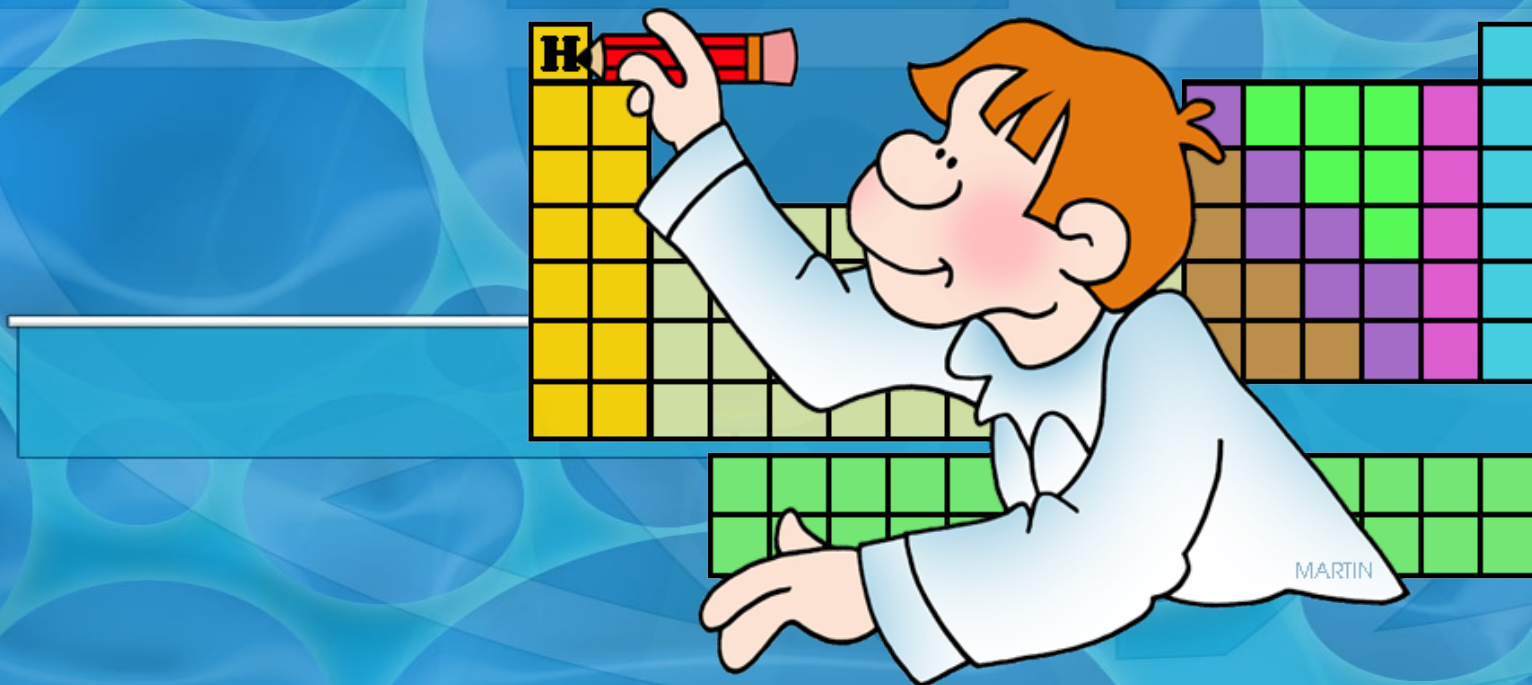


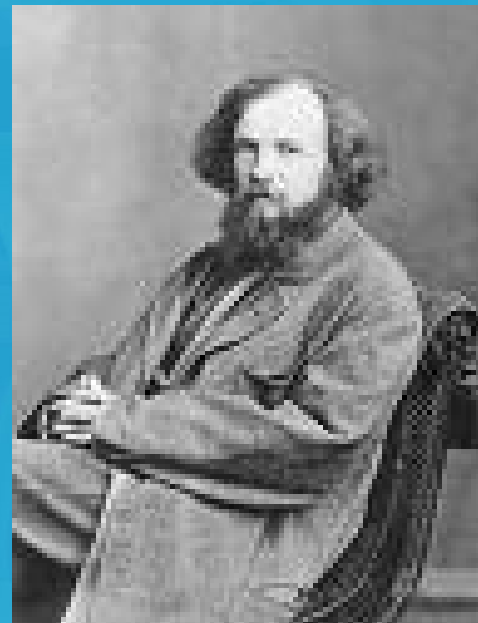
Chapter 5 and Chapter 6

The Periodic Table



Discovering the Elements

- By the year 1869, sixty three elements had been discovered.
- A Russian scientist named Dmitri Mendeleev discovered that the elements followed certain patterns.



Discovering the Elements

- He noticed that if he put the elements in order of increasing atomic mass, patterns appeared.
- He also noticed that the properties of the elements repeated.
- He put these elements in order by atomic mass, but also grouped them according to properties.

Mendeleev's Periodic Table (1872)

TABELLE II

REIHEN	GRUPPE I. — R ² O	GRUPPE II. — RO	GRUPPE III. — R ² O ³	GRUPPE IV. RH ⁴ RO ²	GRUPPE V. RH ³ R ² O ⁵	GRUPPE VI. RH ² RO ³	GRUPPE VII. RH R ² O ⁷	GRUPPE VIII. — RO ⁴
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	—	—	—	—
9	(—)	—	—	—	—	—	—	—
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	—
12	—	—	—	Th=231	—	U=240	—	—



Dmitri Mendeleev
1st to publish an
organized table
of elements.

Figure 2.5 Dmitri Mendeleev's 1872 periodic table. The spaces marked with blank lines represent elements that Mendeleev deduced existed but were unknown at the time, so he left places for them in the table. The symbols at the top of the columns (e.g., R²O and RH⁴) are molecular formulas written in the style of the 19th century.

- Grouped elements by similar chemical properties.
- Arranged elements by increasing mass.

The Modern Periodic Table

- The only major change occurred in 1913, when a scientist named Henry Moseley discovered how to measure an atom's atomic number.
- The Periodic Table was rearranged in order of atomic number instead of atomic mass.

The Modern Periodic Table

- The Periodic Table that we use today is very similar to Mendeleev's first version.
- New elements have been added as they have been discovered.

Periodic Table of the Elements

The periodic table is color-coded by groups and states of matter. The legend indicates:

- Alkali metals:** Orange
- Alkaline earth metals:** Yellow
- Transition metals:** Pink
- Lanthanide series:** Light blue
- Actinide series:** Purple
- Poor metals:** Teal
- Nonmetals:** Green
- Noble gases:** Light blue
- Solid:** White box with 'C'
- Liquid:** Green box with 'Br'
- Gas:** Red box with 'H'
- Synthetic:** Black box with 'Tc'

Atomic masses in parentheses are those of the most stable or common isotope.

Note: The subgroup numbers 1-10 were adopted in 1954 by the International Union of Pure and Applied Chemistry. The names of elements 112-116 are the Latin equivalents of those numbers.

