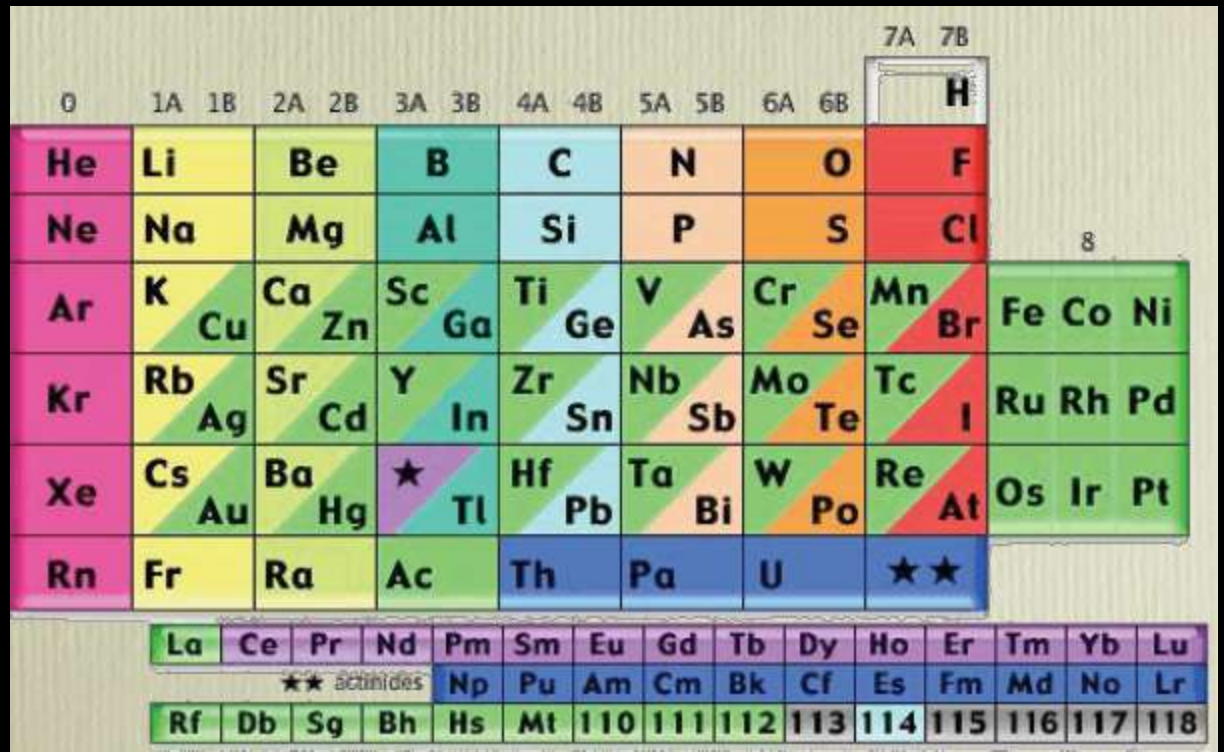
Periodic Table & Families

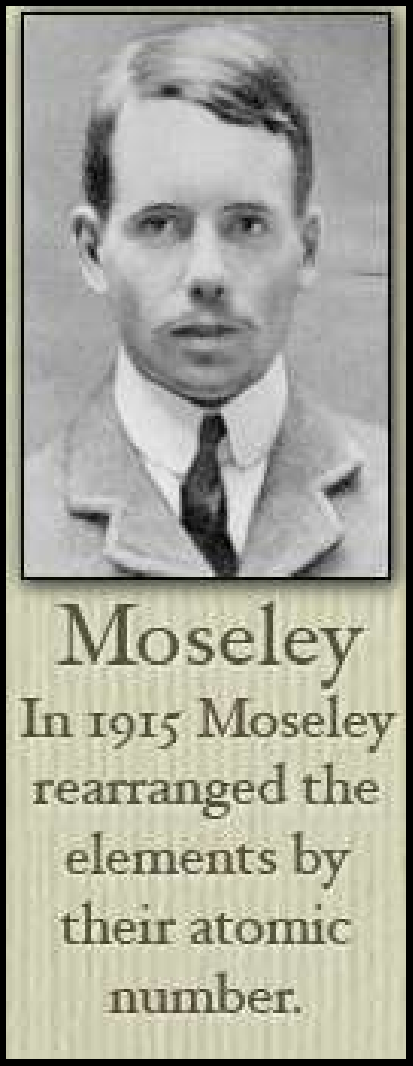
Mendeleev's Table (1871)

- While it was the first periodic table, Mendeleev had very different elements, such as the very reactive potassium and the very stable copper, in the same family.
- Forty years later Moseley rearranged the elements by their atomic number which gave the table better periodicity.





Short form of the Periodic Table



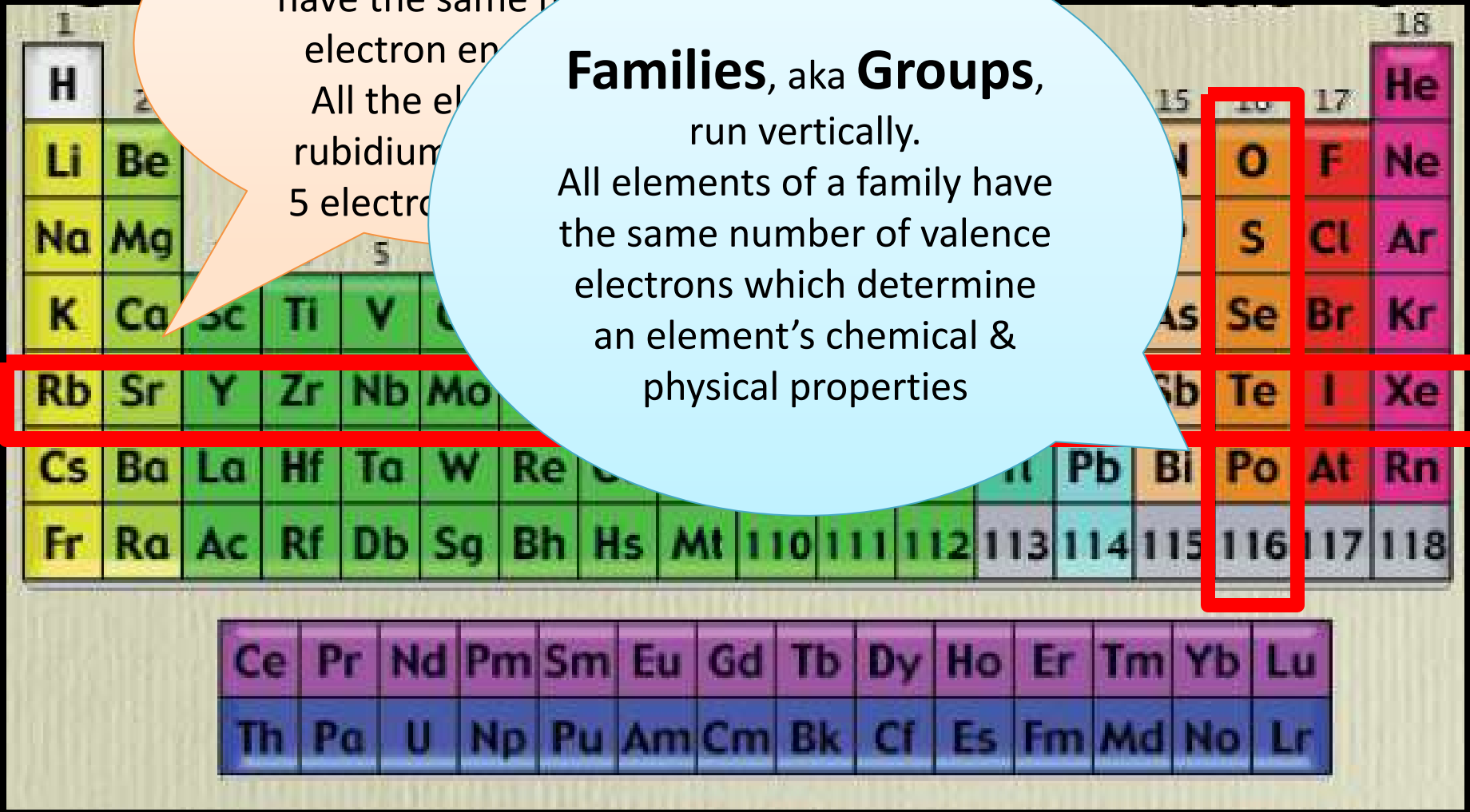
1																	18
H	2											13	14	15	16	17	He
Li	Be											B	C	N	O	F	Ne
Na	Mg	3	4	5	6	7	8	9	10	11	12	Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	110	111	112	113	114	115	116	117	118

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

Periods and Families

Periods run horizontally.
All elements of a peri
have the same n
electron en
All the el
rubidium
5 electr

Families, aka **Groups**, run vertically.
All elements of a family have the same number of valence electrons which determine an element's chemical & physical properties

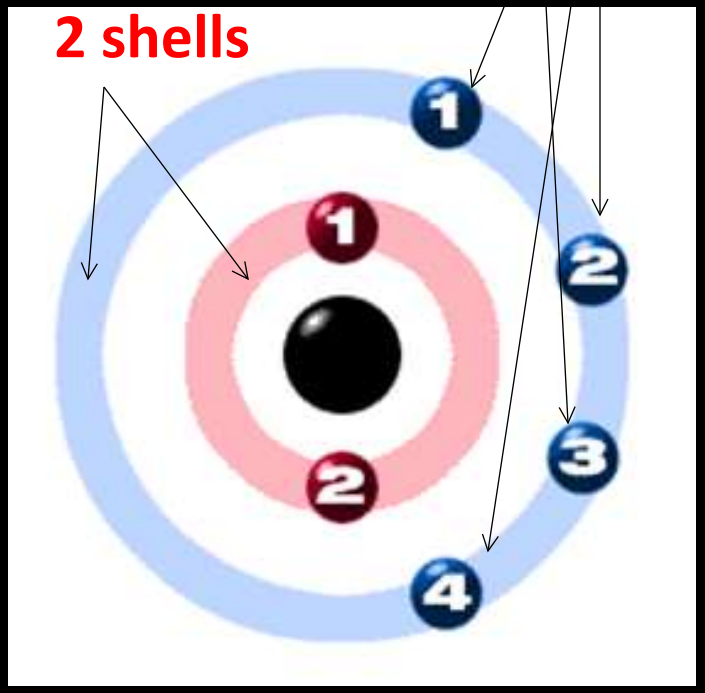


Principle Energy Level (Shells)

Carbon

4^{th} Group = 4 valence electrons

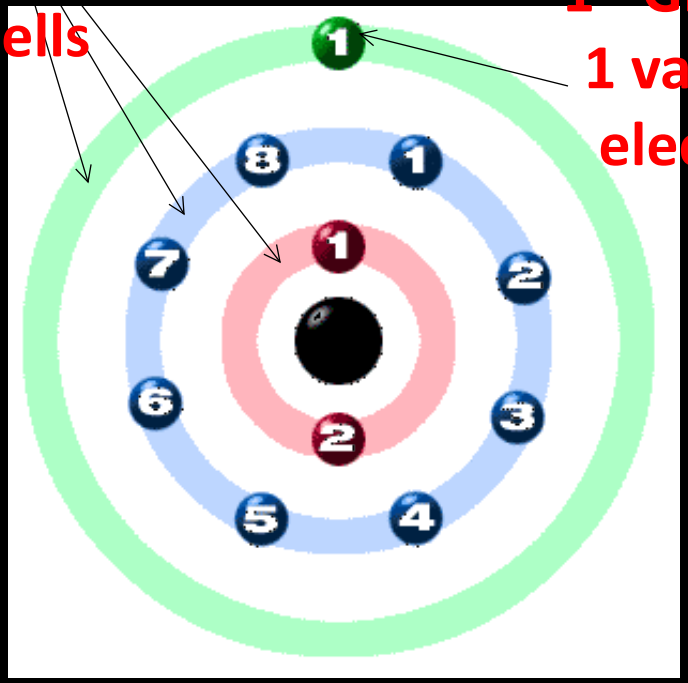
2^{nd} Period = 2 shells

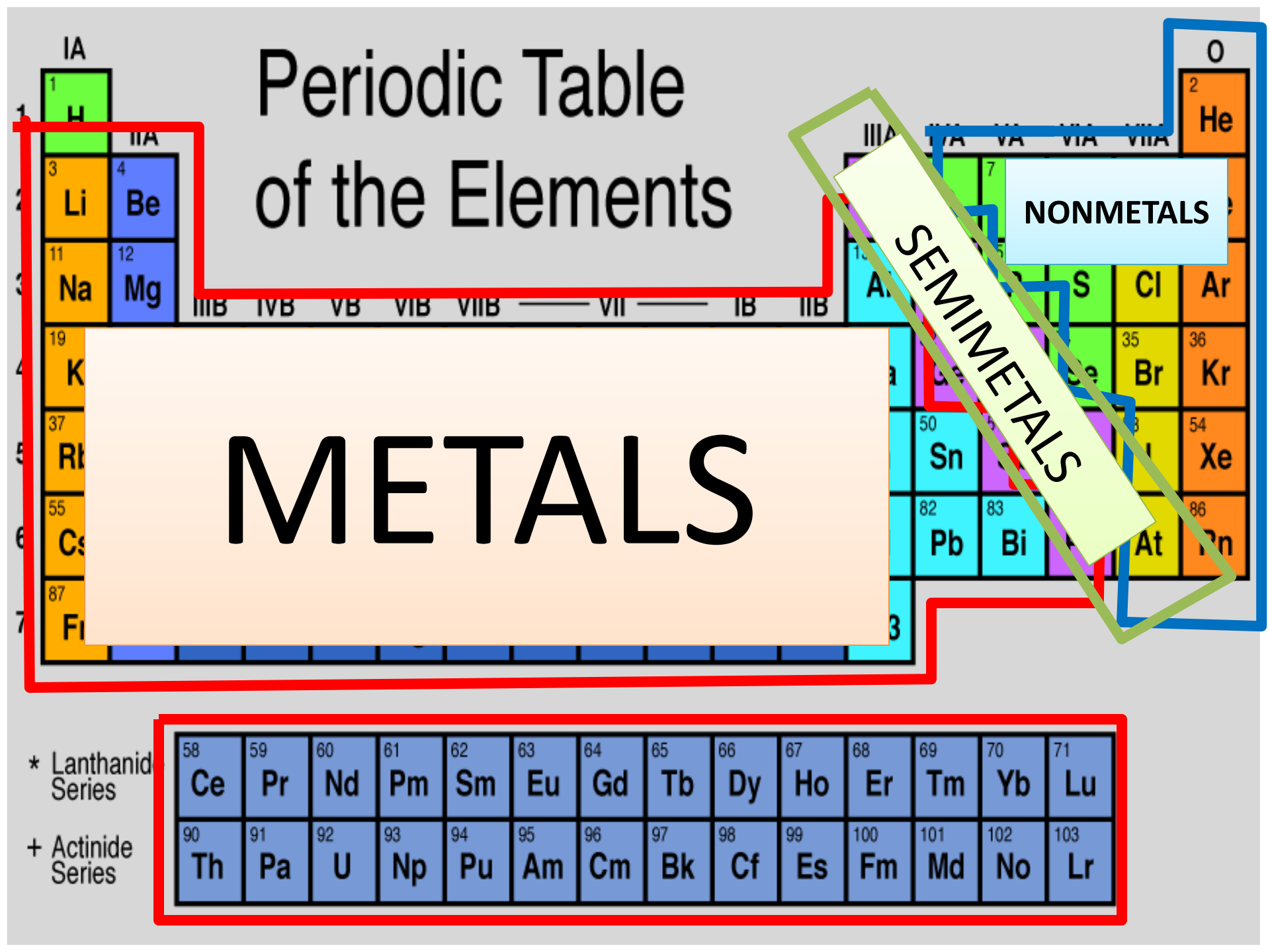


Sodium

3^{rd} Period = 3 shells

1^{st} Group = 1 valence electron




Periodic Table
of the Elements
METALS
SEMIMETALS
NONMETALS
* Lanthanid Series
+ Actinide Series
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 71 Lu
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 103 Lr

METALS

- Silver in color and have luster.
- Solid @ Room Temperature.
- Have high densities.
- Are malleable & ductile.
- Are good conductors of heat & electricity.
- Atoms have between 1-3 valence electrons.
- Atoms have a loose hold on their valence electrons - they give them up easily.
- Corrode (rust) in the presence of oxygen.

