

Chapter 5: The Periodic Table

Element song

how they REALLY made the periodic table

Seems legit

A Typical Nuclide on the periodic table:

12.011

C

Carbon

6

- Average atomic mass
- Protons + neutrons
- Always a decimal
- Element Symbol
- 1st letter is always capitalized
- 2nd letter is always lowercase
- Element name
- Atomic Number
- number of protons

Recognizing a Pattern

Dimitri Mendeleev, the father of the periodic table.

- Organized elements in rows by increasing atomic mass.
- Noticed patterns among the elements

In 1869, Mendeleev Published the first Periodic Table

Recognizing a Pattern


- He started a new row each time the properties of elements repeated.
 - So, elements in the same column have similar properties.
- His table was used to predict elements that had yet to be discovered. (blank spaces)

Mendeleevium was named in his honor.

Properties of Elements


- Atomic radius (decreases from left to right, increases from top to bottom)
- Ionization energy (increases from left to right, decreases from top to bottom)
- Electron affinity (increases from left to right, decreases from top to bottom)
- Nonmetallic character (increases from left to right, decreases from top to bottom)
- Metallic character (increases from right to left, increases from top to bottom)

Recognizing a Pattern



Henry Moseley 1913

I helped recognize the periodic table.



- He corrected discrepancies Mendeleev had some with the properties of some elements fitting in with their assigned groups.
- Moseley arranged elements by their atomic number, or number of protons.

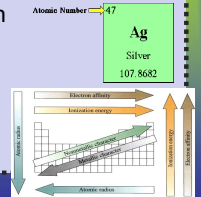
Question

How was Mendeleev's periodic table arranged?


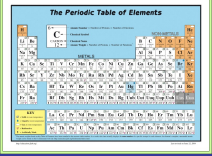
A. By increasing atomic mass
 B. By decreasing atomic mass
 C. By increasing atomic number
 D. By decreasing atomic number

The Modern Periodic Table

- **Periodic Law**- when the elements are arranged in order of increasing number of protons (atomic number), the properties tend to repeat in a pattern
- When you do this the properties of the elements repeat.



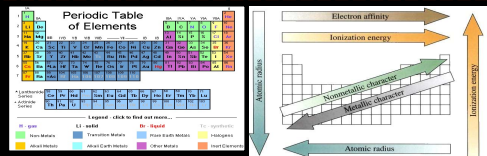
Periodic Table Trends

- In stores, items that are similar are grouped together so they are easier to find.
- Elements are arranged in a certain order based on the number of protons an atom of an element has.

Periodic Table Trends

- The table puts elements into groups with similar characteristics.
- Allows us to recognize trends over the whole array of elements.



atomic radii decrease

metallic properties decrease

Periodic Table of The Elements

atomic radii increase

metallic properties increase

ionisation energies decrease

ionisation energies increase

Periodic Table Trend

Atomic Mass and Atomic Number increases as you move across and down.

Note: The periodic table includes Lanthanide and Actinide series at the bottom.

Periodic Table Trend

Atomic Radii

- Atomic Radius decreases from left to right.
- Down a group, the atomic radius increases.

The greater the number of protons present, the stronger the attraction that holds the electrons closer to the nucleus, and the smaller the size of the shells.

Periodic Table Trend

Periods

- Period**- a horizontal row of elements in the periodic table.
 - Protons and electrons increases as you move across a period from left to right.
 - Shows how many energy levels the atom has.

Periods

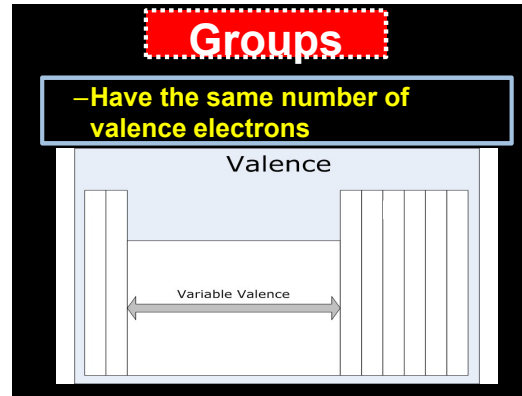
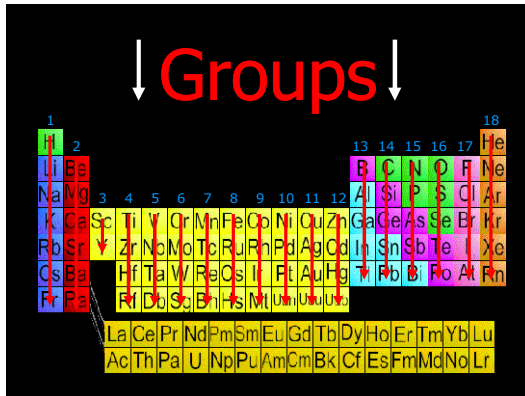
Periods

Elements become less metallic as you move to the right across each period.