1 IA 1 H Hydrogen (1.00794)	2 IIA 4 He Helium (4.002602)											13 IIIA 5 B Boron (10.81)	14 IVA 6 C Carbon (12.011)	15 VA 7 N Nitrogen (14.0064)	16 VIA 8 O Oxygen (15.9994)	17 VIIA 9 F Fluorine (18.9984032)	18 VIIIA 2 Ne Neon (20.1797)											
3 3 11 Na Sodium (22.98976928)	4 4 12 Mg Magnesium (24.3050)	5 5 19 K Potassium (39.0983)	6 6 20 Ca Calcium (40.078)	7 7 21 Sc Scandium (44.955910)	8 8 22 Ti Titanium (47.88)	9 9 23 V Vanadium (50.9415)	10 10 24 Cr Chromium (51.9961)	11 11 25 Mn Manganese (54.938045)	12 12 26 Fe Iron (55.845)	13 13 27 Co Cobalt (58.933195)	14 14 28 Ni Nickel (58.6934)	15 15 29 Cu Copper (63.546)	16 16 30 Zn Zinc (65.38)	17 17 31 Ga Gallium (69.723)	18 18 32 Ge Germanium (72.64)	19 19 33 As Arsenic (74.9216)	20 20 34 Se Selenium (78.96)	21 21 35 Br Bromine (79.904)	22 22 36 Kr Krypton (83.798)									
5 5 37 Rb Rubidium (85.4678)	6 6 38 Sr Strontium (87.62)	7 7 39 Y Yttrium (88.90584)	8 8 40 Zr Zirconium (91.224)	9 9 41 Nb Niobium (92.90638)	10 10 42 Mo Molybdenum (95.94)	11 11 43 Tc Technetium (98)	12 12 44 Ru Ruthenium (101.07)	13 13 45 Rh Rhodium (101.07)	14 14 46 Pd Palladium (106.42)	15 15 47 Ag Silver (107.8682)	16 16 48 Cd Cadmium (112.411)	17 17 49 In Indium (114.818)	18 18 50 Sn Tin (118.710)	19 19 51 Sb Antimony (121.757)	20 20 52 Te Tellurium (127.6)	21 21 53 I Iodine (126.905)	22 22 54 Xe Xenon (131.29)	23 23 55 Cs Cesium (132.90545196)	24 24 56 Ba Barium (137.327)	25 25 57 to 71 Lanthanides	26 26 89 to 103 Actinides	27 27 83 Bi Bismuth (208.98038)	28 28 84 Po Polonium (209)	29 29 85 At Astatine (210)	30 30 86 Rn Radon (222)			
7 7 87 Fr Francium (223)	8 8 88 Ra Radium (226)	9 9 104 Rf Rutherfordium (261)	10 10 105 Db Dubnium (262)	11 11 106 Sg Seaborgium (263)	12 12 107 Bh Bohrium (264)	13 13 108 Hs Hassium (265)	14 14 109 Mt Meitnerium (266)	15 15 110 Ds Darmstadtium (271)	16 16 111 Rg Roentgenium (272)	17 17 112 Uub Ununbium (285)	18 18 113 Uut Ununtrium (284)	19 19 114 Uuq Ununquadium (289)	20 20 115 Uup Ununpentium (288)	21 21 116 Uuq Ununhexium (289)	22 22 117 Uuh Ununheptium (289)	23 23 118 Uuo Ununoctium (289)	24 24 119 Uue Ununennium (289)	25 25 120 Uuq Ununquadium (289)	26 26 121 Uub Ununbium (289)	27 27 122 Uut Ununtrium (289)	28 28 123 Uuq Ununquadium (289)	29 29 124 Uub Ununbium (289)	30 30 125 Uut Ununtrium (289)	31 31 126 Uuq Ununquadium (289)	32 32 127 Uub Ununbium (289)	33 33 128 Uut Ununtrium (289)	34 34 129 Uuq Ununquadium (289)	35 35 130 Uub Ununbium (289)

Periodic Law

- -
- When elements are arranged in order of increasing atomic number, there is a periodic repetition of their physical and chemical properties.