SEMIMETALS

- border between metals and nonmetals on the periodic table.
- properties of both metals and nonmetals
- brittle than metals, less brittle than most nonmetallic solids
- semiconductors of electricity
- possess metallic luster

NONMETALS

- poor conductors of heat and electricity
- tend to be brittle
- gases at room temperature

Checking for understanding

List 4 characteristics for each group of elements:

Metals	Semimetals	Nonmetals
1		
2		
3		
4		

Alkali Metals

- Extremely reactive, only found in compounds
- Can be extracted from compounds using electricity
- Reacts violently with water to form H_2 (g) and a base
- Alkali means base (as opposed to acid)

Periodic Table of the Elements

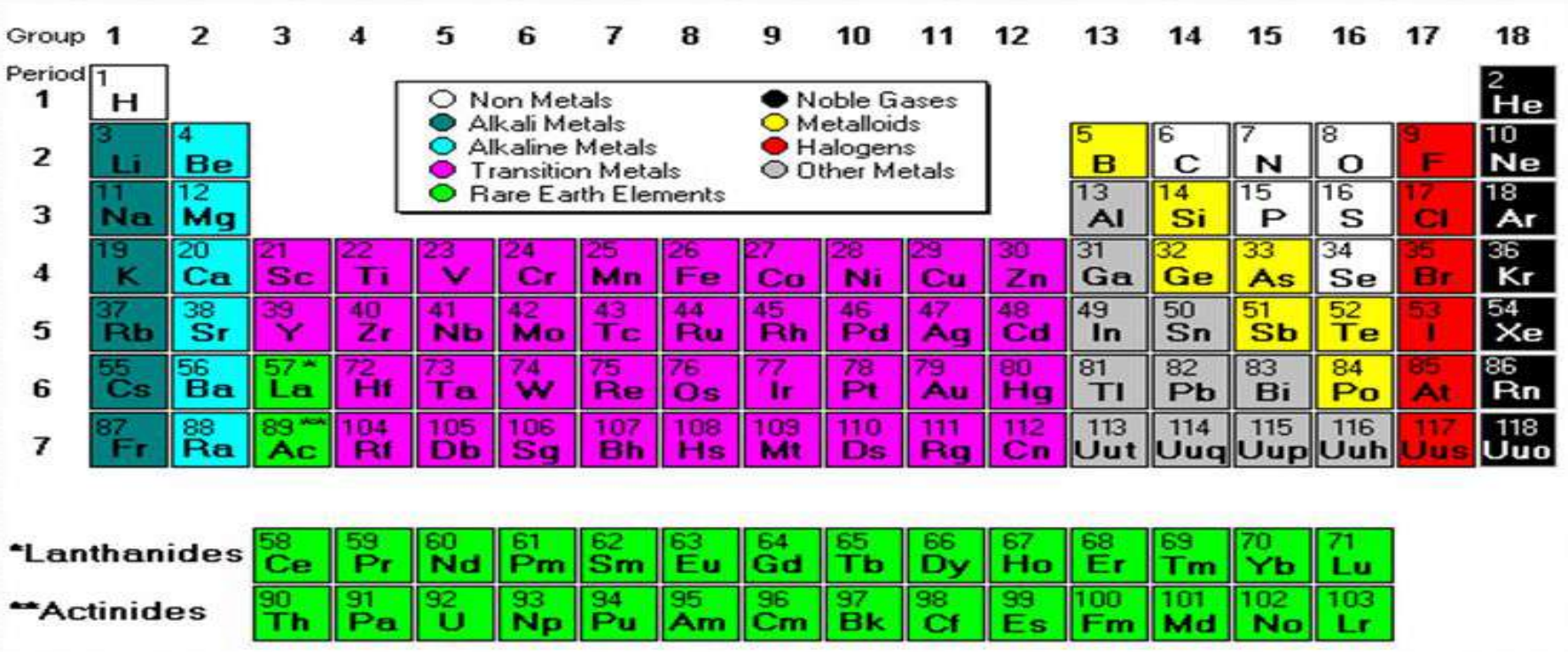
	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	O
1	1 H															2 He
2	3 Li	4 Be									5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg									13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 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	57 *La	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	89 +Ac	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110 110	111 111	112 112	113 113					

* Lanthanide Series	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	71 Lu
+ Actinide Series	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	103 Lr

Color groups-but notice the different colors for elements in those groups

Coloring Part 2: Color by Type

- Get another Periodic Table
- Color Code the periodic table as below
- Make a key or legend as seen below



Alkali Earth Metals

- Very reactive, only found in compounds
- Can be extracted from compounds using chemical reactions
- Reacts quickly with water for form H_2 (g) and a base
- Alkaline means base

Periodic Table of the Elements

	IA												IIIA	IVA	VA	VIA	VIIA	O
1	1 H	IIA																2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg	IIIB	IVB	VB	VIB	VIIB	— VII —		IB	IIB		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	57 *La	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	89 +Ac	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110 110	111 111	112 112	113 113					

* Lanthanide Series	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	71 Lu
+ Actinide Series	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	103 Lr

Transition Metals

- Range of reactivities

do

Boron Family, 3-A

Boron, Aluminum, Gallium, Indium and Thallium.

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	O
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	57 *La	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	89 +Ac	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110 110	111 111	112 112	113 113					

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+ Actinide Series	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	103 Lr

Carbon Family, 4-A

Contain a wide variety of elements from 1 nonmetal (C), 2 metalloids (Si & Ga) IA and 2 metals (Pb & Sn).

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	O
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	57 *La	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	89 +Ac	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110 110	111 111	112 112	113 113					

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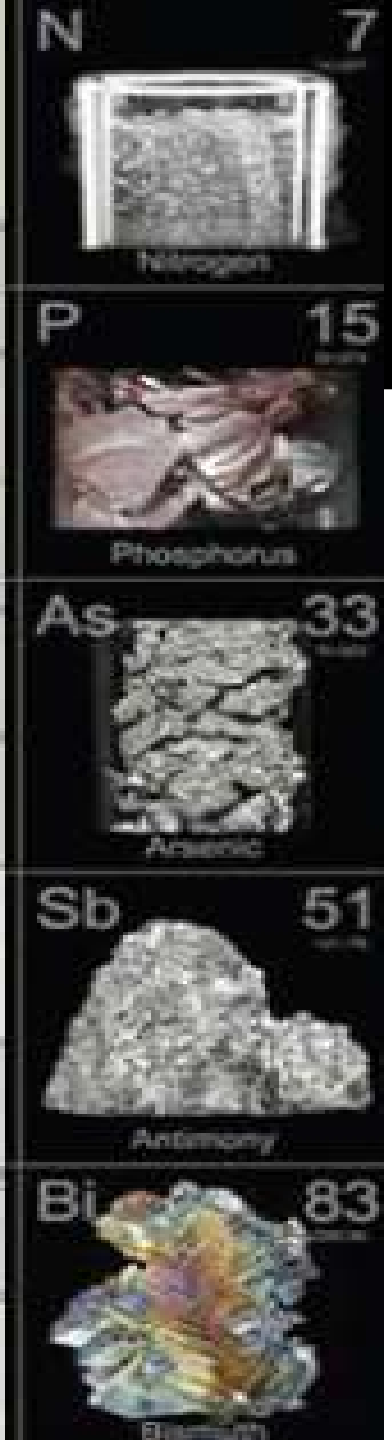
+ Actinide Series	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr



Nitrogen Family, 5-A

Nitrogen, Phosphorus, Astatine, Antimony & Bismuth.

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	O
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
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7	87 Fr	88 Ra	89 +Ac	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110 110	111 111	112 112	113 113					

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+ Actinide Series	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	103 Lr

Oxygen Family, 6-A

Oxygen, Sulfur, Selenium,
Tellurium & Polonium

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	O
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	57 *La	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
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+ Actinide Series	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	103 Lr

Halogen, 7-A

- Extremely reactive and corrosive, only found in compounds
- Can be extracted from compounds using electricity
- Reacts violently with metals to form halide compounds (like NaCl)

Periodic Table of the Elements

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	O
1 H															2 He
3 Li	4 Be									5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg									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
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+ Actinide Series	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	103 Lr

Noble Gases, 8-A

- Completely nonreactive, never found in compounds
- Xe and Kr can be forced to react with F2 in the lab
- They have a stable octet, so they don't need to bond

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
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
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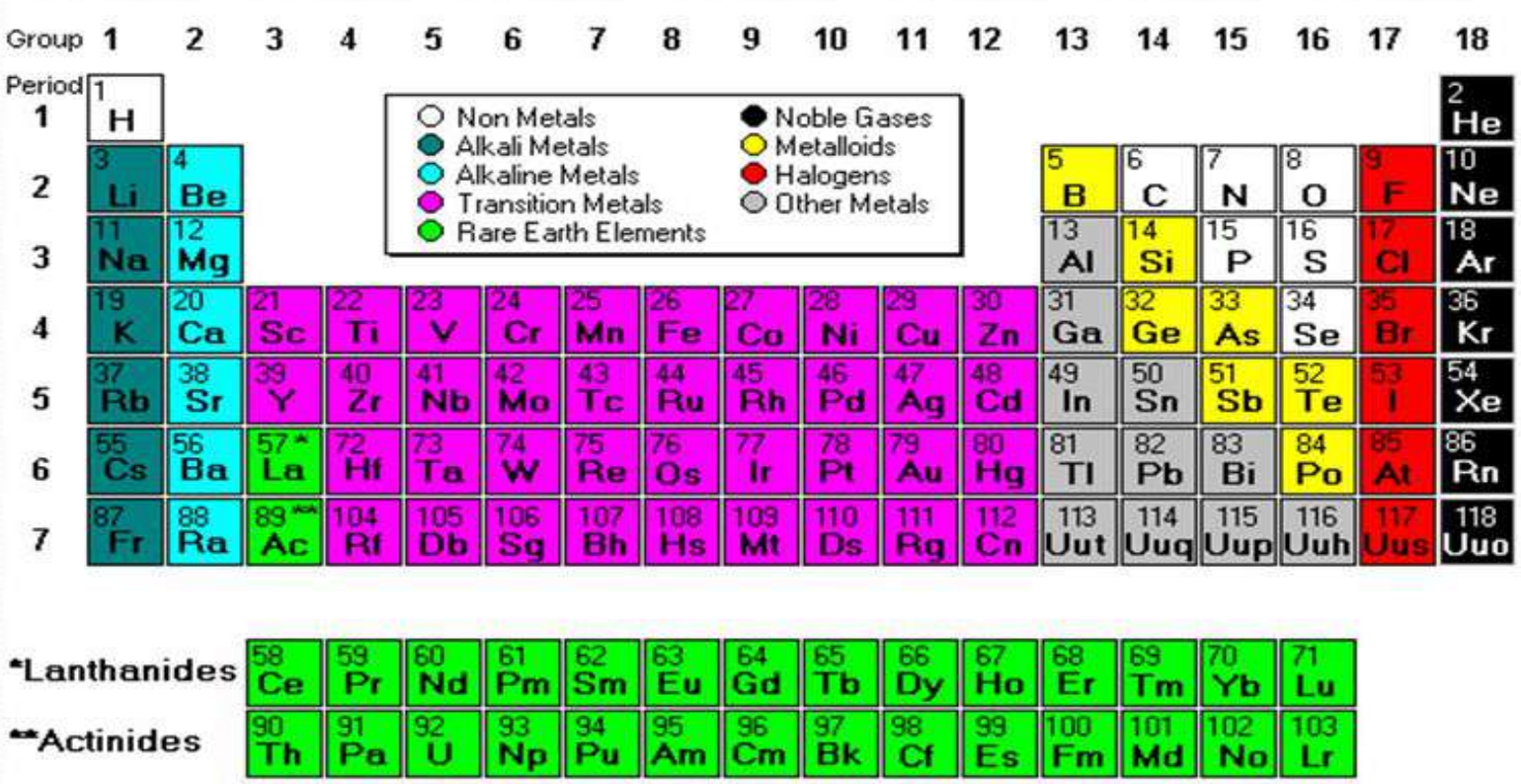
+ Actinide Series	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

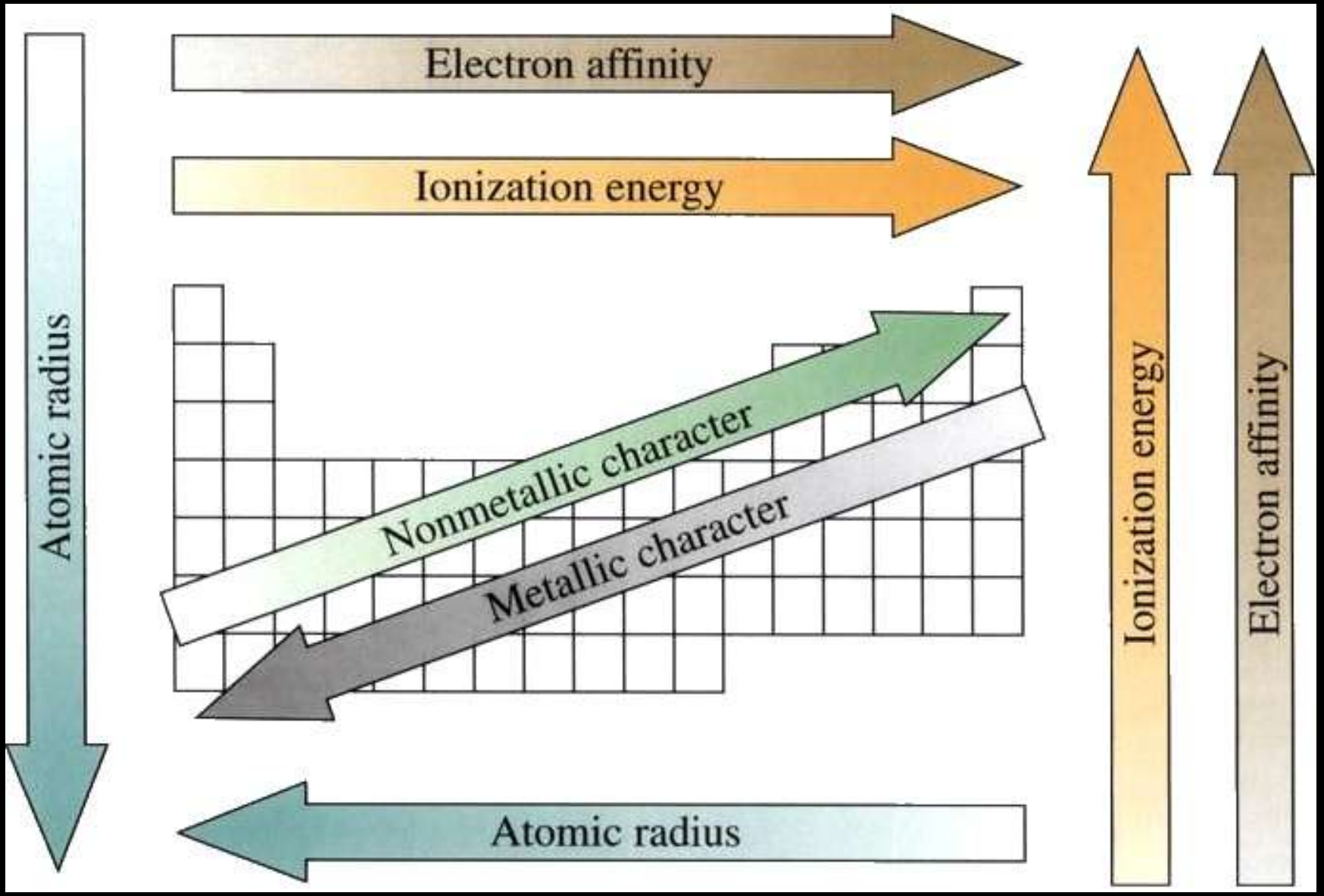
Your periodic table

Coloring Part 2: Color by Type

- Get another Periodic Table
- Color Code the periodic table as below
- Make a key or legend as seen below



Add in the following



Checking for understanding

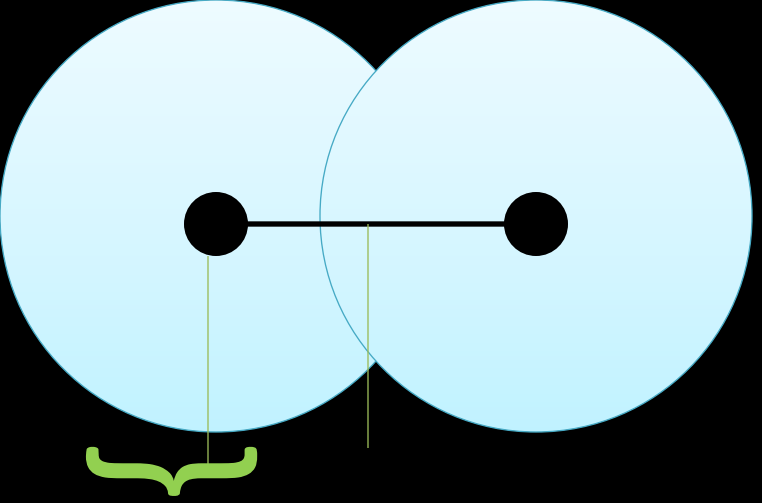
Complete the following organizer:

	Group # on periodic table	Number of valence electrons	Reactivity	List all in that category
Alkali metals				
Alkali earth metals				
Halogens				
Noble gases				

Periodic Trends

Periodic Trend

- As you go from left to right, the number of protons increase.
- As you go from left to right, the number of electrons in the same energy level increase.
- As you go from top to bottom, electrons are farther away.
- As you go from top to bottom, more shells are added.



Atomic Radii

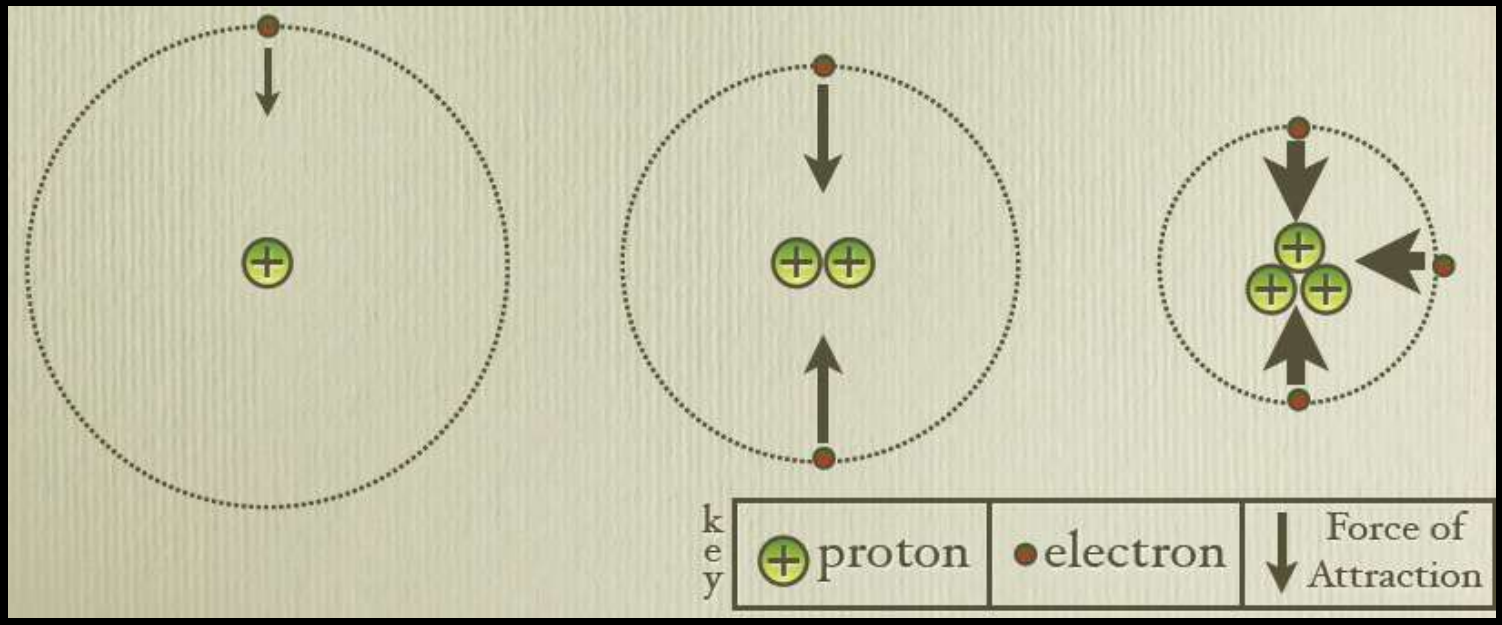
half the distance between two nuclei of a diatomic molecule