Periodic Table Trend

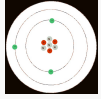
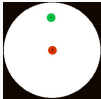
Groups

- Group**- a vertical column of elements in the periodic table.
 - Also called a family
 - Have the same properties

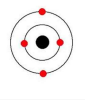


Groups

Valence Electrons

Lithium- Grp 1 Hydrogen- Grp 1



H	2																		
Li	Be																		
Na	Mg																		
K	Ca																		
Rb	Sr																		
Cs	Ba																		
Fr	Ra																		

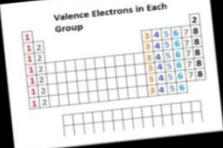
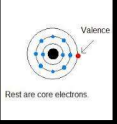
Beryllium- Grp 2

Grp 1 (1) has 1e-
 Grp 2 (2) has 2e-
 Grp 13 (3) has 3e-
 Grp 14 (4) has 4e-
 Grp 15 (5) has 5e-
 Grp 16 (6) has 6e-
 Grp 17 (7) has 7e-
 Grp 18 (8) has 8e- (a full octet).

The Role of Electrons

The chemical properties of each group are largely determined by the number of valence electrons.

- Located on the outer most energy shell

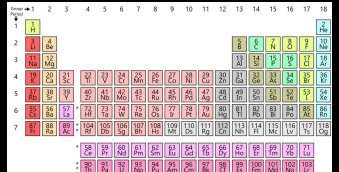



What group does it belong too?

The Role of Electrons

Location

- Representative elements are located in columns 1-2 and 13-18.
- Subtract 10 from the group number to determine number of valence electrons.
- Octet Rule- atoms tend to gain or lose electrons in order to obtain eight electrons on the valence shell.



Location

- If you know where an element is located on the periodic table, you can figure out how its electrons are arranged.

The Role of Electrons

Memorize Valence Electrons Rhyme

• "1+, 2+, 3+, skip, 3-, 2-, 1-, zip"

H	2																		
Li	Be																		
Na	Mg																		
K	Ca																		
Rb	Sr																		
Cs	Ba																		
Fr	Ra																		

F⁻

This tells you the ionic charge and oxidation numbers for the elements in the 8 REPRESENTATIVE GROUPS, 1A-8A, as you count from left to right.

Try This

1. Identify the valence electrons.
2. Identify the oxidation numbers (charges).
3. Name the families

Ion Formation

electrons

- Form by changing the number of electrons
- Ionization is the process of **adding or removing electrons** from an atom.

• It happens to atoms that do NOT have their outermost energy levels filled with electrons.

Ion Formation

is positively charged

The two types of ions are:

Cation- an ion with a positive charge. (+)

- An electron is removed from an atom and the result is this positive ion.

Ex) elements in Group 1, 2, &13

Anion- an ion with a negative charge (-)

- An electron is added to the atom to make a more negative ion.

Ex) elements in groups 15, 16, &17

Lithium has one valence electron, so it would rather give it away than collect 7 more electrons to fill its outer energy level.

Fluorine has 7 valence electrons, so it would rather collect 1 more electron to fill its outer energy level, than give 7 away.

- Hydrogen has one valence electron; it's in the Alkali Metal Family
- All other elements in this family, Li, Na, K, Rb, and Cs, also have only one valence electron.

- Fluorine has seven valence electrons
- This places it in the halogen family

- Alkali metals have one valence electron
 - Sodium
- Halogens have seven valence electrons
 - Chlorine

What's going to happen?

Sodium Chloride

Na Sodium atom Cl Chlorine atom

Na⁺ Sodium ion (a cation) Cl⁻ Chloride ion (an anion)

Group 1 Group 7

Sodium chloride (NaCl)

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Periodic Trends

- First Ionization Energy**
—energy required to remove an e⁻ from a neutral atom
- First Ionization Energy**
•Increases to the RIGHT and UP

Periodic Trends

Phases at Room Temperature

Trends	How is the Trend Organized on the Periodic Table
Location of Gases	18 He Ne Ar K Xe Rn 17 F Cl 16 O 15 N 1 H
Location of Liquids	Hg, Br
Location of Solids	Everything that is not a gas or a liquid.