Elements can be divided into three categories:

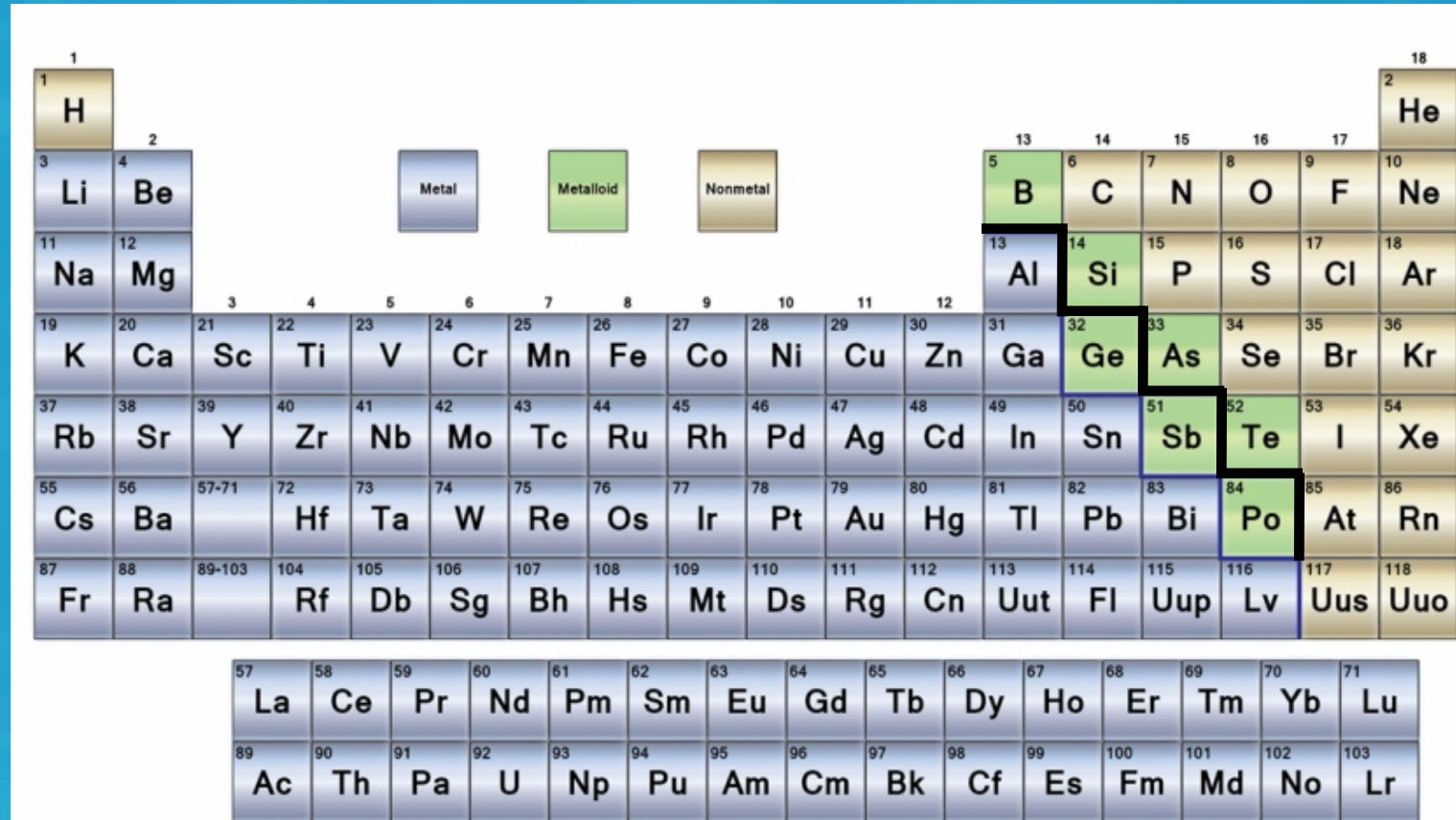
Metals - left of the staircase. Form positive ions (cations). Have luster, good conductors, malleable, ductile, most are solids

Nonmetals - right of the staircase

Form negative ions (anions)

Good insulators, dull, brittle, shatter easily

Metalloids (Semi-metals) - either side of the staircase. Intermediate characteristics



The periodic table is color-coded to show the classification of elements. A staircase line separates metals (left) from nonmetals (right). Metalloids are located along this staircase. The legend indicates: Metal (blue), Metalloid (green), and Nonmetal (yellow).