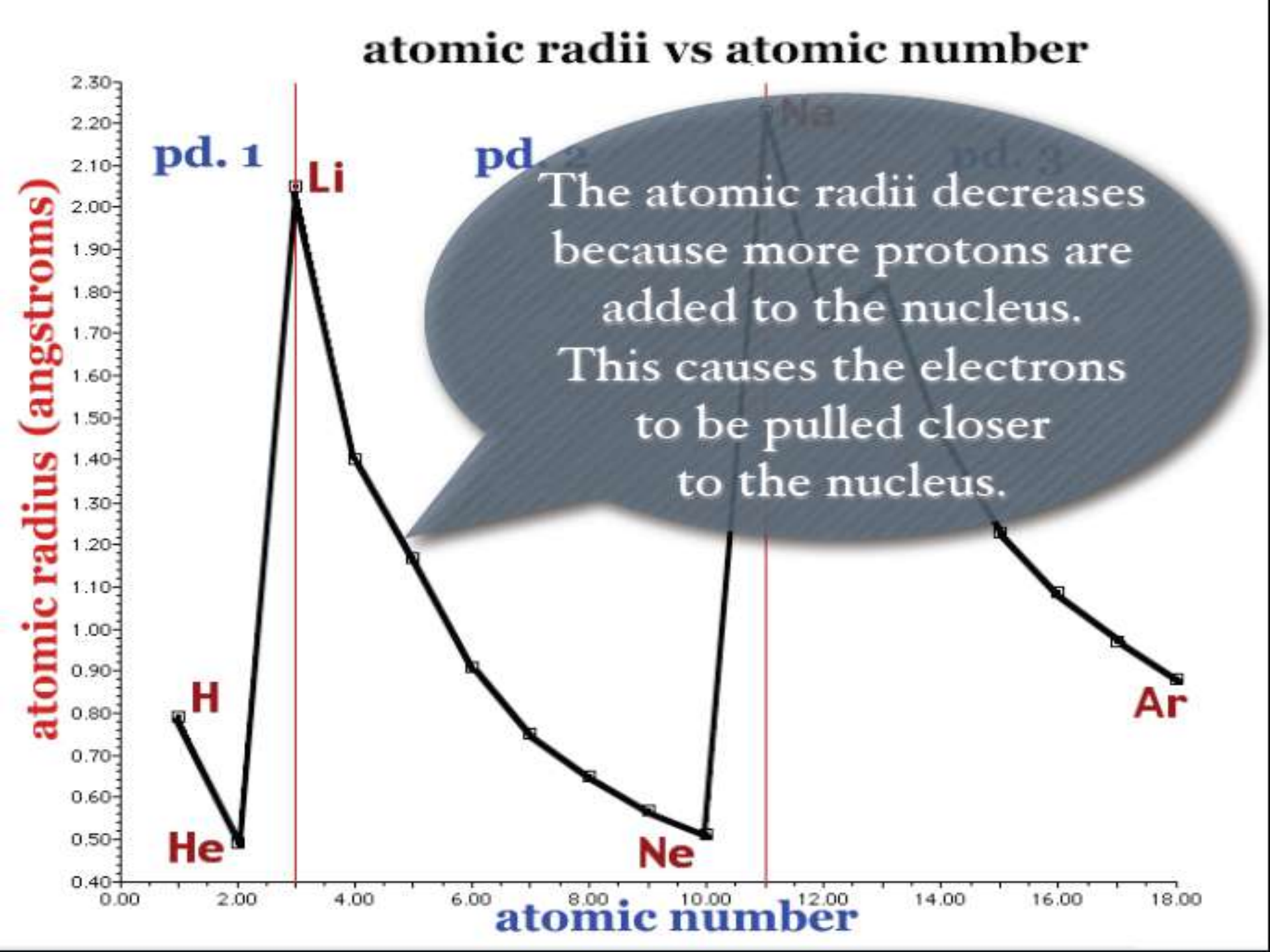
Radius

- Two variable determine the atomic radius of a atom:
  the *number of protons in the nucleus*
  the *number of electron energy levels in the atom*.
- The number protons and radius are inversely proportional.
  As protons increase, the radius decreases.
- The number of energy levels and radius are proportional.
  As energy levels increase, the radius also increases.

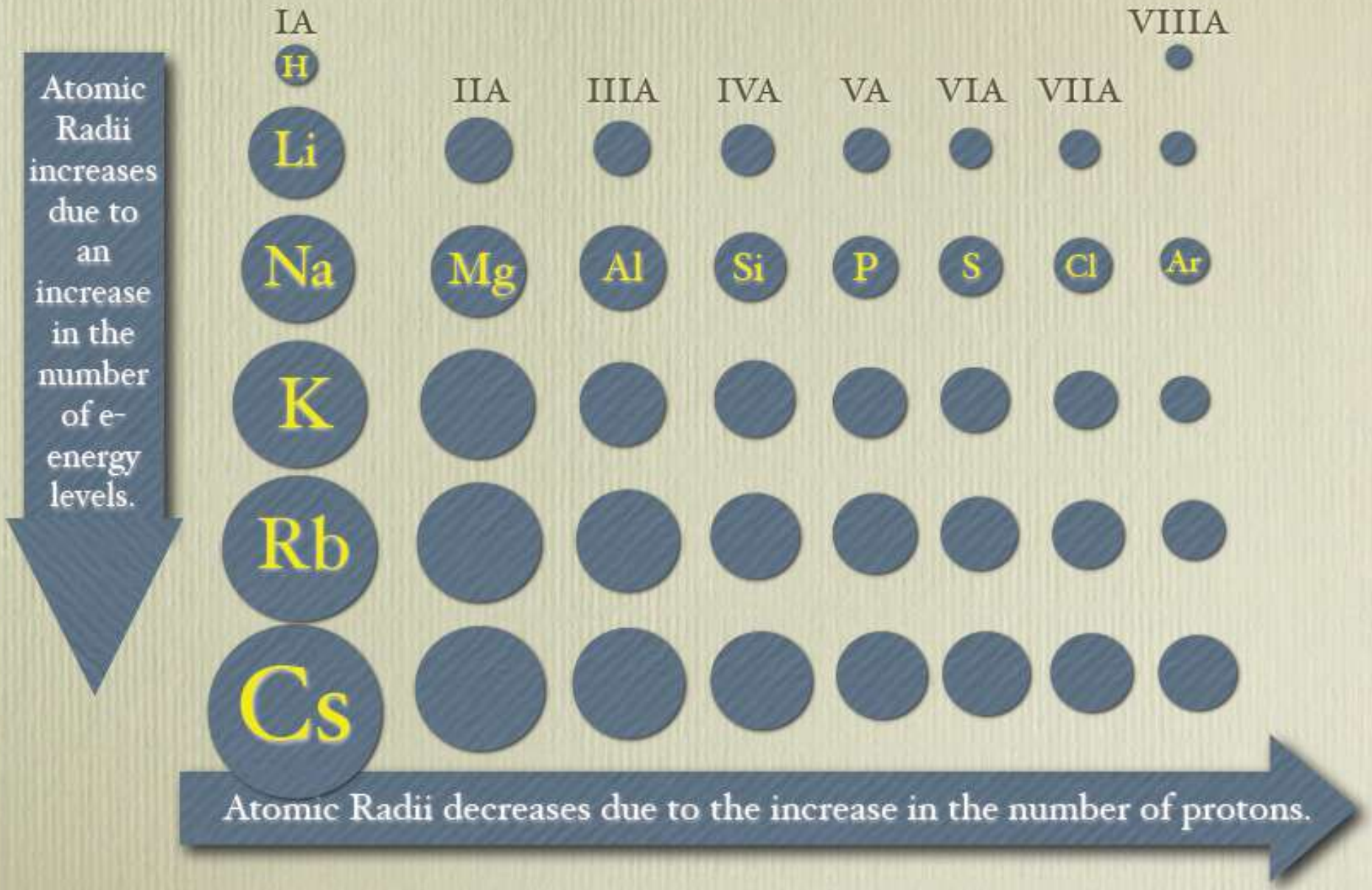
Atomic Radii and Proton

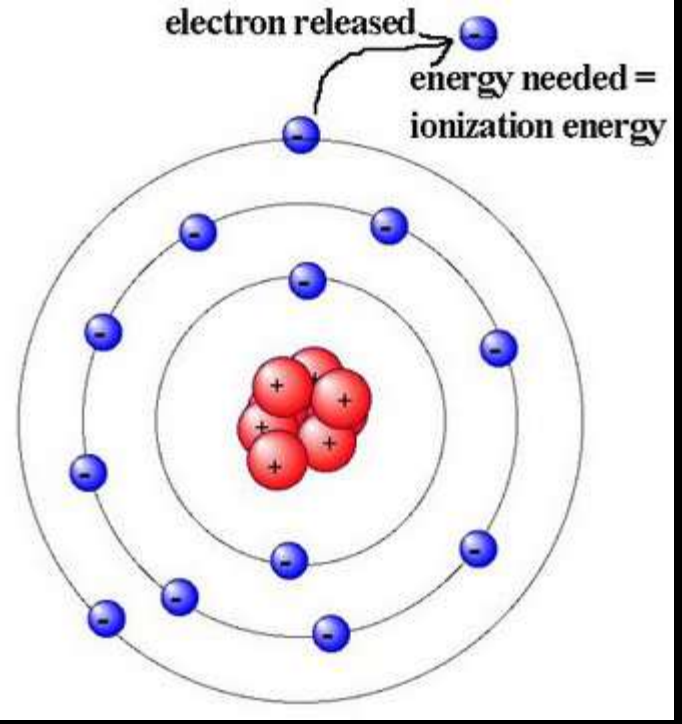
- **L to R**, more protons → more pulling → closer to the nucleus → smaller the bond radius → **smaller atomic radius**
- **T to B**, more electron shells → electrons are farther away → inefficient pulling → bigger the bond radius → **larger atomic radius**




atomic radii vs atomic number
atomic radius (angstroms)
atomic number
pd. 1
pd. 2
pd. 3
Li
Na
H
He
Ne
Ar
The atomic radii decreases because more protons are added to the nucleus. This causes the electrons to be pulled closer to the nucleus.
2.30
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00

Atomic Radii of the Elements

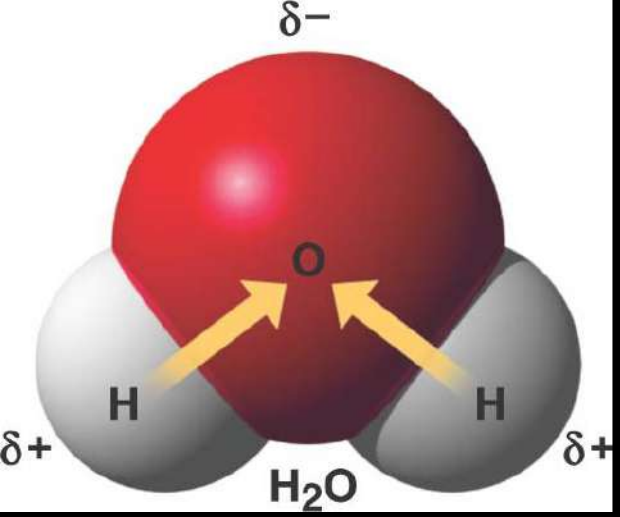




Ionization Energy

the energy required to remove the most loosely held valence electron from the atom to form a positive ion when the atom is in the gas phase

- **L to R**, more protons → stronger pulling → tighter the atom → more energy needed to remove an electron → **I.E increases**
- **T to B**, more electron shells → electron shielding → farther electrons feel less attraction → less energy to remove an electron → **I.E decreases**



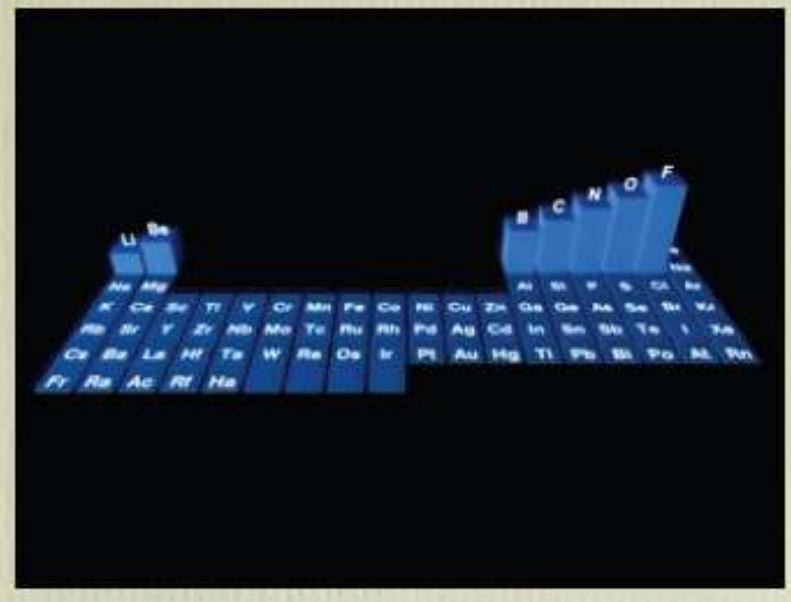
Electronegativity

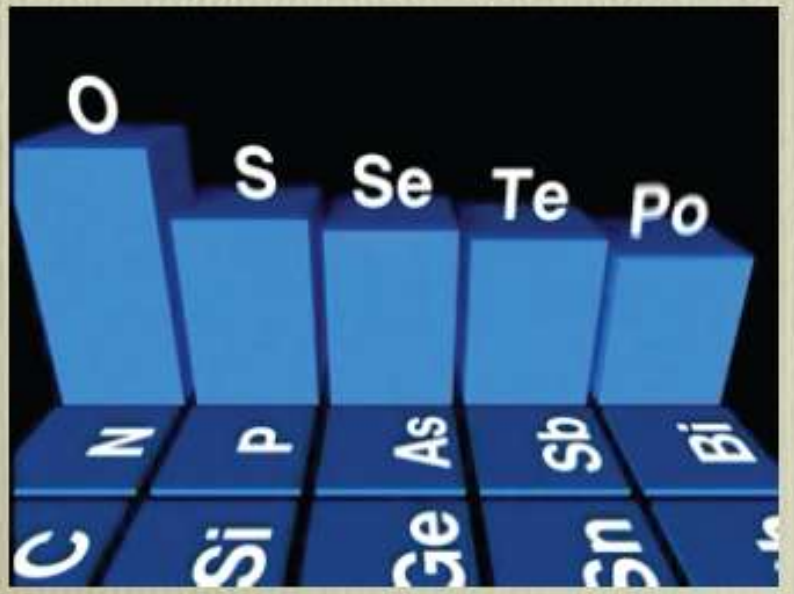
The ability of an atom to attract valence electrons to itself.

- **L to R**, more protons → more pulling from nucleus → easier to attract another electron → **increase in electronegativity**
- **T to B**, more electron shells → farther away → less effective pulling → **decrease in electronegativity.**

Periodic Trends: Electronegativity

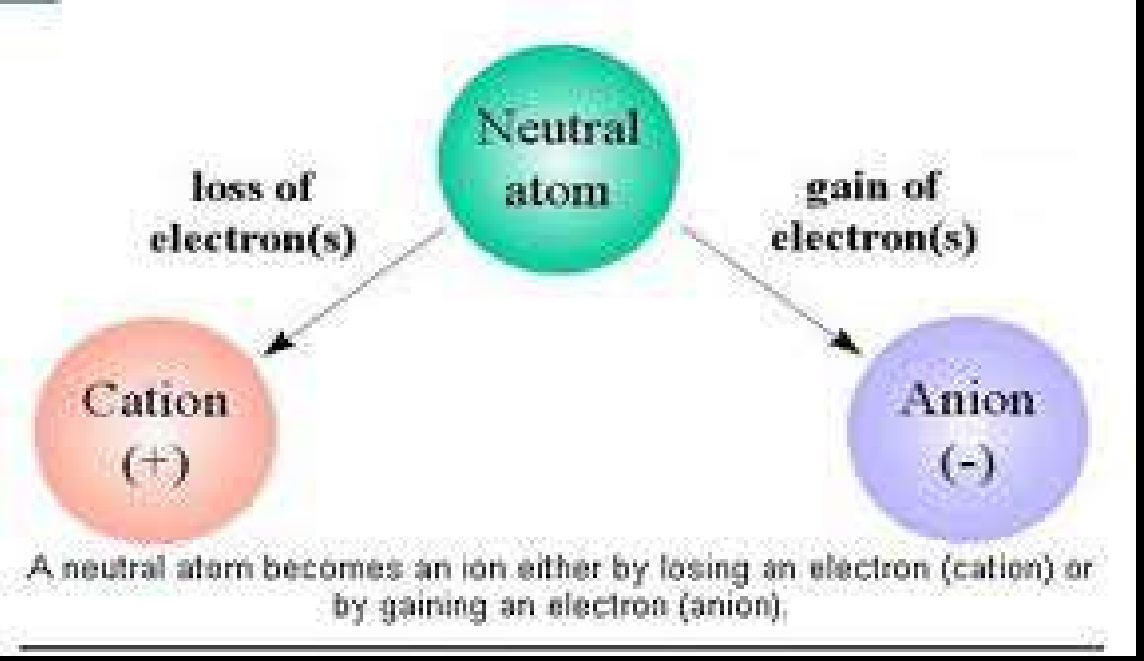
The ability of an atom to attract valence electrons to itself.





Periodic Trends: Ionization Energy

The energy required to remove and electron from an atom.