Phases at Room Temperatures

Periodic Table of the Elements
Natural Form

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*** Elements > 104 exist only for very short half-lives and the data is unknown.***

Lanthanoids: La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu

Actinoids: Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr

GROUPS: I-VII, VIII, IX, X, XI, XII, XIII, XIV, XV, XVI, XVII, XVIII, IUPAC, 1-18

PERIODS: 1-7

BLOCKS: S, P, D, F

TRANSITION METALS: I-VIII

POST-TRANSITION METALS: I-VI

NON-METALS: I-VI

HALOGENS: I-VII

NOBLE GASES: I-VIII

Periodic Trends

Chemical Reactivity- how likely an atom will react with other substances

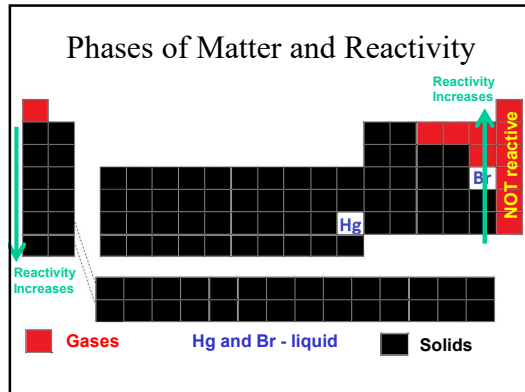
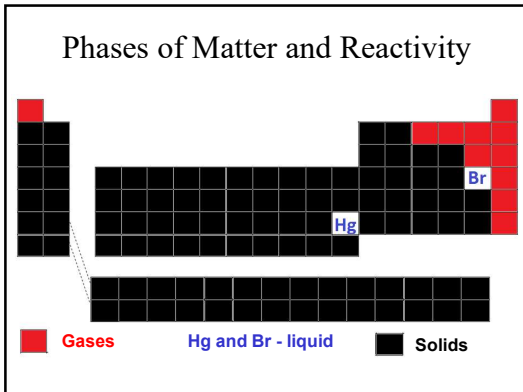
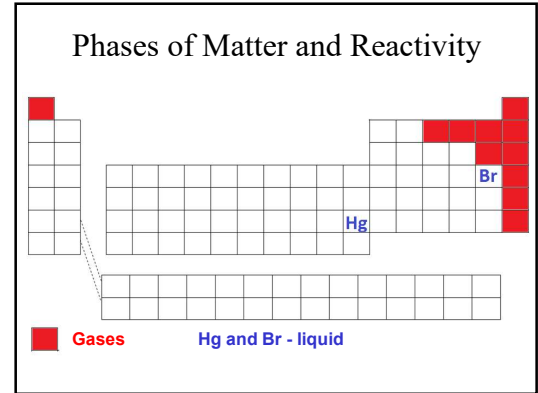
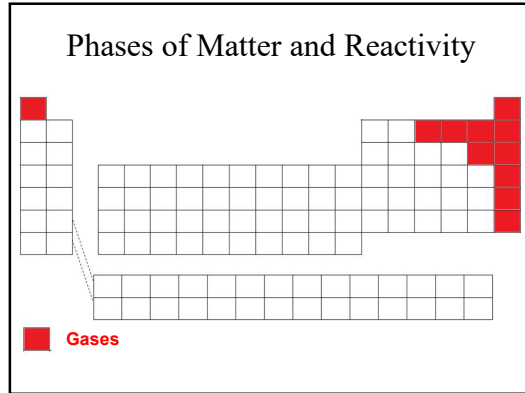
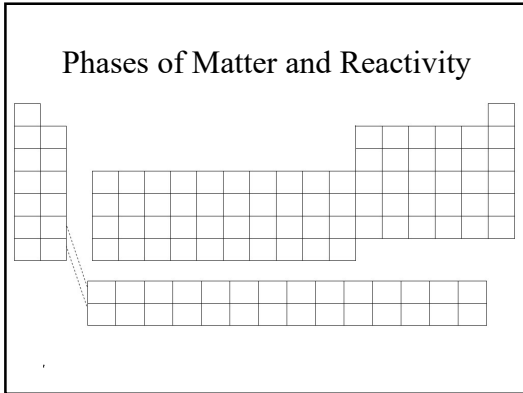
Trends	How is the Trend Organized on the Periodic Table
Reactivity of Group 1	Increases as you go down the group. (Metals) Highly reactive (Cesium & Francium)
Reactivity of group 17	Increases as you go up the group (Non-metals) Highly reactive (Fluorine)