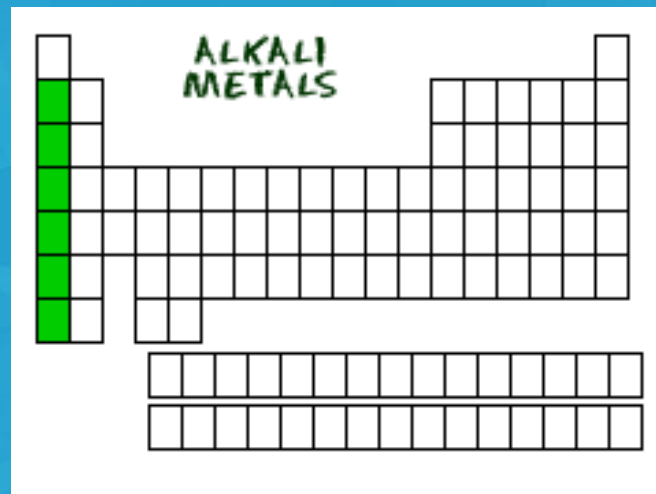
1																	18
H																	He
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47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

Periodic Table Structure

- The periodic table is arranged in periods (horizontal rows) and families/groups (vertical columns).
- Each new period adds another energy level for electrons.
- Groups may be identified by 1-18 or by Group A/B numbers.

Periodic Table Families

- Alkali Metals (Group 1A)
- One valence electron
- The most reactive metals, therefore usually found in compounds in nature (rarely found by themselves)
- Always form cations with +1 charge



ALKALI METALS

3 Li 6.941	LEAST REACTIVE ↓ MOST REACTIVE
11 Na 22.99	
19 K 39.10	
37 Rb 85.47	
55 Cs 132.9	
87 Fr 223	

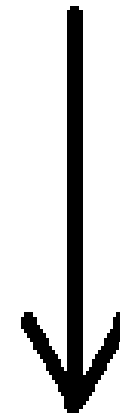
Periodic Table Families

- Alkaline Earth Metals (Group 2A)
- Two valence electrons
- Reactive metals, therefore usually found in compounds in nature (rarely found by themselves)
- Always form cations with a +2 charge.

ALKALINE EARTH METALS

4
Be
9.0122
12
Mg
24.305
20
Ca
40.08
38
Sr
87.62
56
Ba
137.53
88
Ra
226.0254

LEAST
REACTIVE



MOST
REACTIVE

Periodic Table Families

- Noble Gases (Group 8A)
- Eight valence electrons (full)
- Most are nonreactive/inert
- Do not form ions since it's valence electrons are full

THE NOBLE GASES

A simplified periodic table diagram where the noble gas column (Group 8A) is highlighted in red. The table shows the general structure of the periodic table with the noble gases at the far right.

2	He Helium 4.003
10	Ne Neon 20.180
18	Ar Argon 39.948
36	Kr Krypton 84.798
54	Xe Xenon 131.294
86	Rn Radon 222.018
118	Uuo Ununoctium unknown