Ionic Radii

Cation- Positively charged ions formed when an atom of a metal loses one or more electrons

Smaller than the corresponding atom

Anion - Negatively charged ions formed when nonmetallic atoms gain one or more electrons

Larger than the corresponding atom

Metallic Character

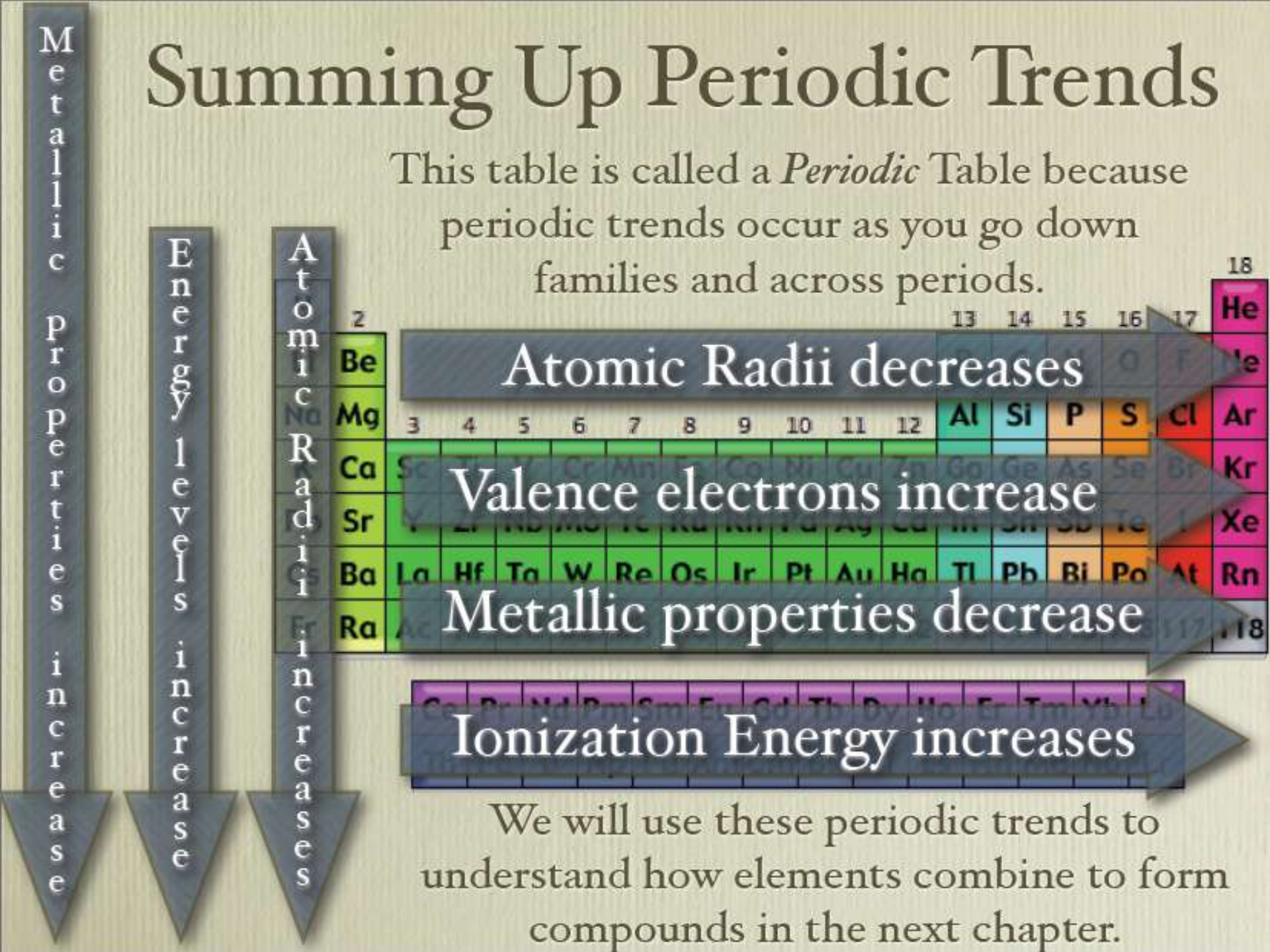
- ***the degree to which an element matches the characteristics of metals***
- Metals lose electrons and form + ions, therefore elements that have low electronegativity and lose electrons easily have high metallic character.

Nonmetallic Character:

- ***the degree to which an element matches the characteristics of nonmetals. Nonmetals***
- gain electrons and form - ions, therefore elements which have high electronegativity and gain electrons easily have high nonmetallic character.

Summing Up Periodic Trends

This table is called a *Periodic* Table because periodic trends occur as you go down families and across periods.



We will use these periodic trends to understand how elements combine to form compounds in the next chapter.

Checking for understanding

Copy and complete frame sentences about the periodic table:

The number of protons _____ going right.

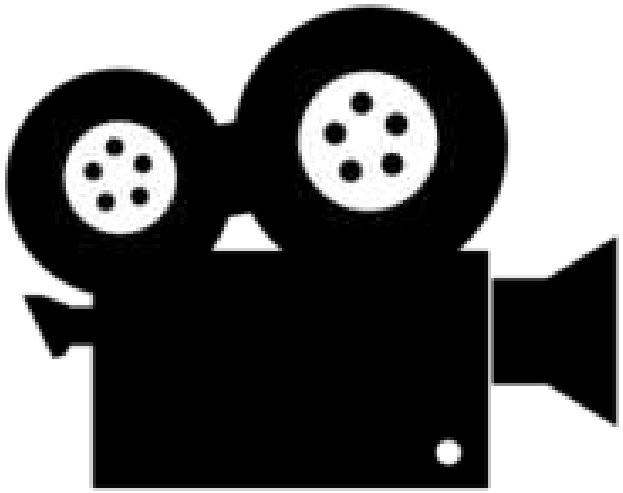
As the number of protons _____ the atomic radii _____. Ionization energy _____ left to right, because _____.

Electronegativity increases _____ due to _____ and decreases _____ _____ because _____.

Cations are _____ than their corresponding ions, and anions are _____ than there corresponding ions.

Click Below for the Video Lectures

Periodicity

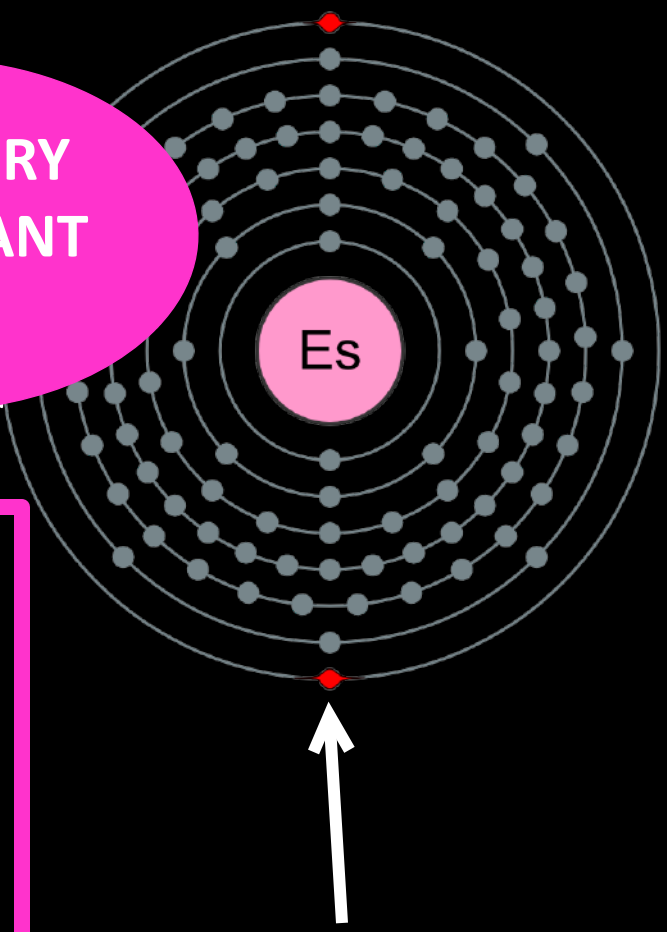


Ions

Chemical Compounds

- An atom consist of a positively charged nucleus (protons and neutrons) and orbiting el
- Valence electrons are ele the outmost shell (energy They are the electrons avail ble for bonding.

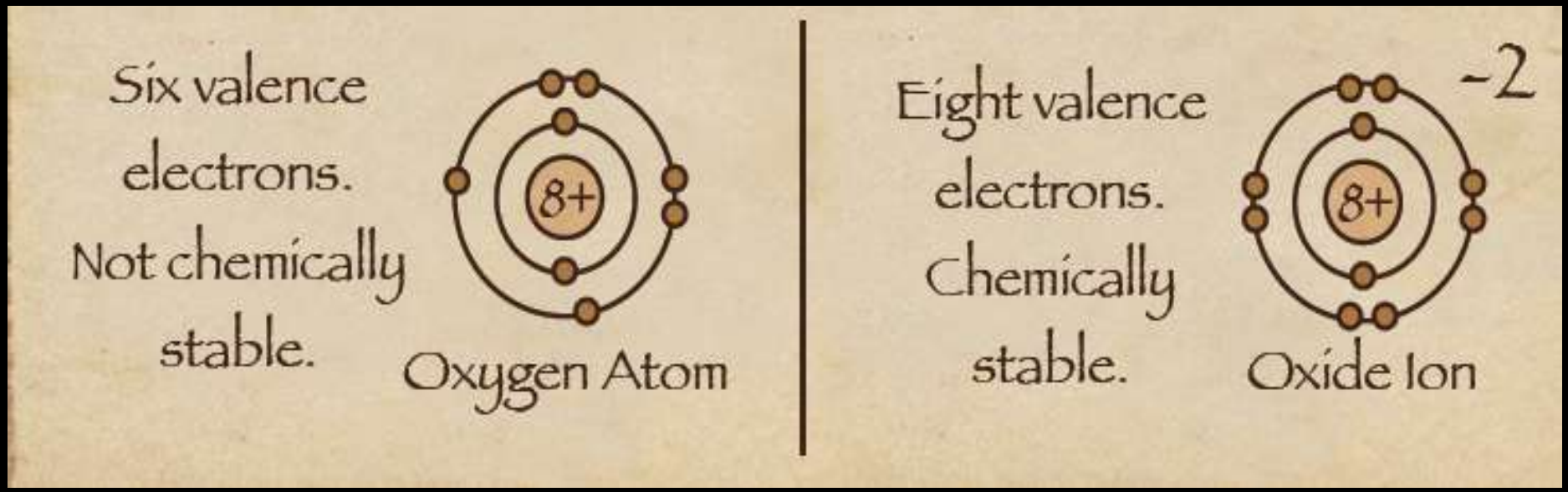
VERY VERY IMPORTANT !!!!



- Atoms of elements are not chemically stable until they have 8 valence electrons (octet rule).
- Atoms gain, lose or share electrons with other atoms to be come chemically stable (have 8 valence electrons).

Oxygen Atom vs. Oxygen Ion

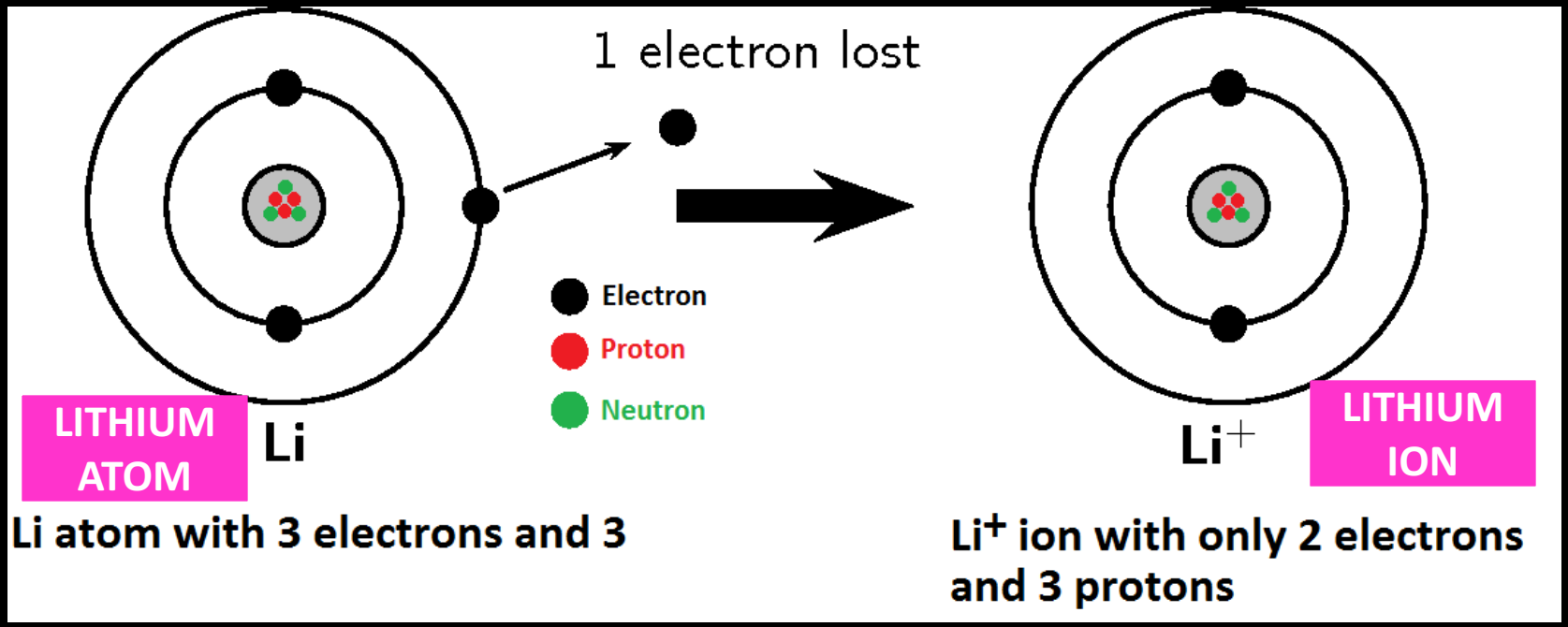
- Atoms of elements are not chemically stable until they have 8 valence electrons (octet rule).
- Atoms gain, lose or share electrons with other atoms to be come chemically stable (have 8 valence electrons).



Metals

- Metals loose valence electrons to fulfill octet.

METAL LOOSES ELECTRON→ CATION (+)

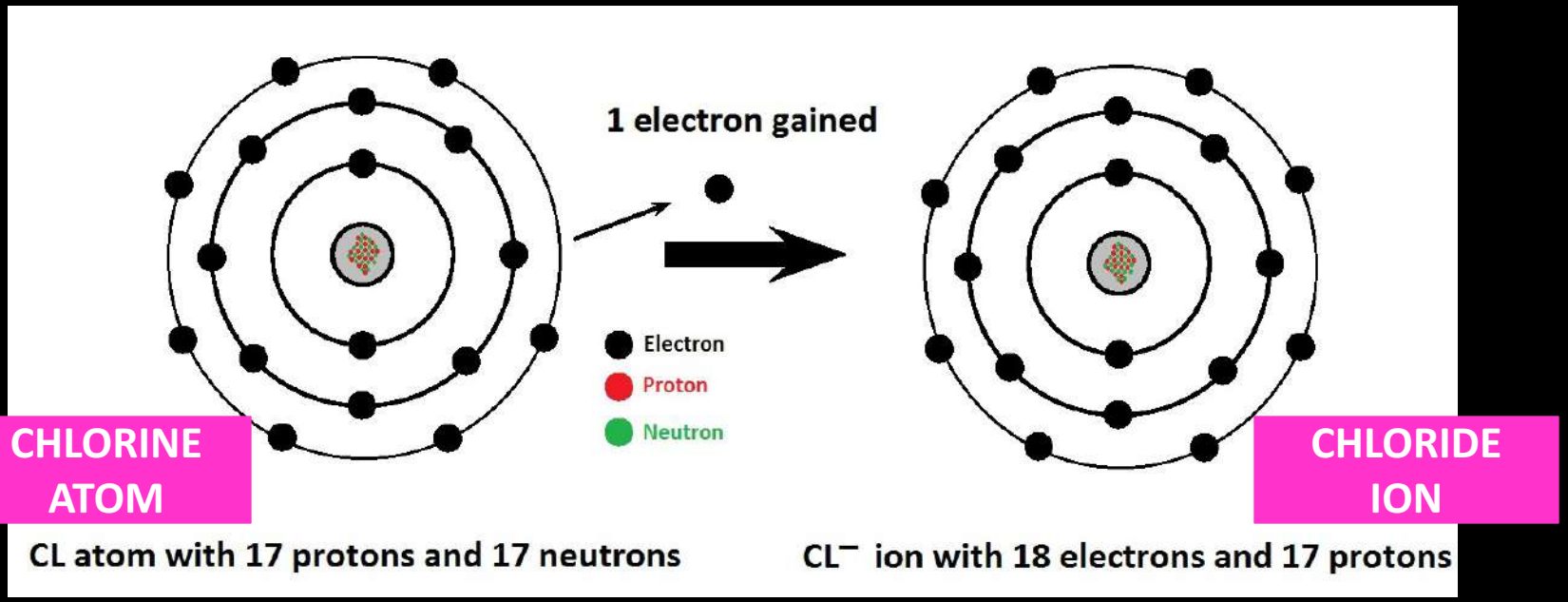


- When an atom looses electrons, its radius decreases

Nonmetals

- Nonmetals gain valence electrons to fulfill octet.

NONMETAL GAIN ELECTRON→ ANION (-)



- When an atom gains electrons, its radius increases

Period 4 Transition Metals

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
+3	+4 +3	+5 +4	+6 +3	+4 +6	+2 +3	+2 +3	+2 +3	+2 +1	+2

Cations

- Positive ions retain the name of the element.
- If the atom is capable of forming more than one possible ion (like Fe can form charges of +2 or +3...) then a Roman numeral is placed after the ion name, signifying the charge.

Mn^{+4} Manganese (IV) Mn^{+6} Manganese (VI)

Fe^{+2} Iron (II) Fe^{+3} Iron (III)

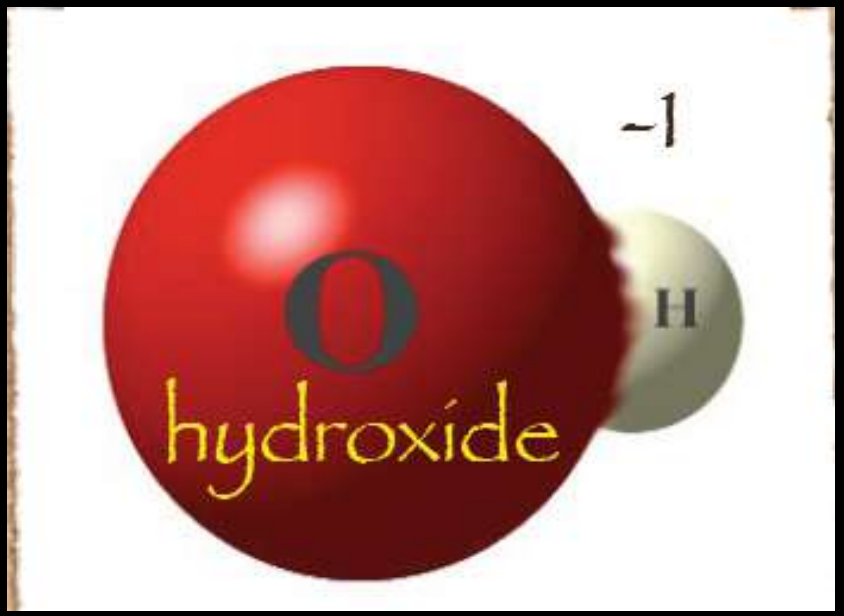
Cu^{+1} Copper (I) Cu^{+2} Copper (II)

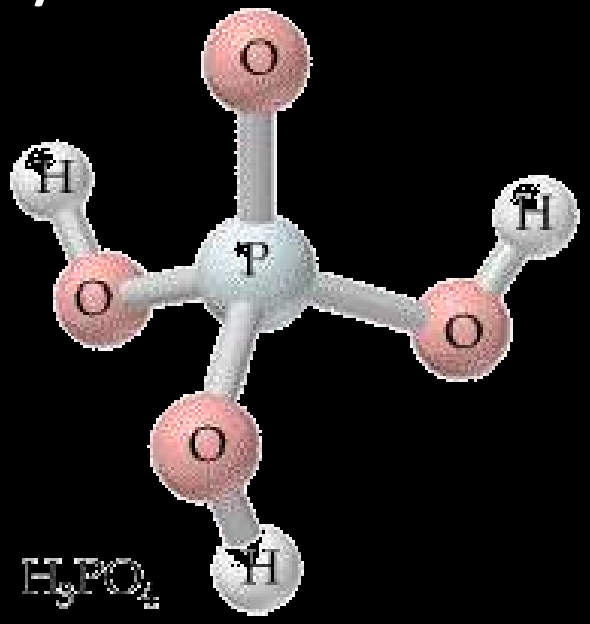
Anion

- Negative ions are named after the element, with the second syllable replaced with the suffix -ide.