Chemical Reactivity

Reactivity increases (down Group 1)

Reactivity increases (up Group 17)

Reactivity decreases (across the table)

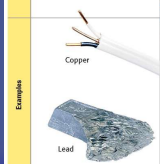

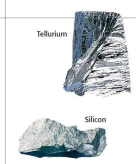


How Are Elements Classified?

- Elements in each category have similar properties
- Three main categories of elements:

A diagram showing three categories of elements with representative images: Metals (a metal bar), Nonmetals (a yellow powder), and Semiconductors (a glowing orange sphere). A legend below the images identifies each category.

How Are Elements Classified?

	Metals	Nonmetals	Semiconductors
Properties	<ul style="list-style-type: none"> Metals are good conductors of electricity. Metals are ductile (easily drawn into thin wires) and malleable (easily shaped or formed). Most metals are shiny. 	<ul style="list-style-type: none"> Nonmetals are poor conductors of electricity. Nonmetals are not malleable or ductile. Most nonmetals are not shiny. 	<ul style="list-style-type: none"> Semiconductors share properties with metals and nonmetals. Semiconductors can conduct electricity under certain conditions. Semiconductors are the main components of chips in computers and in other electronic devices.
Elements	 <p>Copper Lead</p>	 <p>Carbon Sulfur</p>	 <p>Tellurium Silicon</p>

Semiconductors



Metals										Metalloids						Nonmetals			
1	2											13	14	15	16	17	18		
1 H	2 He											5 B	6 C	7 N	8 O	9 F	10 Ne		
3 Li	4 Be											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		
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 Cn	113 Uuq	114 Uuh	115 Uus	116 Uuq	117 Uuh	118 No		
Lanthanide series		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				
Actinide series		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				


How Are Elements Classified?

Metals

OR

- Characteristics:
 - Good conductors of heat and electricity
 - Shiny
 - Malleable- can be flattened into sheets
 - Ductile- can be stretched or shaped into wires
 - Most are solids at room temperature.
 - Tend to lose electrons
 - Ex: Copper and Lead



Metals

Shiny

Malleable


Families

Alkali Metals

Na
Sodium

Alkaline-earth Metals

Ca
Calcium



The transition metals gold, silver, and platinum are often shaped to make jewelry.

Transition Metals

Metals






- Almost 75% of all elements are classified as metals.
- They are classified based on their physical properties: hardness, shininess, malleability, conductivity, magnetism, and ductility.





Metals

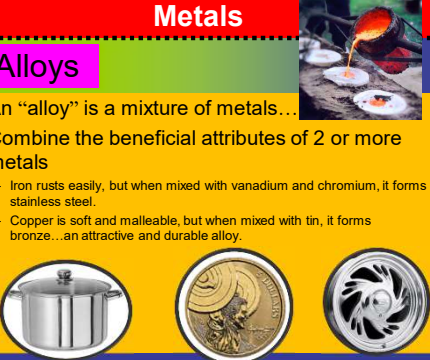
- Chemical properties: The ease and speed in which an element reacts with other elements is called its "reactivity."
- Metals show a wide range of chemical properties, or reactivity.
 - Iron will react with oxygen in the air to form iron oxide (rust).
 - Gold and chromium are unreactive.

Metals

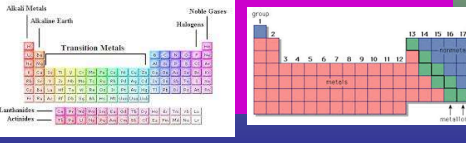
Alloys

- An "alloy" is a mixture of metals...
- Combine the beneficial attributes of 2 or more metals
 - Iron rusts easily, but when mixed with vanadium and chromium, it forms stainless steel.
 - Copper is soft and malleable, but when mixed with tin, it forms bronze...an attractive and durable alloy.