Polyatomic Ions

- Polyatomic (many atom) ions are covalent molecules with a charge. They behave as if they were a one-atom ion.





Note: ammonium is the only polyatomic ion with a + charge.

Checking for understanding

- What are the 3 ways atoms can achieve 8 valence electrons (=octet)?
- How do metals become ions?
- How do nonmetals become ions?
- Name these cations:

  Al^{3+} Ba^{2+} Ca^{2+}

- Name these anions:

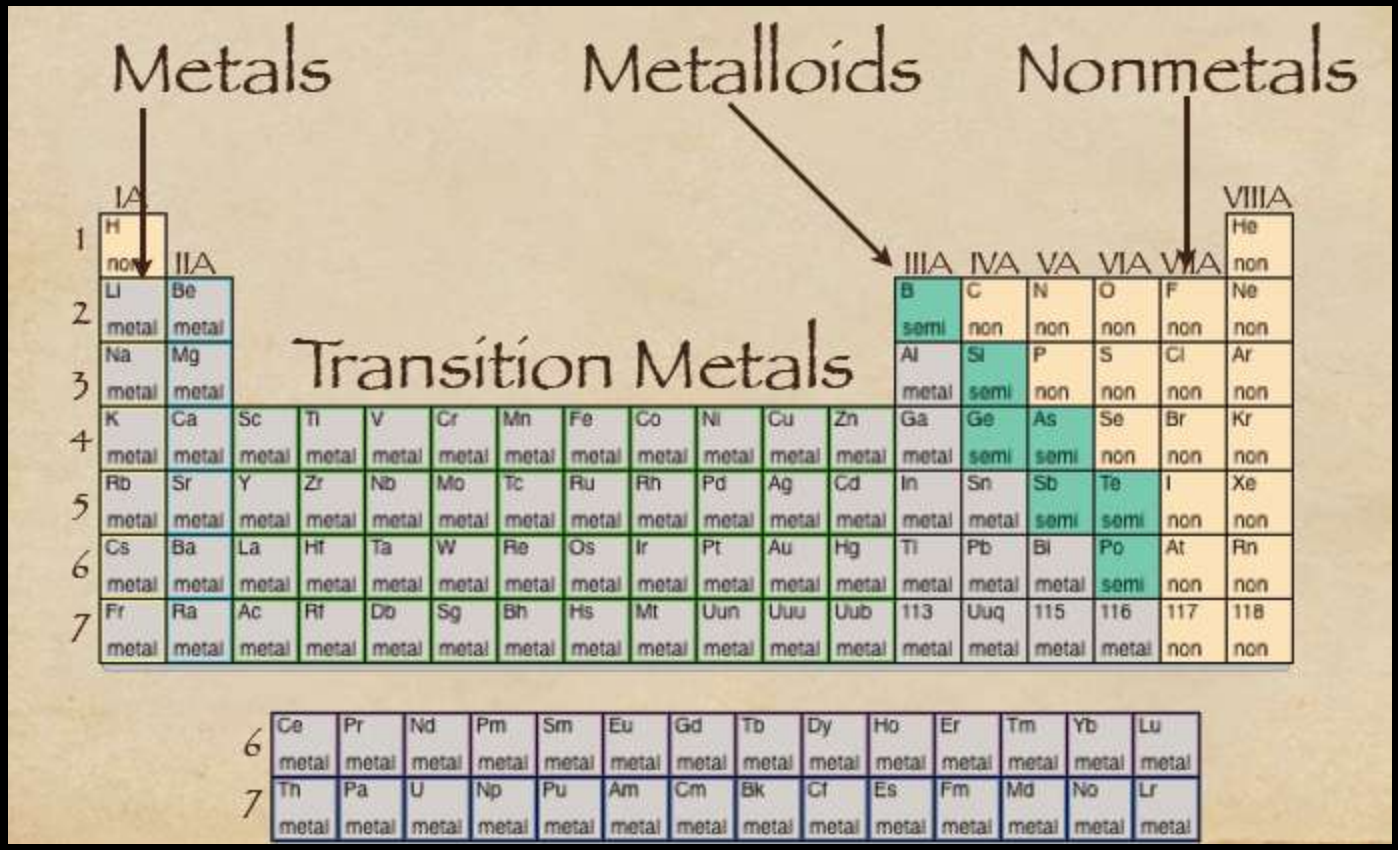
  O^{2-} F^{-} S^{2-}

Types of Bonding

Types of Compounds

Ionic = Metal + Nonmetal

Covalent = 2 Nometals or Metalloid & Nonmetal

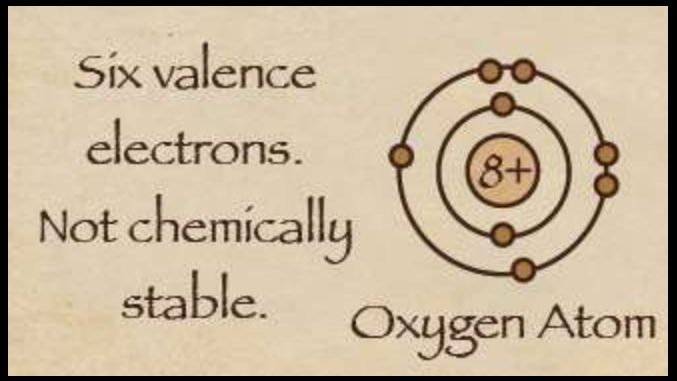


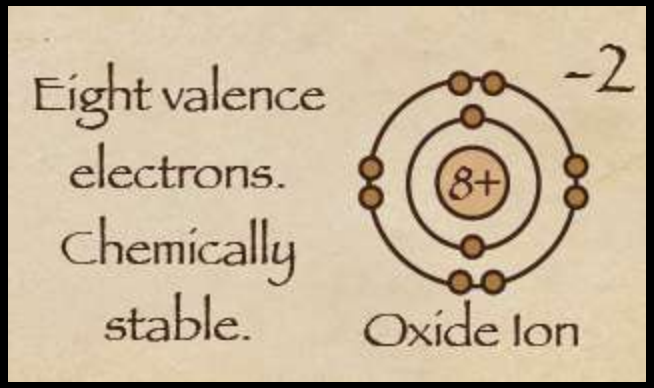
Chemical Compounds

- An atom consist of a positively charged nucleus (protons and neutrons) and orbiting electrons.

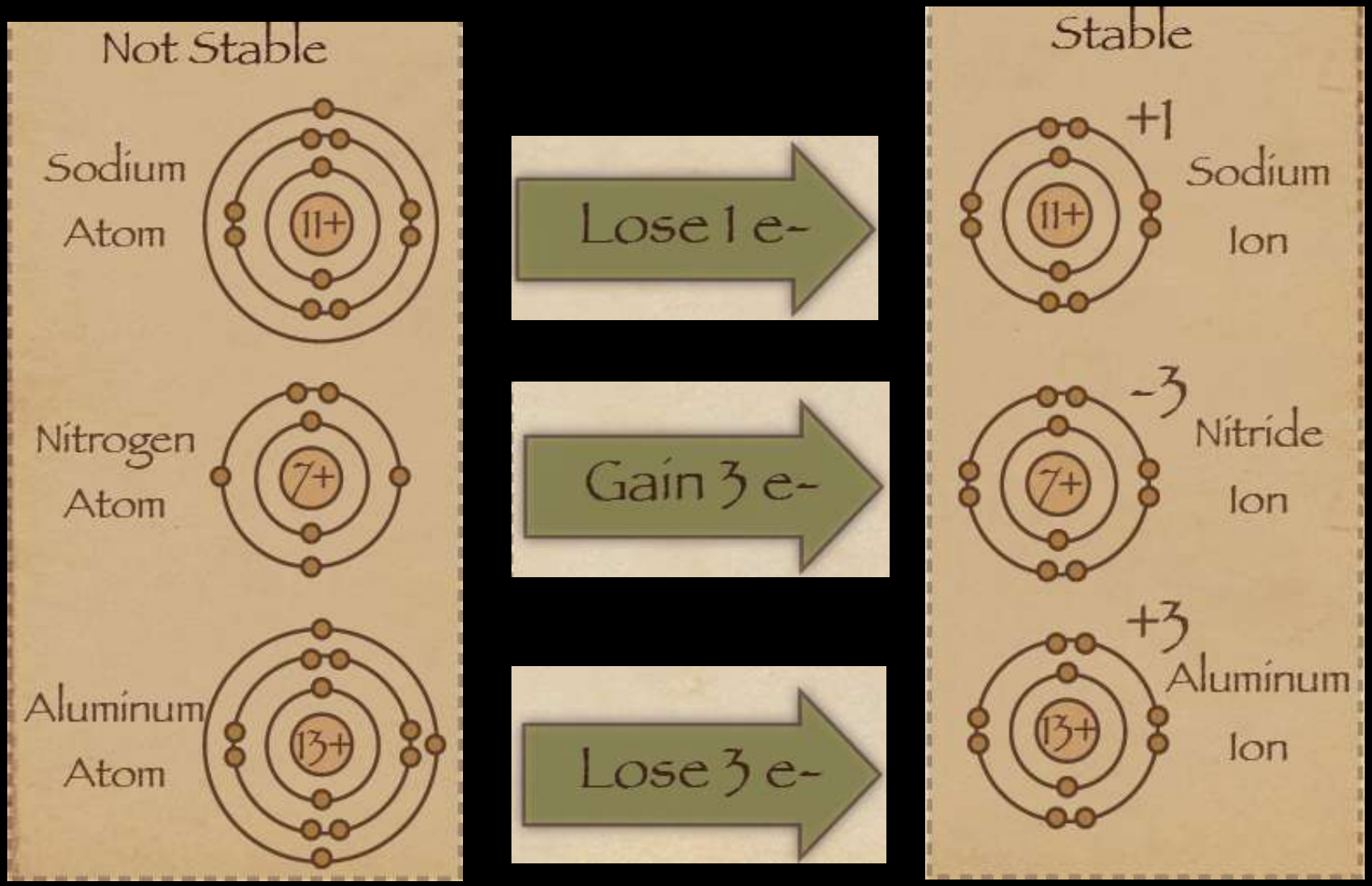
Atoms of elements are not chemically stable until they have 8 valence electrons (octet rule).

Atoms gain, lose or share electrons with other atoms to become chemically stable (have 8 valence electrons).





Atoms & Ions:


Not Stable
Sodium Atom
11+
Nitrogen Atom
7+
Aluminum Atom
13+
Lose 1 e-
Gain 3 e-
Lose 3 e-
Stable
+1
Sodium Ion
11+
-3
Nitride Ion
7+
+3
Aluminum Ion
13+

Two Types of Compounds

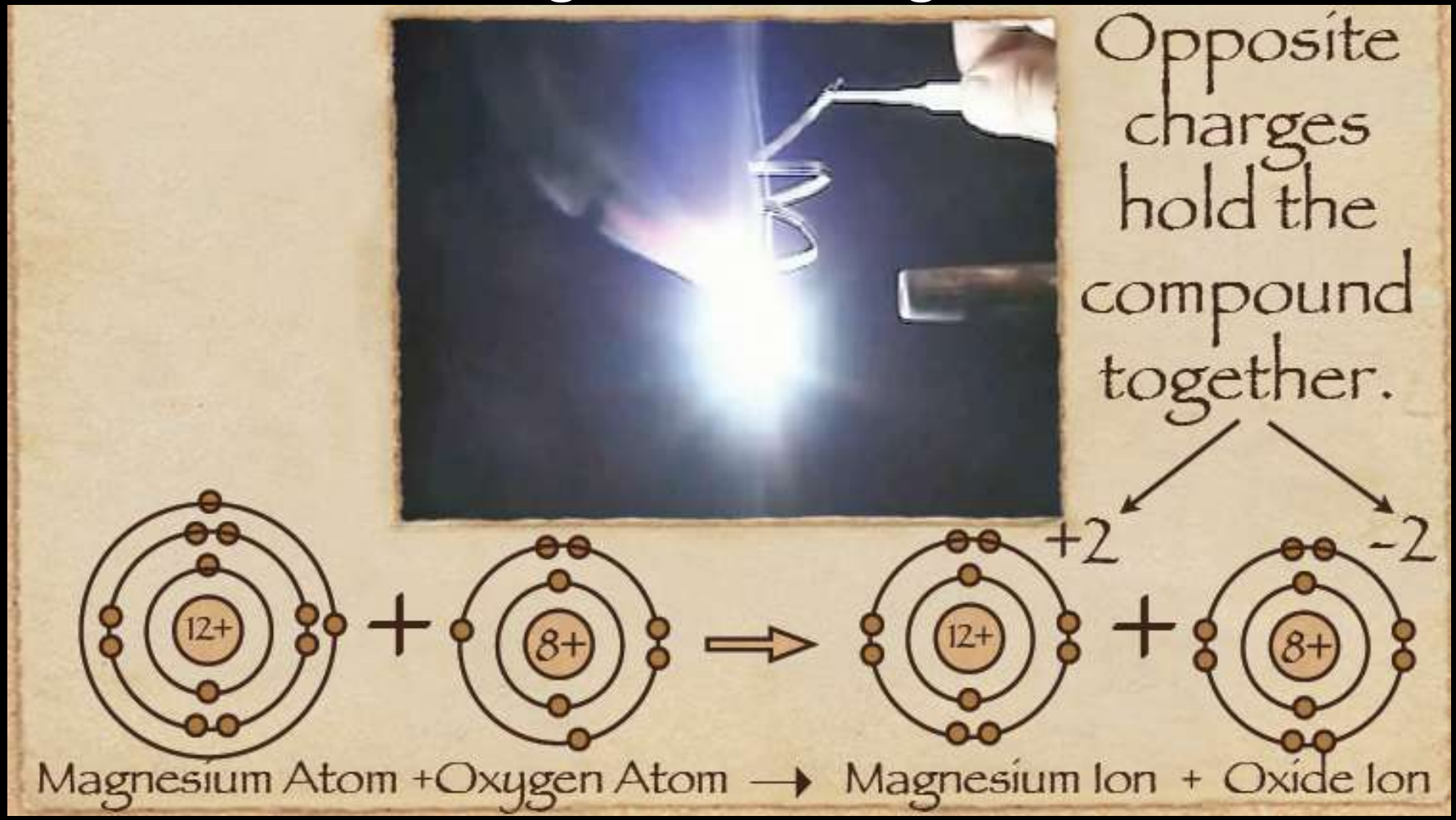
- Ionic - occurs when a metal transfers all its valence electrons to a nonmetal.
  - The metal becomes a cation (+ion), while the nonmetal becomes an anion (- ion).

- Covalent - two nonmetals share electrons.
  - Neither loses or gains electrons - they share electrons. Neither atom becomes an ion.

Ionic Compounds

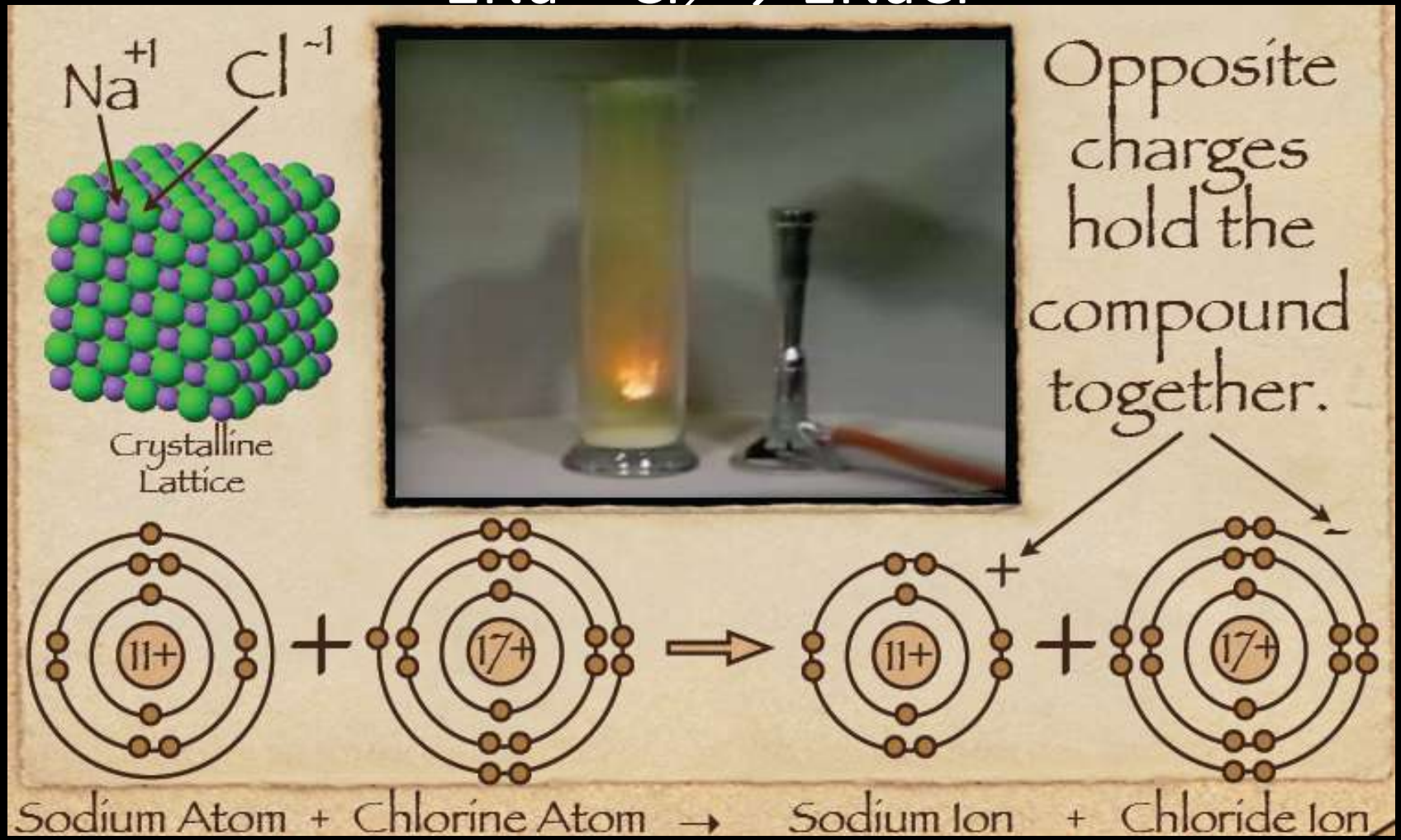
Oxidizing Magnesium

$2Mg + O_2 \rightarrow 2MgO$



Formation of Sodium Chloride

$2Na + Cl_2 \rightarrow 2NaCl$



Ionic Compound Formation

1. Occurs between a metal atom and a nonmetal atom
2. The nonmetal atom has a higher electronegativity than the metal atom, and therefore wins the competition for the valence electrons.
3. The nonmetal atom gains electrons from the metal atom, which loses all of its valence electrons to the nonmetal.
4. The number of electrons lost or gained will be the number needed by each atom to form a stable octet (8 valence electrons)
5. The metal atom loses electrons and becomes a + charged cation.
6. The nonmetal atom gains electrons and becomes a - charged anion.
7. The two oppositely charged ions attract each other.