Metals

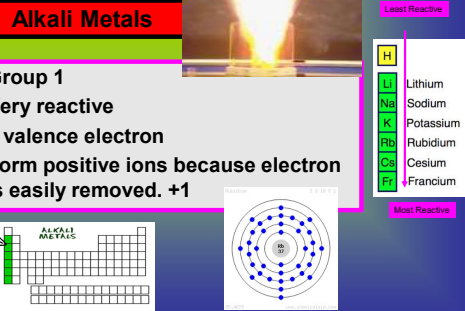
- Families of metals:
 - Alkali metals
 - Alkaline-earth metals
 - Transition metals



Metals

Alkali Metals

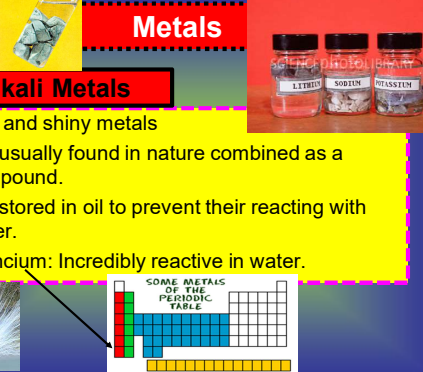
- Group 1
- Very reactive
- 1 valence electron
- Form positive ions because electron is easily removed. +1



Metals

Alkali Metals

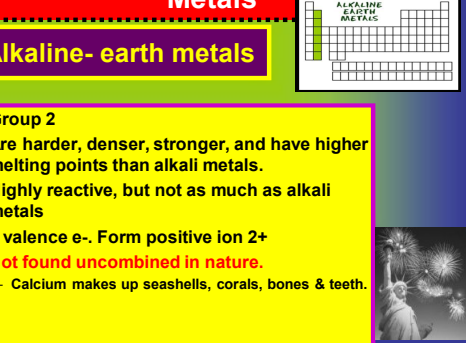
- Soft and shiny metals
- Are usually found in nature combined as a compound.
- Are stored in oil to prevent their reacting with water.
- Francium: Incredibly reactive in water.



Metals

Alkaline- earth metals

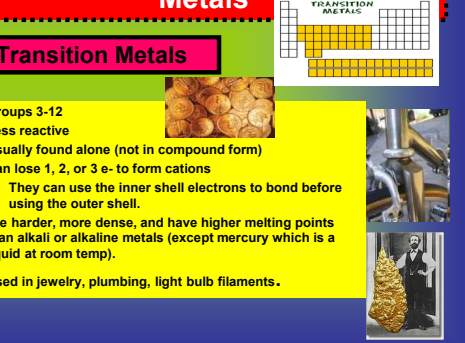
- Group 2
- Are harder, denser, stronger, and have higher melting points than alkali metals.
- Highly reactive, but not as much as alkali metals
- 2 valence e-. Form positive ion 2+
- Not found uncombined in nature.
 - Calcium makes up seashells, corals, bones & teeth.



Metals

Transition Metals

- Groups 3-12
- Less reactive
- Usually found alone (not in compound form)
- Can lose 1, 2, or 3 e- to form cations
 - They can use the inner shell electrons to bond before using the outer shell.
- Are harder, more dense, and have higher melting points than alkali or alkaline metals (except mercury which is a liquid at room temp).
- Used in jewelry, plumbing, light bulb filaments.


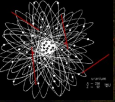


Transition Metals

Lanthanides and Actinides





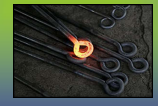

- Also known as the “rare earth elements”
- Rare, soft, malleable metals.
- Some actinides are highly radioactive (they have unstable nuclei)

LANTHANIDES													
58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
ACTINIDES													
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Transition Metals

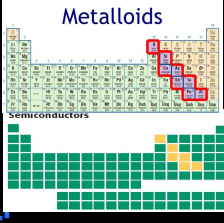
- Good conductors
- Malleable and ductile
- High Density
- High Luster (shiny)
- Conducts heat well
- Most solid
- Except Hg

How Are Elements Classified?

Metalloids (Semi-Conductors)

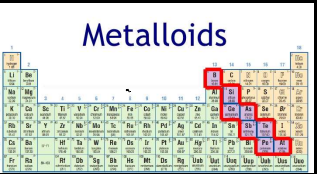


- Characteristics:
 - Varying ability to conduct electricity
 - Can be used to make semiconductors-main components of chips in computers and electronic devices.
 - Share properties of metals and nonmetals.