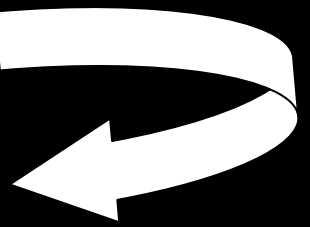
Ionic Bonding: The Formation of Sodium Chloride

- Sodium has 1 valence electron
- Chlorine has 7 valence electrons

An electron transferred gives each an octet

Na: $1s^2 2s^2 2p^6 3s^1$

Cl: $1s^2 2s^2 2p^6 3s^2 3p^5$



Ionic Bonding:
The Formation of Sodium Chloride

This transfer forms ions, each with an octet:

Na^+ $1s^2\boxed{2s^2 2p^6}$

Cl^- $1s^2 2s^2 2p^6\boxed{3s^2 3p^6}$

Ionic Bonding:
The Formation of Sodium Chloride

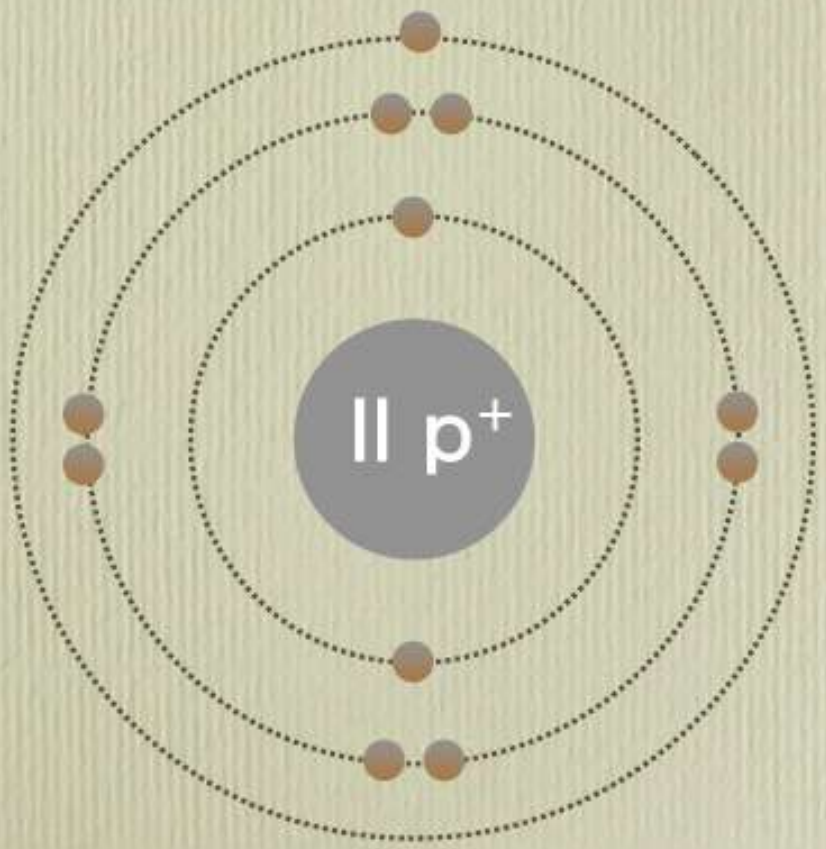
The resulting ions come together due to electrostatic attraction (opposites attract):

Na^+ Cl^-

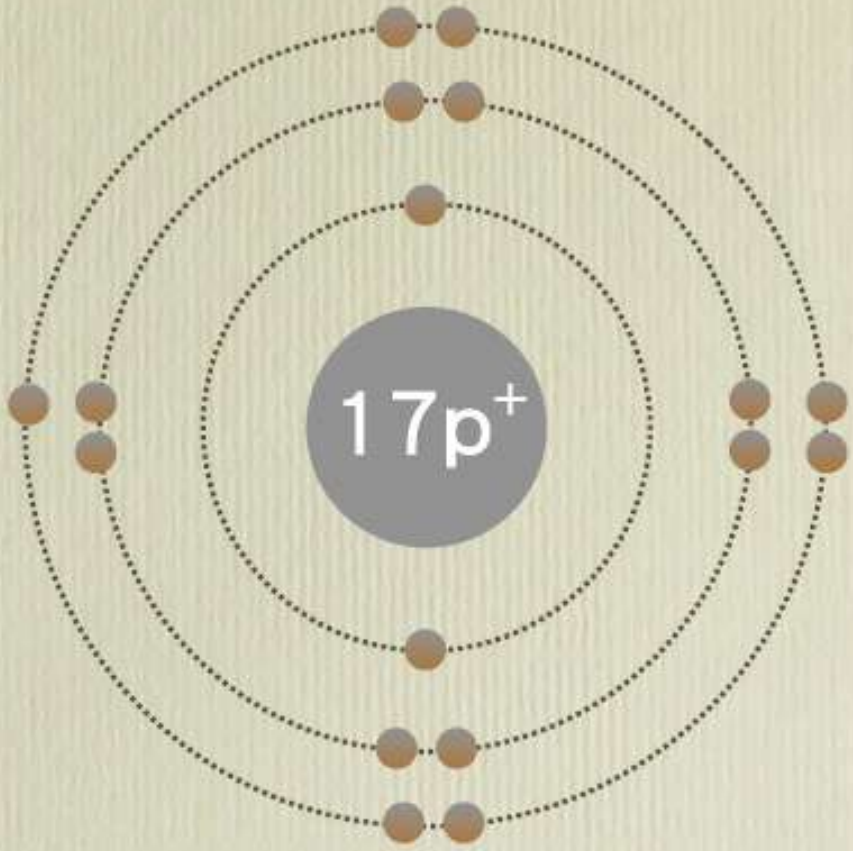
CATION ANION

The net charge on the compound must equal zero

Sodium Chloride

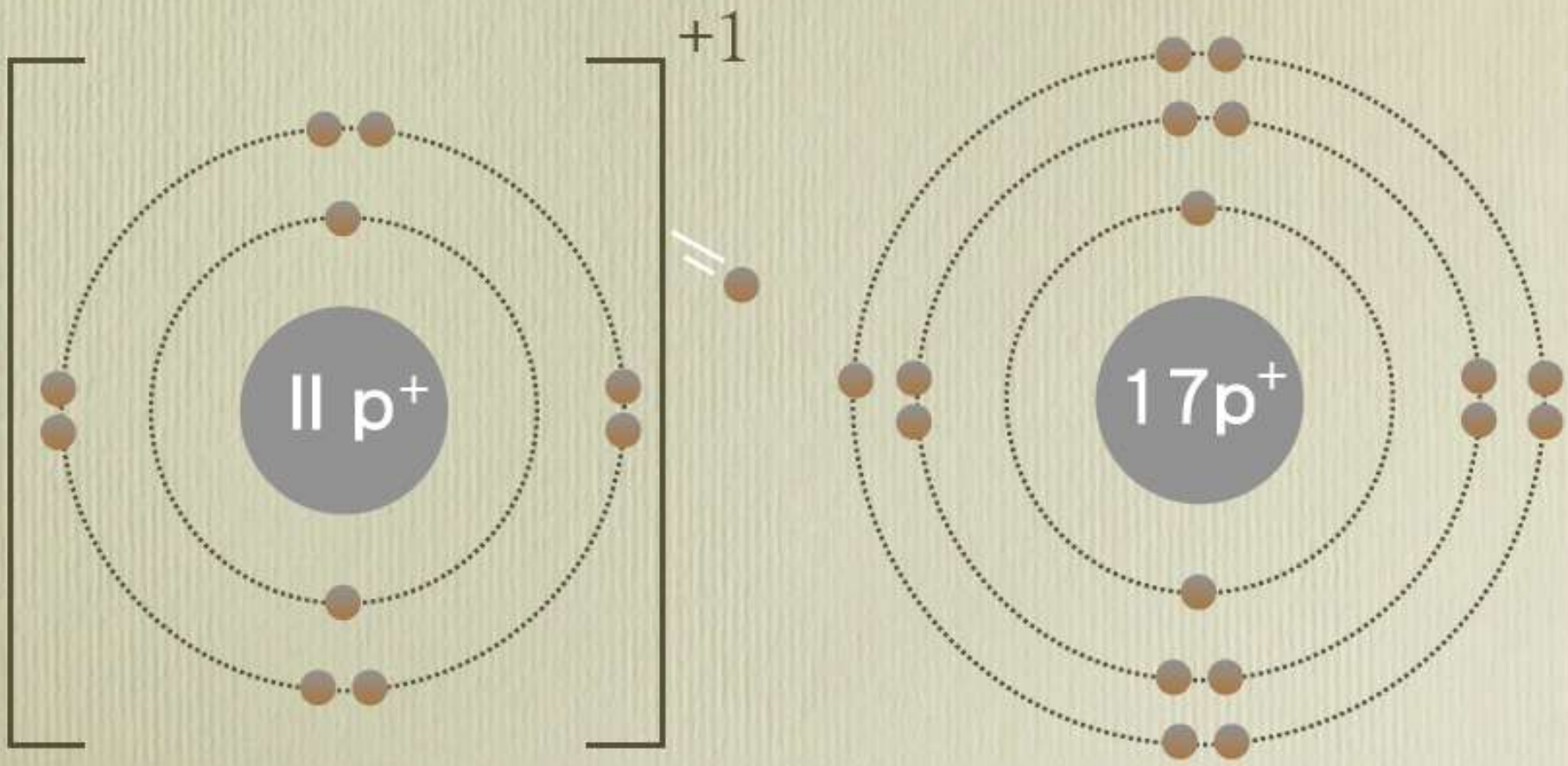


Sodium Atom



Chlorine Atom

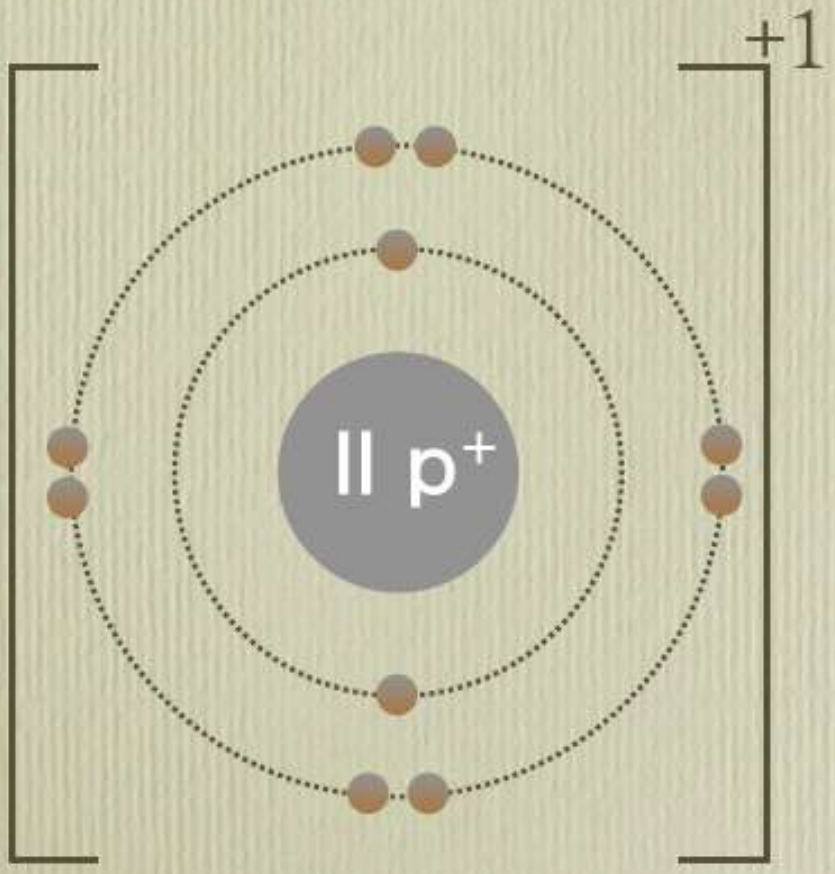
Sodium Chloride



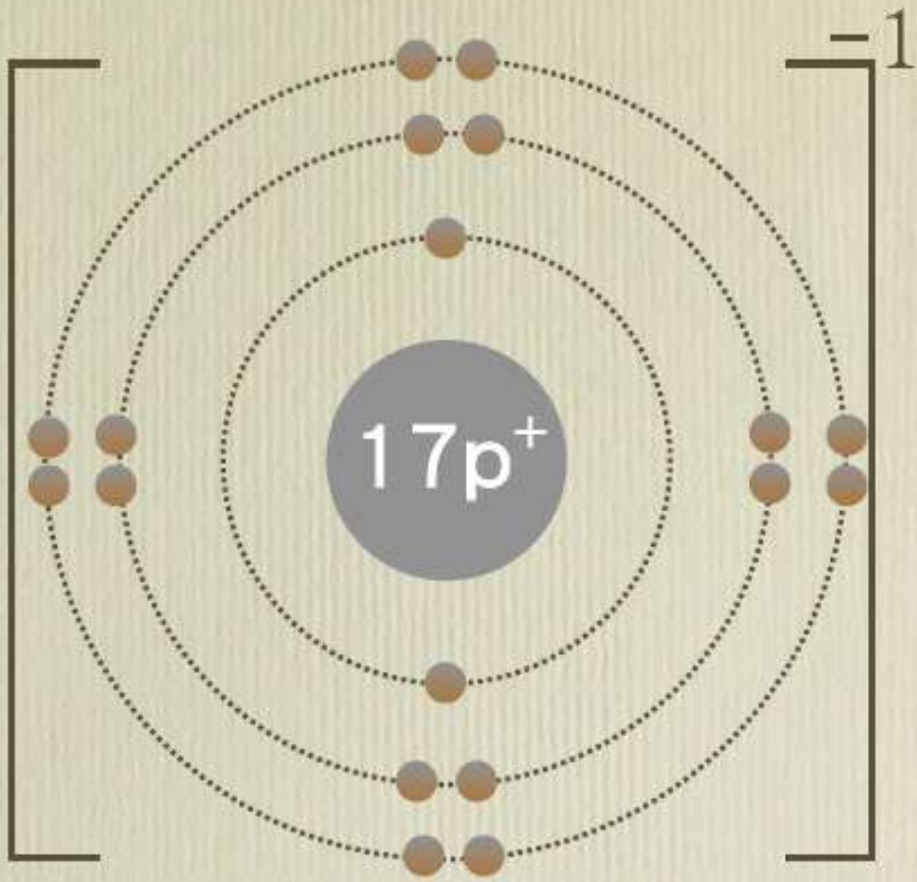
Sodium Cation

Chlorine Atom

Sodium Chloride

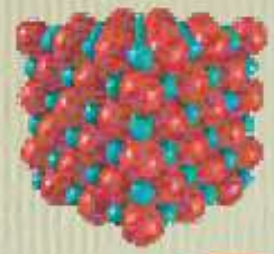


Sodium Cation

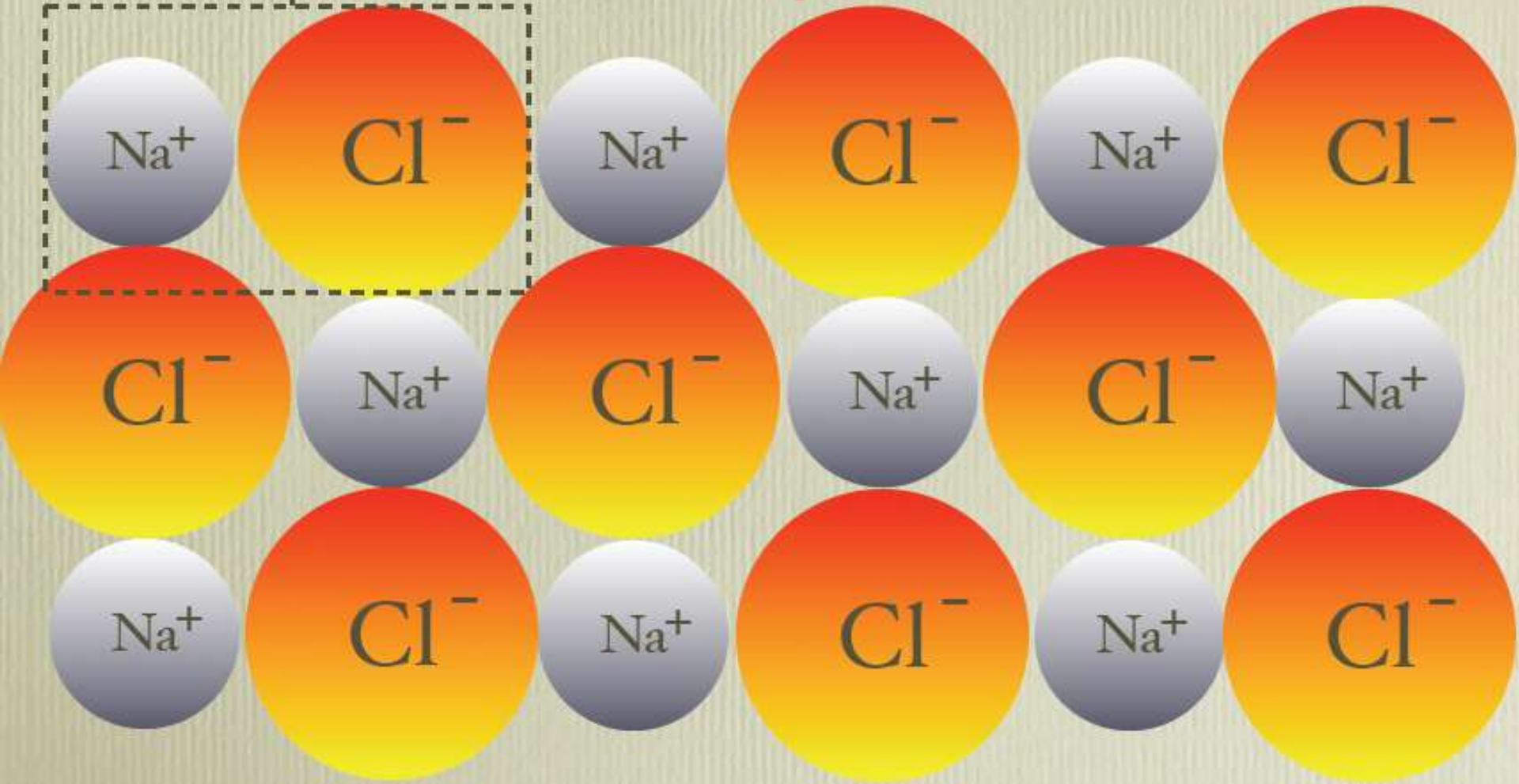


Chloride Anion

Let's construct a crystalline lattice of NaCl.