Metalloids/Semiconductors

- On the border between the metals and the non-metals are the “metalloids.”
- Metalloids have some properties of metals and some properties of non-metals.
- As “semiconductors” they’re varying ability to conduct electricity makes them useful in industry

Metalloids


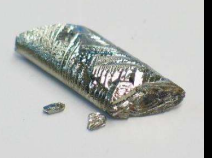
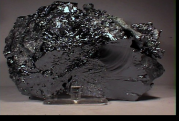
Metalloids/Semiconductors

- Example: Si (shown here) has a metallic luster but it is brittle.
- Metalloids are useful in the semiconductor industry.





Metalloids/Semiconductors

- Semi-conductor
- Can luster
- Brittle

Determine the number of valence electrons, which energy level is filling, metal or nonmetal or metalloid, and phase of matter for:

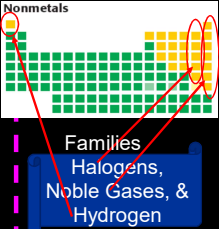
	Valence e-	Charge	Energy level	Phase
1. Cs				
2. Xe				



How Are Elements Classified?

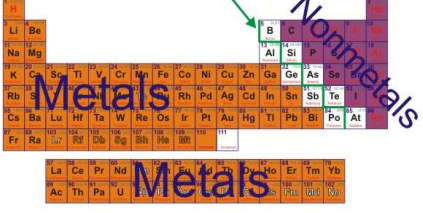
Non Metals

- Characteristics:**
 - Poor conductors of heat and electricity
 - Mostly dull (not shiny)
 - Brittle, not malleable or ductile
 - Many are gases at room temperature.
 - Tend to gain electrons



Families
Halogens,
Noble Gases, &
Hydrogen

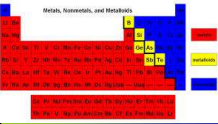

Elements that border on the amphoteric line (shown in green) are metalloids. They have characteristics of both metals and nonmetals. Aluminum (Al), however, definitely has mostly metallic characteristics, and boron (B) is mostly nonmetallic.



Metals	Nonmetals
1. Have luster	1. Are dull
2. Are malleable and ductile	2. Are brittle
3. Conduct heat and electricity	3. Do not conduct heat or electricity very well
4. Tend to lose electrons	4. Tend to gain electrons

Nonmetals

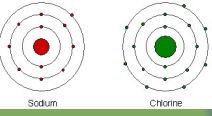
- All 17 nonmetals are extremely important to living things.
- Right of the zigzag line on the Periodic Table, except Hydrogen
- Most are gases, some are crumbly solids, and Bromine is the only liquid.

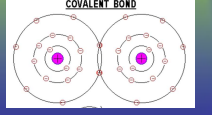
NonMetals

Chemical properties

- Most react easily to form compounds.
- Metal elements transfer their valence electrons to the nonmetal when combine.
- Nonmetals with other nonmetals, valence electrons are shared.



Sodium Chlorine






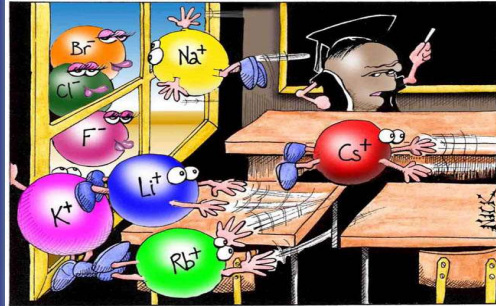
COVALENT BOND

NonMetals

Poor Conductors of electricity 	Dull in color (no shine) 	Transparent/Translucent 
Brittle (break when hit) 	Poor conductors on heat 	

• They exist as a... (s), (l), (g).

<p>Solid</p>  <p>S Sulfur</p>	<p>Liquid</p>  <p>Br Bromine</p>	<p>Gas</p>  <p>Cl Chlorine</p>
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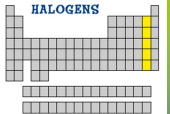



"Perhaps one of you gentlemen would mind telling me just what it is outside the window that you find so attractive..?"

NonMetals

Families of nonmetals:

- Oxygen Family
- Nitrogen Family
- Carbon family
- Halogens
 - Group 17 and are very reactive.
 - Poisonous as gas, but form compounds that are very useful.