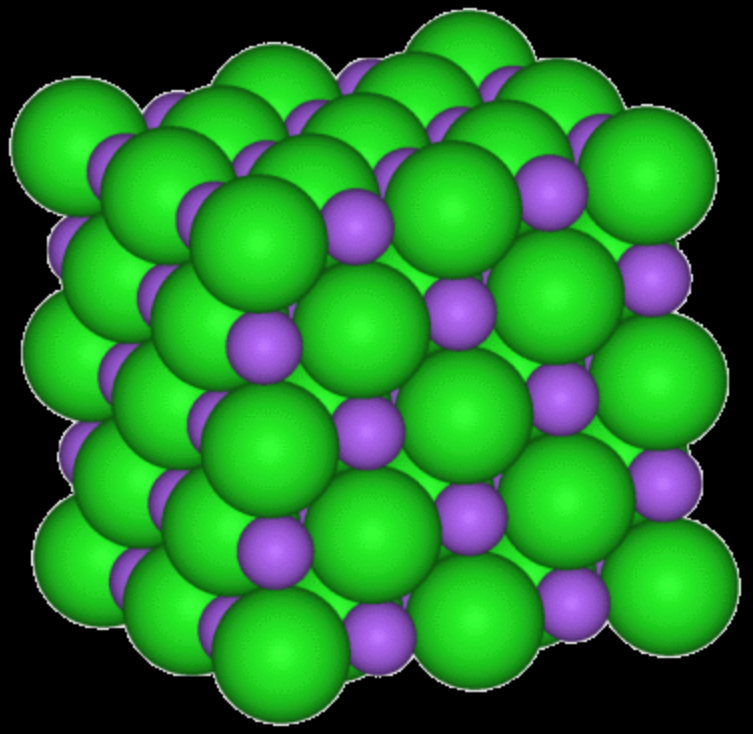
Unit Cell



Sodium Chloride Crystal Lattice

Ionic compounds form solid *crystals* at ordinary temperatures.

Ionic compounds organize in a characteristic crystal lattice of alternating positive and negative ions.



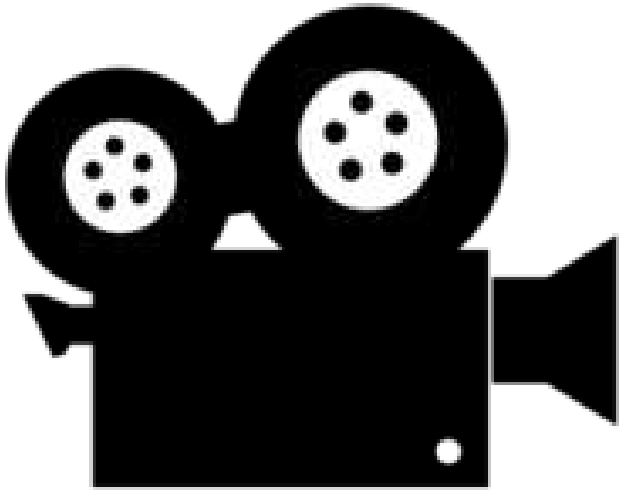
All salts are ionic compounds and form crystals.

Properties of Ionic Compounds

1. High melting and boiling points (NaCl melts at a temperature of 1074 K, compared to 273 K for water)
2. Low vapor pressure (they don't tend to evaporate, where substances like water evaporate easily)
3. Brittle (crushes easily into powder, unlike pure metals, which are malleable)
4. Ionic liquids and solutions conduct electricity because the charged particles are free to move around and carry their electrical charge from one place to another.
5. Ionic solutions (like salt water) are called electrolytes, because they can conduct electricity through them. Electrolytes are used by the body to conduct current through nerves and muscles.
6. Ionic solids do not conduct electricity because the ions are held together in the crystal lattice and can't move around.

Click Below for the Video Lectures

Ionic Bonding



Real World Application
IONIC BONDING

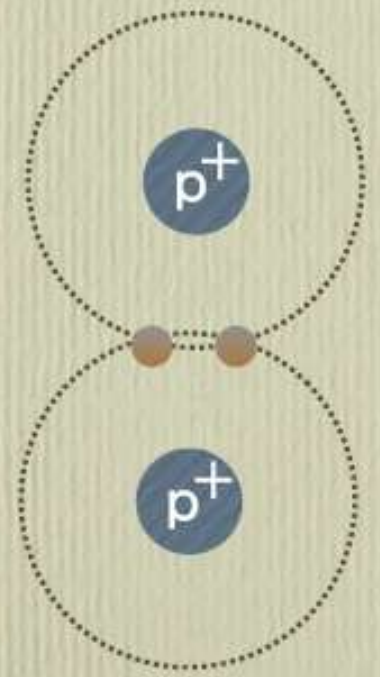
- Besides from the common household object of table salt (NaCl), many rocks in our Earth are held together via ionic bonding. Out in space, cosmic dust is also due to ionic bonding.

Covalent Compound

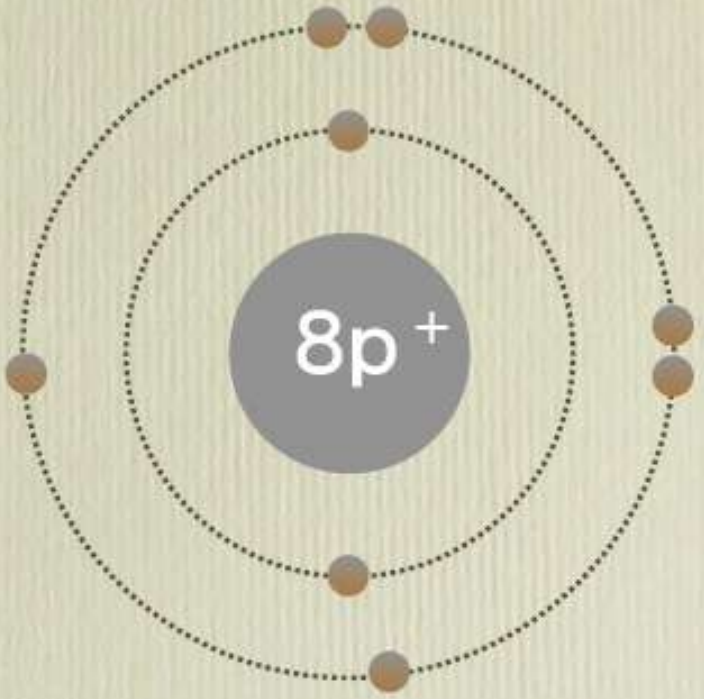
Covalent Compound Formation

1. Two NONMETAL atoms attempt to gain each other's valence electrons. They do not have enough difference in electronegativity to do so, therefore they share them.
2. The electrons shared are the unpaired valence electrons.
3. The bonded atoms actually become part of each other. This makes for a bond much stronger than an ionic bond.
4. This bond can not be broken by dissolving in water or melting, so covalent compounds never conduct electricity, regardless of the phase (exception later this year).