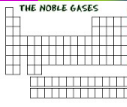




NonMetals

Families of nonmetals:

5. The Noble Gases

- Full valence shell (8 electrons). Octet rule
 - Except Helium
- Do not react at all with any other elements.
- Colorless, odorless gases at room temp
- Glow brightly when electricity passes through them.

• Who is in the family?
Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe), and Radon (Rn)



What About Hydrogen?

6. Hydrogen Family

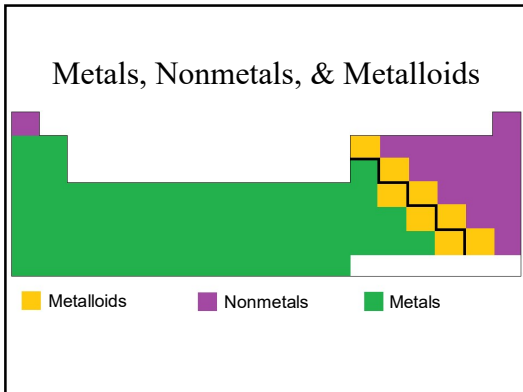
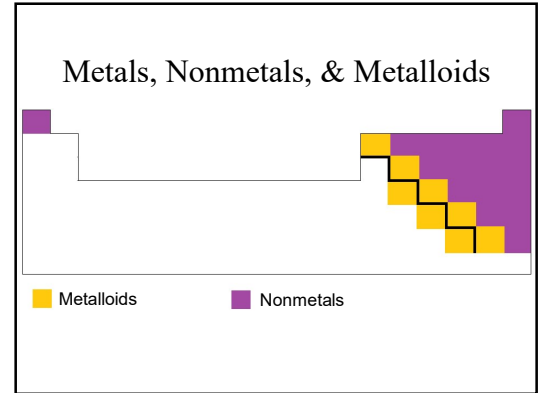
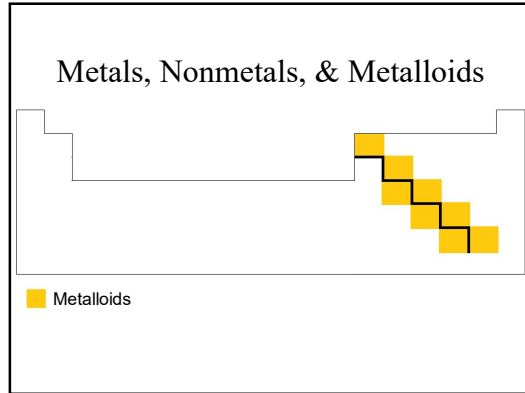
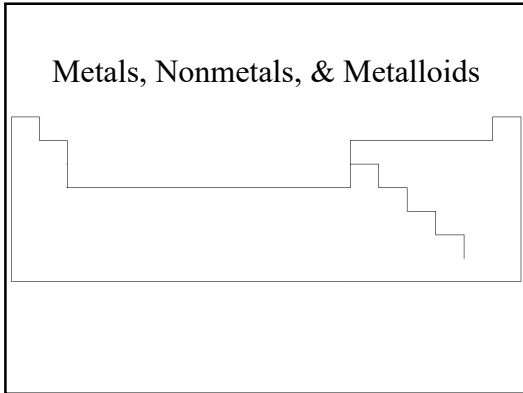
stands alone

1
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Hydrogen
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Reactive


Colorless, odorless gas at room temp

Explosive reaction with oxygen

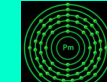



Synthetic elements

- All elements greater than atomic # 92 are man-made (synthetic).
- Are radioactive.
 - Technium- 99 most stable isotope, 56 n
 - Promethium-147, used in some glow-in-the-dark paints.
 - Americium-241, found inside smoke detectors
 - *** radioactive elements are harmful even in small amounts, so do not handle them unprotected.



Pm 61
Promethium





Valence Electrons	Oxidation Charge	Groups	Families
Mass Number ^	Atomic Number	Periods	Energy Levels
Electrons			
1	2	13	14
H 1.008	He 4.003	B 10.81	C 12.011
Li 6.941	Be 9.012	N 14.007	O 15.999
Na 22.990	Mg 24.305	F 18.998	Ne 20.180
K 39.098	Ca 40.078	Ar 39.948	Kr 83.796
Rb 85.468	Sr 87.62	Xe 131.29	Rn 222
Cs 132.905	Ba 137.327	Po 209	At 210
Fr 223	Ra 226	Ac 227	Th 232
Pa 231	U 238.029	Np 237	Pu 244
Am 243	Cm 247	Bk 247	Cf 251
Pu 244	Am 243	Cm 247	Bk 247
Cf 251	Bk 247	Cf 251	Es 252
Es 252	Fm 257	Md 288	No 289
Md 288	Lr 260	101	102
Lr 260	102	103	104
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254	255	256	257
255			

Periodic Table of the Elements © www.elementsdatabase.com

The properties of the elements

Metals	Metalloids are in-between	Nonmetals
<ul style="list-style-type: none"> - Luster – Shininess - Malleable – Being able to flatten and bend - Ductile – Can stretch or be pulled - Conductive – Heat and Electric 		<ul style="list-style-type: none"> - Dull – no luster - Brittle – Cracks, fractures, and breaks easily in solid form - Insulator – Does not allow Heat and Electric to pass

Important Families on the periodic table

Column and name	Characteristics
Alkali metals	Extremely soft – cut with a butter knife
Alkali earth metals	Most reactive metals Not found as a pure metal in nature
Alkali earth metals	Soft but not as soft as alkali metals Second most reactive metals Not found as a pure metal in nature but has its uses Magnesium fire starters.

Important Families on the periodic table

Column and name	Characteristics
Halogens	Most reactive nonmetals Combine with alkali and alkali metals to make Salts like NaCl
Noble Gases	Used as Disinfectants NO REACTION

Practice

element	Valence e-	Energy levels	Metal/ non-metal/ metalloid	phase
At	7	6	Metalloid	Solid
Sb	5	5	Metalloid	Solid
Sr	2	5	Metal	Solid
Rb	1	5	Metal	Solid
Ne	8	2	Non-metal	Gas

Practice

element	Valence e-	Energy levels	Metal/ non-metal/ metalloid	phase
Hg	1,2 or 3	6	Metal	Liquid
F	7	2	Non-metal	Gas
Li	1	2	Metal	Solid
Ti	1, 2 or 3	4	Metal	Solid
Ra	2	7	Metal	Solid

Determine the number of valence electrons, which energy level is filling, metal or nonmetal or metalloid, and phase of matter for:

	Valence e-	Energy level	metal?	Phase
1. Cs				
2. Si				
3. I				
4. Ru				

Manganese (Mn)

- Valence Electrons • **Varies**
- Number of Energy Levels • **4**
- Metal, Nonmetal or Metalloid? • **Metal**
- Phase • **Solid**

Bromine (Br)

- Valence Electrons • **7**
- Number of Energy Levels • **4**
- Metal, Nonmetal or Metalloid? • **Nonmetal**
- Phase • **Liquid**

Nitrogen (N)

- Valence Electrons • **5**
- Number of Energy Levels • **2**
- Metal, Nonmetal or Metalloid? • **Nonmetal**
- Phase • **Gas**

Cesium (Cs)

- Valence Electrons • **1**
- Number of Energy Levels • **6**
- Metal, Nonmetal or Metalloid? • **Metal**
- Phase • **Solid**

Radon (Rn)

- Valence Electrons • **8**
- Number of Energy Levels • **6**
- Metal, Nonmetal or Metalloid? • **Nonmetal**
- Phase • **Gas**

Silicon (Si)

- Valence Electrons • 4
- Number of Energy Levels • 3
- Metal, Nonmetal or Metalloid? • Metalloid
- Phase • Solid

Bohrium (Bh)

- Valence Electrons • varies
- Number of Energy Levels • 7
- Metal, Nonmetal or Metalloid? • Metal
- Phase • Solid

Radium (Ra)

- Valence Electrons • 2
- Number of Energy Levels • 7
- Metal, Nonmetal or Metalloid? • Metal
- Phase • Solid

Tin (Sn)

- Valence Electrons • 4
- Number of Energy Levels • 5
- Metal, Nonmetal or Metalloid? • Metal
- Phase • Solid

Aluminum (Al)

- Valence Electrons • 3
- Number of Energy Levels • 3
- Metal, Nonmetal or Metalloid? • Metal
- Phase • Solid

Astatine (At)

- Valence Electrons • 7
- Number of Energy Levels • 6
- Metal, Nonmetal or Metalloid? • Metalloid
- Phase • Solid

Mercury (Hg)

- Valence Electrons • varies
- Number of Energy Levels • 6
- Metal, Nonmetal or Metalloid? • Metal
- Phase • Liquid