Formation of Water

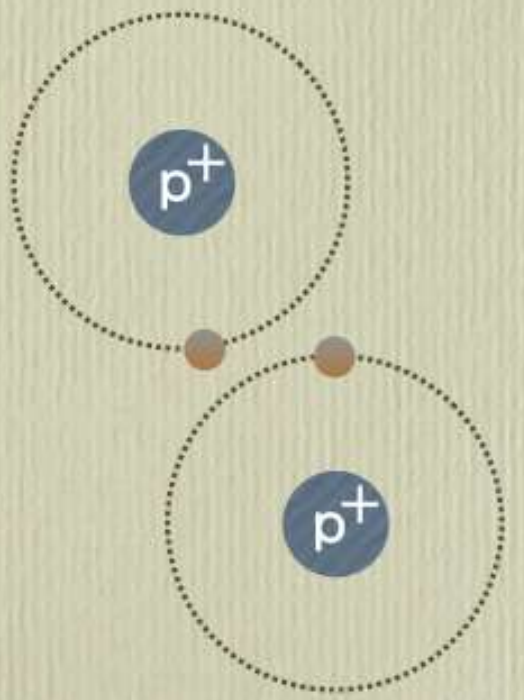


Hydrogen Atoms

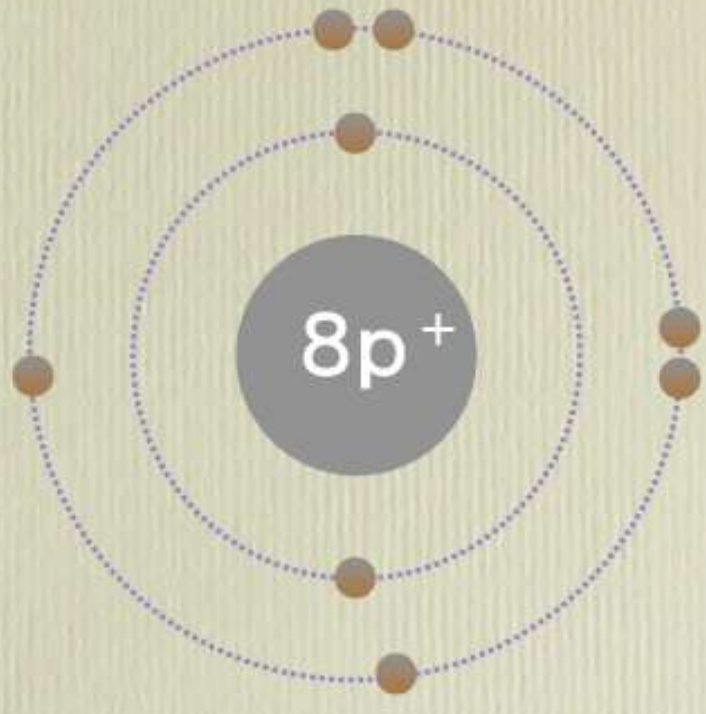


Oxygen Atom

Formation of Water

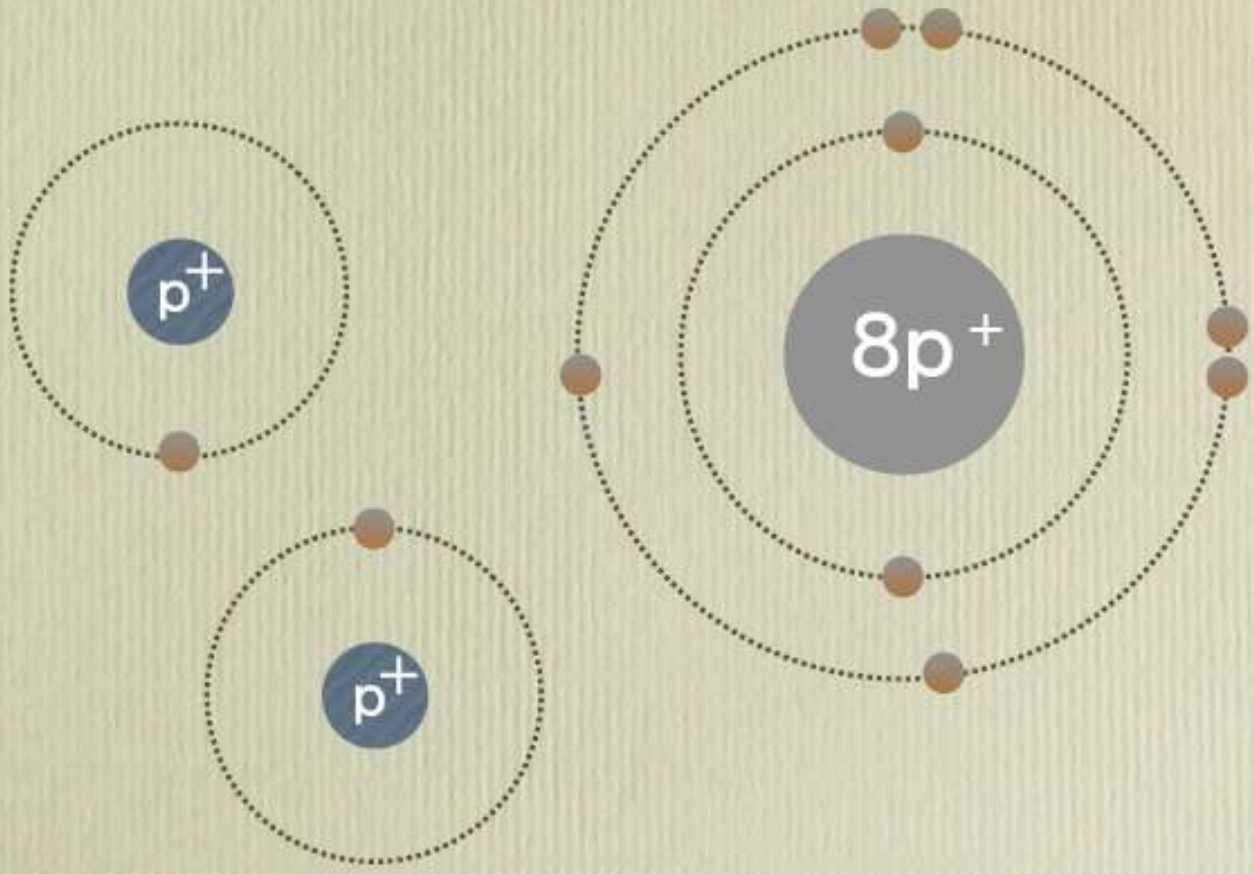


Hydrogen Atoms

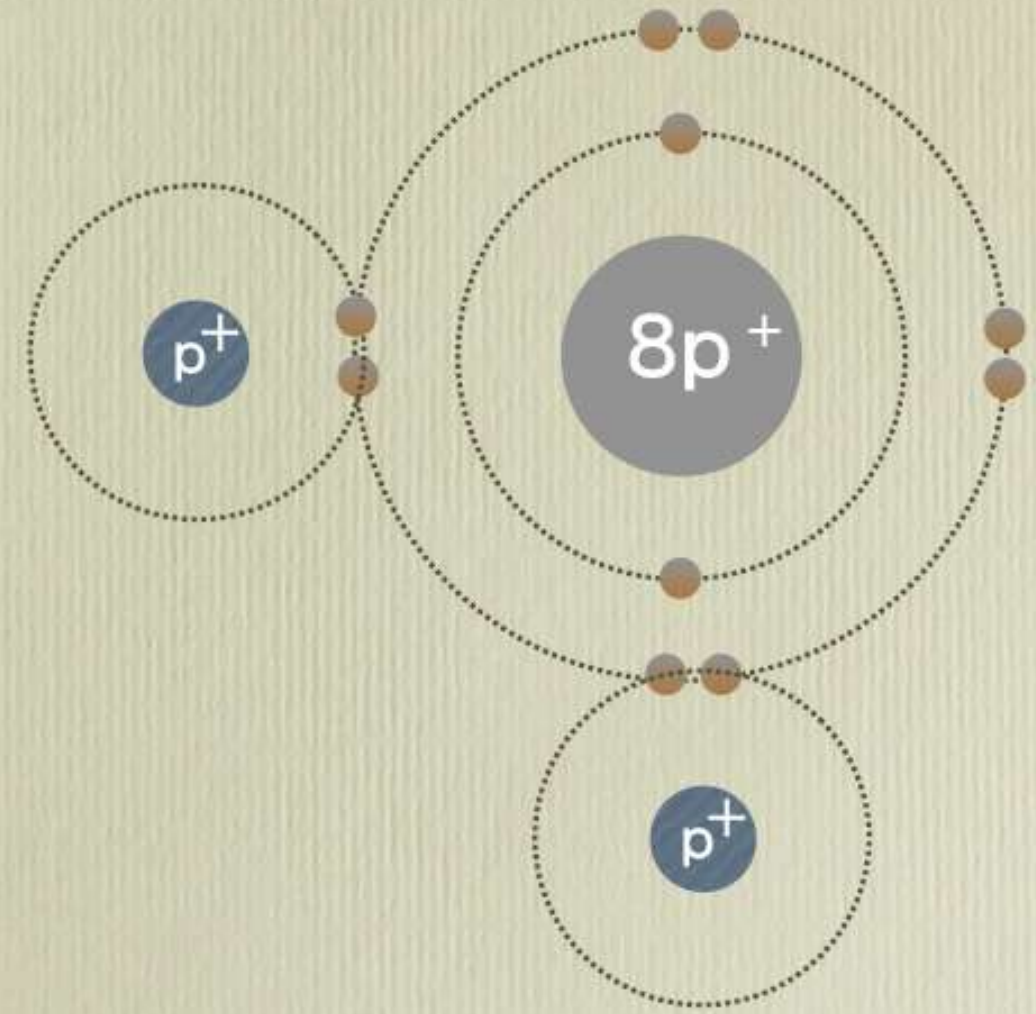


Oxygen Atom

Formation of Water

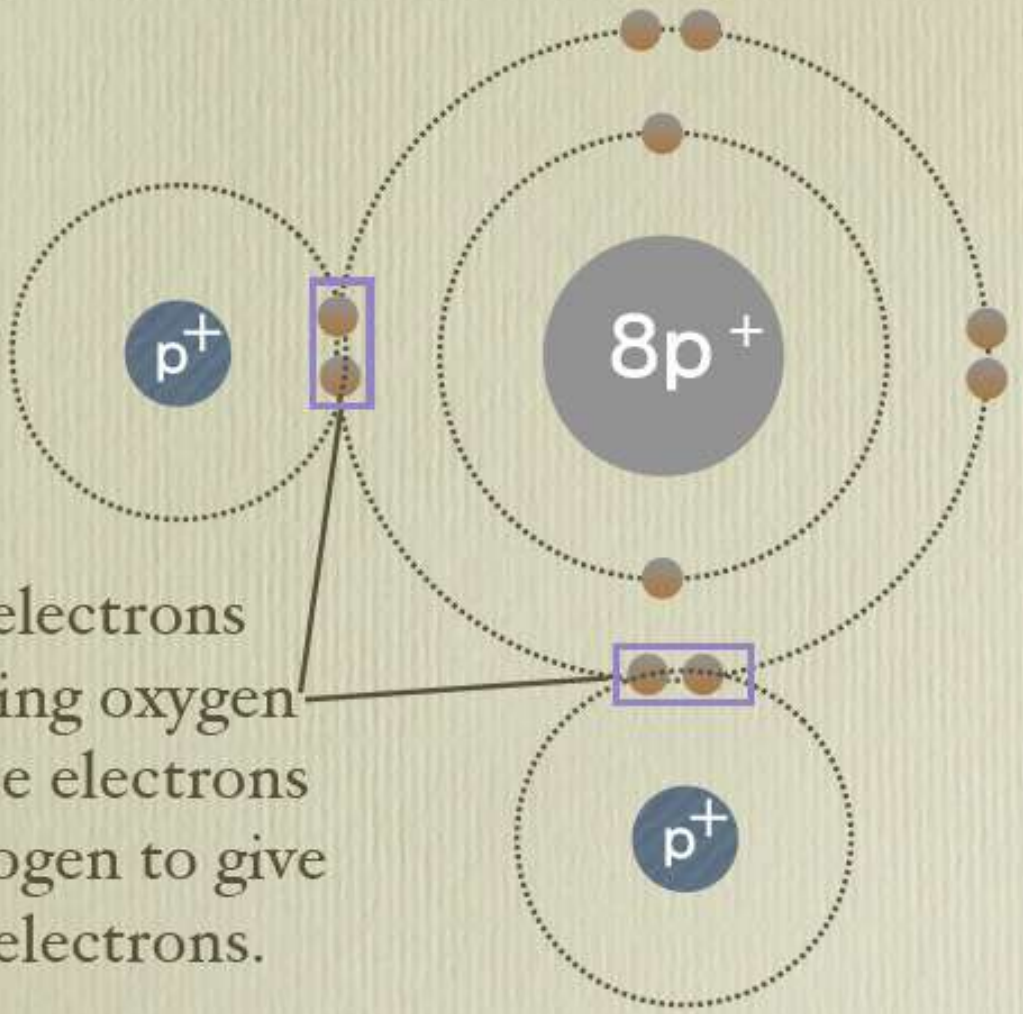


Water



Water Molecule

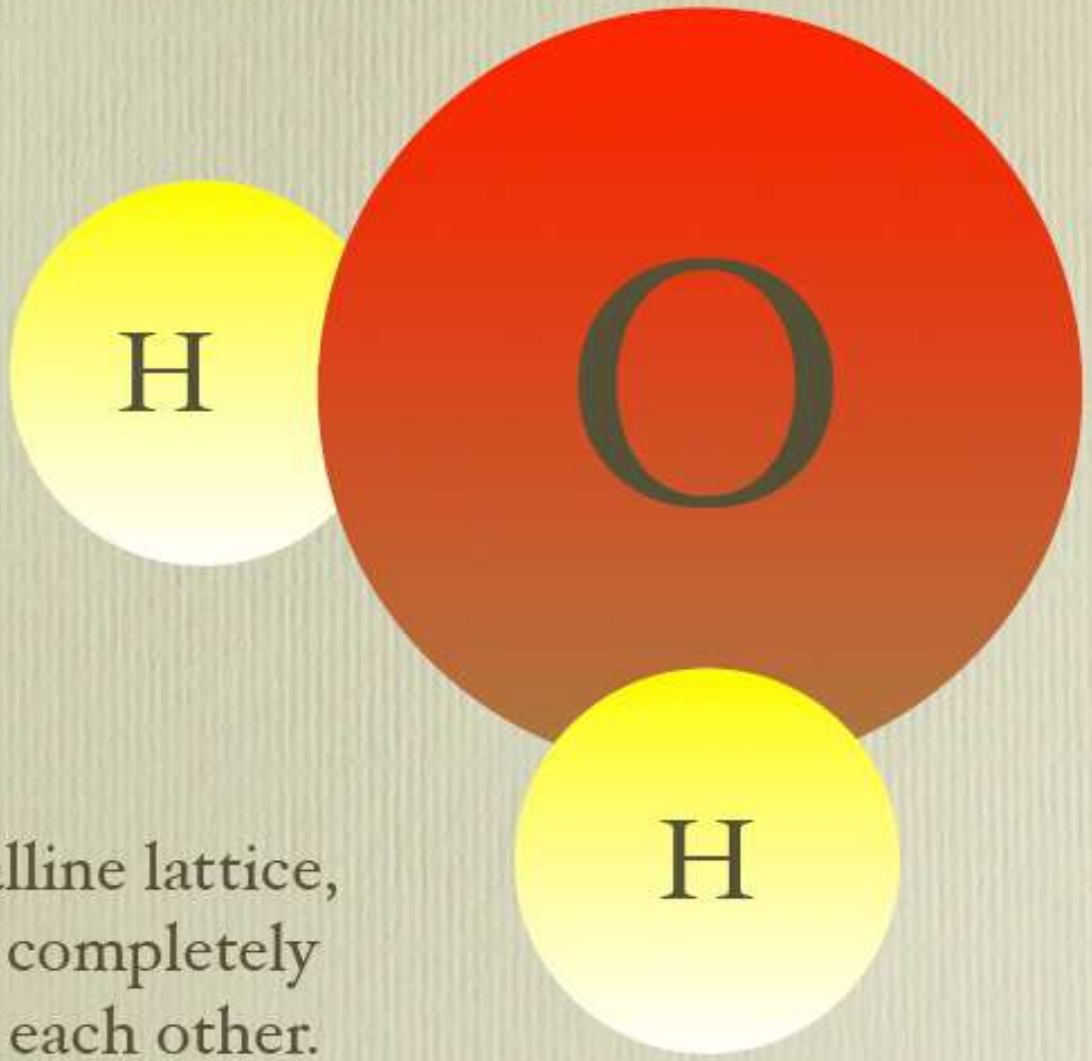
Water



Shared pair of electrons spend time orbiting oxygen to give it 8 valence electrons and orbiting hydrogen to give them 2 valence electrons.

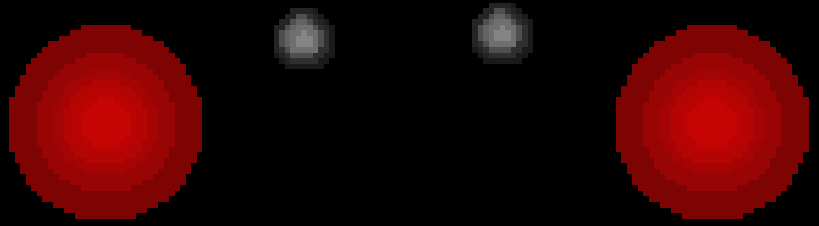
Water Molecule

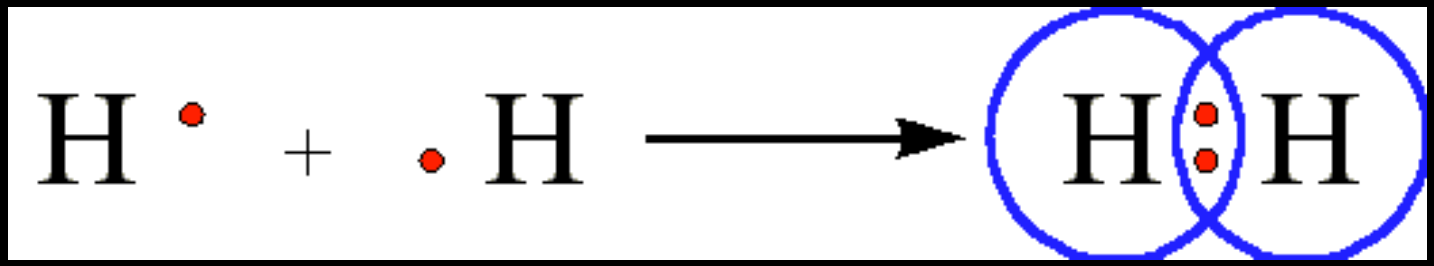
Water



Unlike a crystalline lattice, molecules are completely separate from each other.

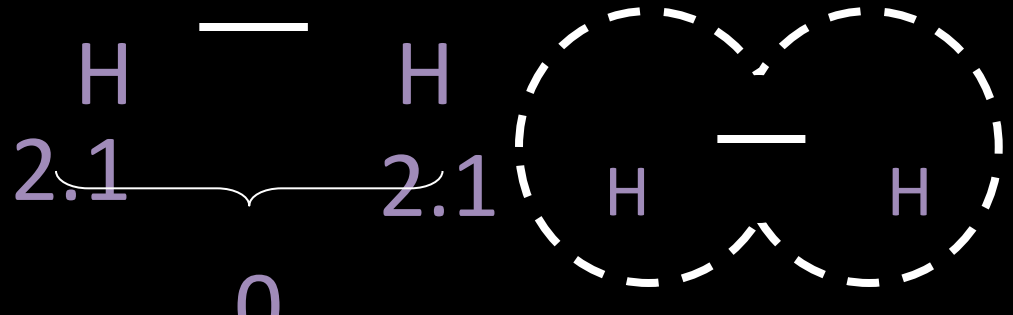
Water Molecule




H
+
H
H
H

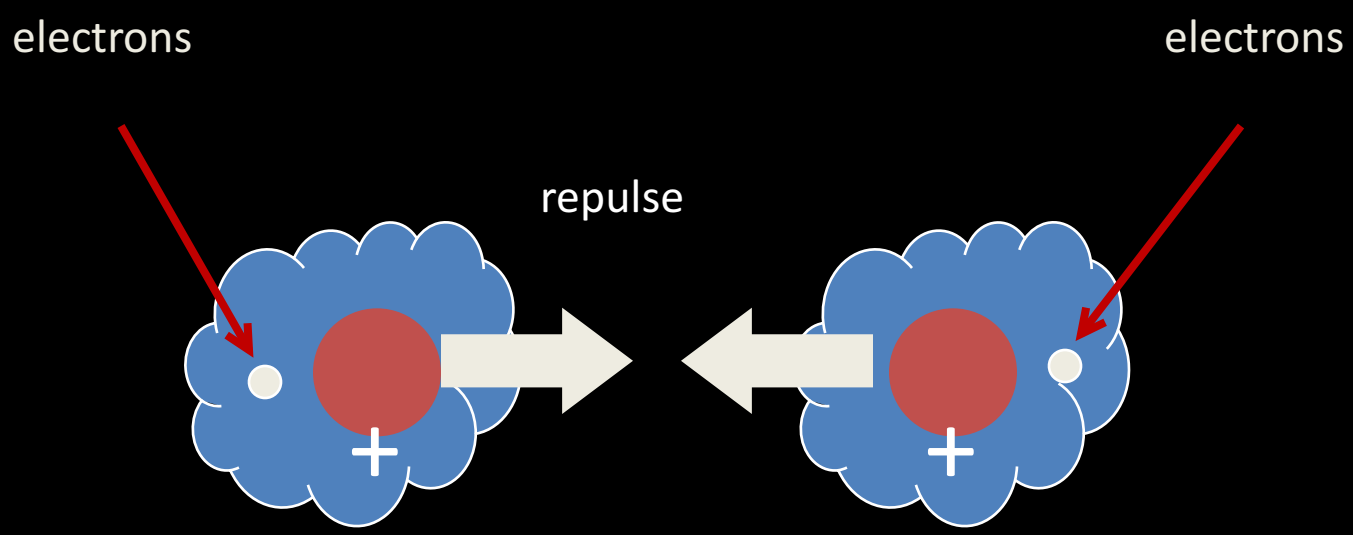
Two types of Covalent Bonding

- **Nonpolar Covalent - formed between nonmetal atoms with an electronegativity difference of 0.**
  - The electrons are being shared equally in the bond.
  - Examples include the diatomic molecules (Br_2, I_2, N_2, Cl_2, H_2, O_2 and F_2) molecules, which form when nonmetal atoms that are unstable by themselves bond together to form more stable molecules, because each bonded atom now has a stable octet of 8 valence electrons.



How does H_2 form?

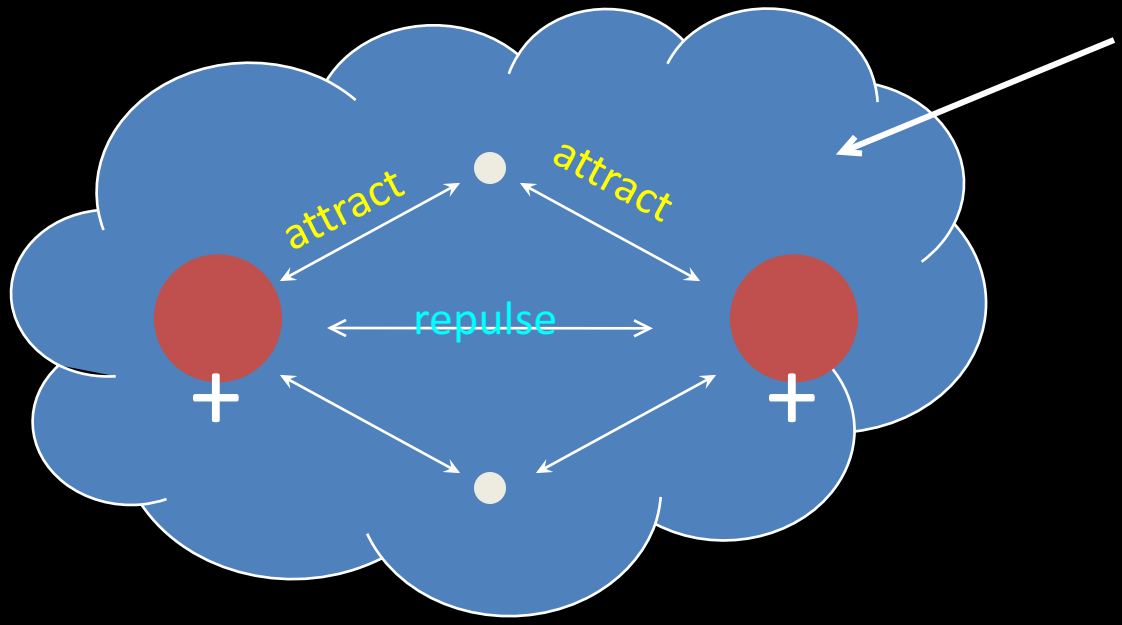
- The nuclei repel



How does H_2 form?

- The nuclei repel

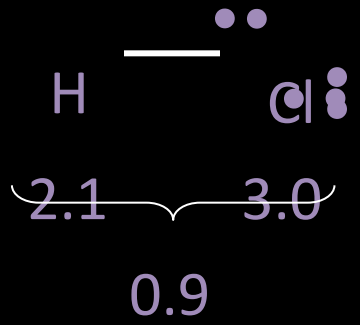
  But they are attracted to electrons
- They share the electrons, creating molecular orbital



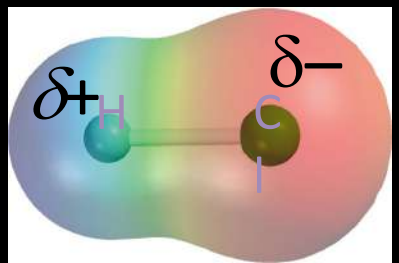
Molecular orbital
- space that shared electrons move within

Two types of Covalent Bonding

- **Polar Covalent - formed between nonmetal atoms with an electronegativity difference less than 2.0.**
  - The electrons are being shared unequally in the bond.
  - The electrons spend more time with the more electronegative atom, giving it a slight negative charge, and the less electronegative atom becomes slightly positive.
  - The charged ends of the bonds form POLES (oppositely charged ends), which is why the bond is called "polar".
  - Writing "partial" all the time is a pain, so use the lower-case Greek letter "delta" instead: δ



Partially positive = δ + Partially negative = δ-



What type of bonds are each of the following (Ionic, polar covalent , nonpolar covalent) and label δ + , δ- , if polar covalent.

(a) KF

0.8 4.0 3.2 =Ionic

(b) HBr

2.1 2.8 0.7 = Polar
δ + δ -

(c) Br_2

2.8 2.8 0 = Non-polar

(d) H_2S

2.1 2.5 0.4 = Polar
δ + δ -

(e) CsCl

0.7 3.0 2.3 = Ionic

Properties of Covalent Molecules

1. Molecules are particles made up of covalently bonded nonmetal atoms
2. Since no ions are formed, molecular substances will never conduct electricity (exception to follow much later in the course)
3. Molecules can have partially charged ends, like a magnet, thanks to polar covalent bonds.
4. Since these partially charged ends have much less charge than ions do, molecular substances have low melting and boiling points

Ionic vs. Covalent

IONIC

- M – NM
- Greater then 2.0
- Ionic compound
- Metal atom (low EN) loses e- to nonmetal atom (high EN)
- Metal is OXIDIZED, nonmetal is REDUCED
- Metal atom forms + ion, nonmetal atom forms – ion
- Oppositely charged ions attract
- The attraction between the ions is the ionic bond

COVALENT

- NM – NM
- 0 to less than 2.0
- Molecular Compound
- NONPOLAR COVALENT
  - Two nonmetal atoms with an END of 0 share their unpaired valence electrons EVENLY
  - No oppositely charged ends
- POLAR COVALENT
  - Two nonmetal atoms with an END of higher than 0 but less than 2.0 share their unpaired valence electrons UNEVENLY
  - The atom with the lower EN develops a slightly positive charge (δ+)
  - The atom with the higher EN develops a slightly negative charge (δ-)

Checking for understanding

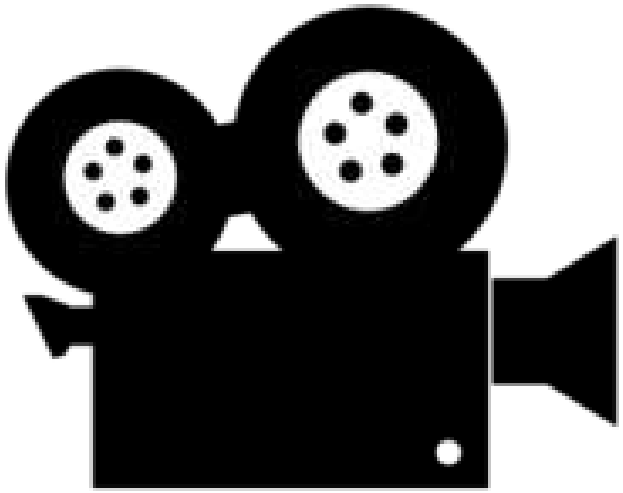
	Ionic bonding	**Covalent bonding**
Electrons are		
Groups bonded together (metal/nonmetal)		
Conductivity		
Electronegativity		

Real World Application
COVALENT BONDING

- Covalent bonding is when two atoms are held together by sharing electrons. It can be thought of as a rubber band strip, with two objects at either end. The bond can stretch, but will eventually break if stretched far enough.

Click Below for the Video Lectures

Covalent Bonding



Metallic Bonding

Metallic Bonding

- Metals don't technically form compounds with other metals. Metal atoms share electrons by losing them. In a way it is like a game of "hot potato" with their valence electrons.
- If one could see metal atoms in action they would appear as positively charged kernels surrounded by a sea of moving (conducting) electrons.
- These electrons are evenly distributed throughout the metal and yet able to move freely. This allows metals to conduct electricity in all phases.

Real World Application
METALLIC BONDING

- Metal alloys are created through metallic bonding. Two examples of alloys are brass (zinc and copper) and steel (carbon and iron). Metallic bonding is utilized for its conductive properties to help transfer electricity throughout a house via copper wiring.

Click Below for the Video Lectures

Metallic Bonding