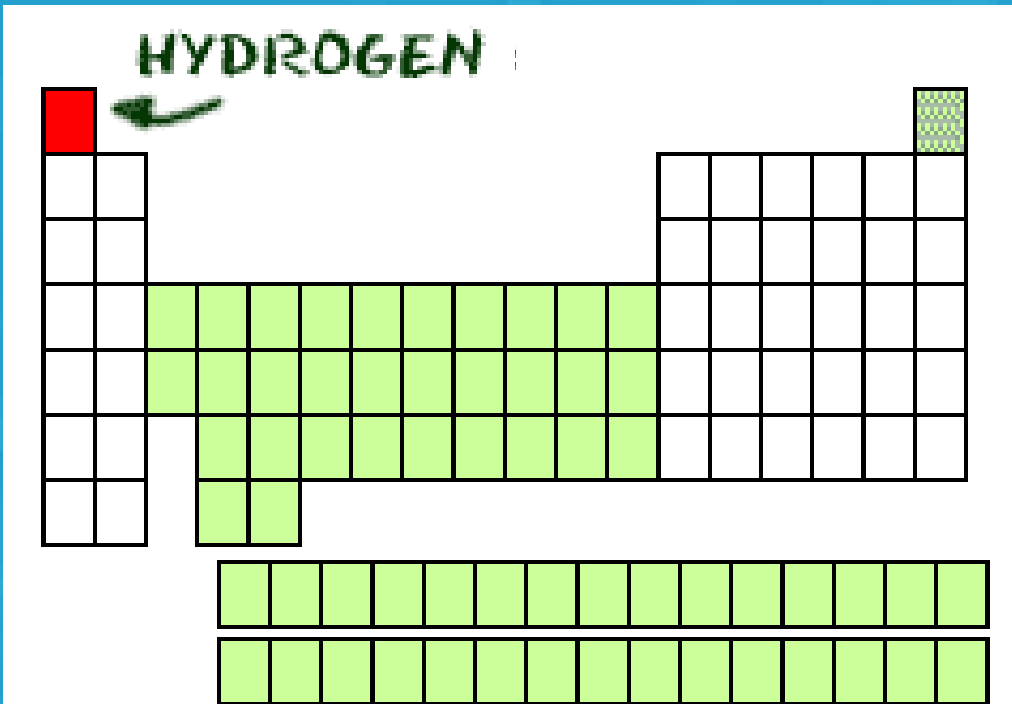
Periodic Table Families

- Transition Metals, B Group (Group 3B-2B)
- Most common metals, known as d block metals
- Can form ions with multiple charges
- Example Cu can form a +1 or +2 cation

Main groups		Transition-metal groups										Main groups																						
1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 9B	10 10B	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A																	
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									
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	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	71 Lu
87 Fr	88 Ra	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	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og			

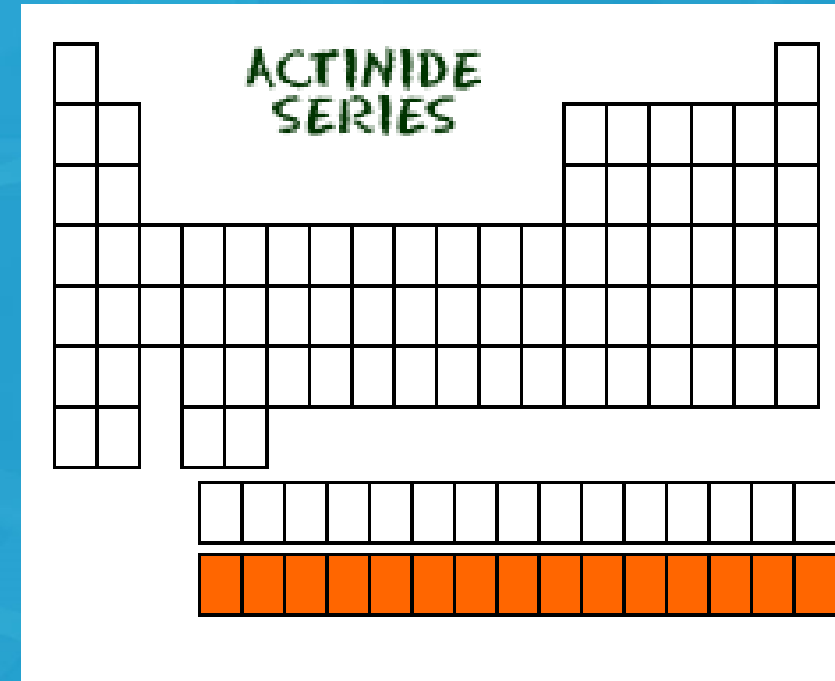
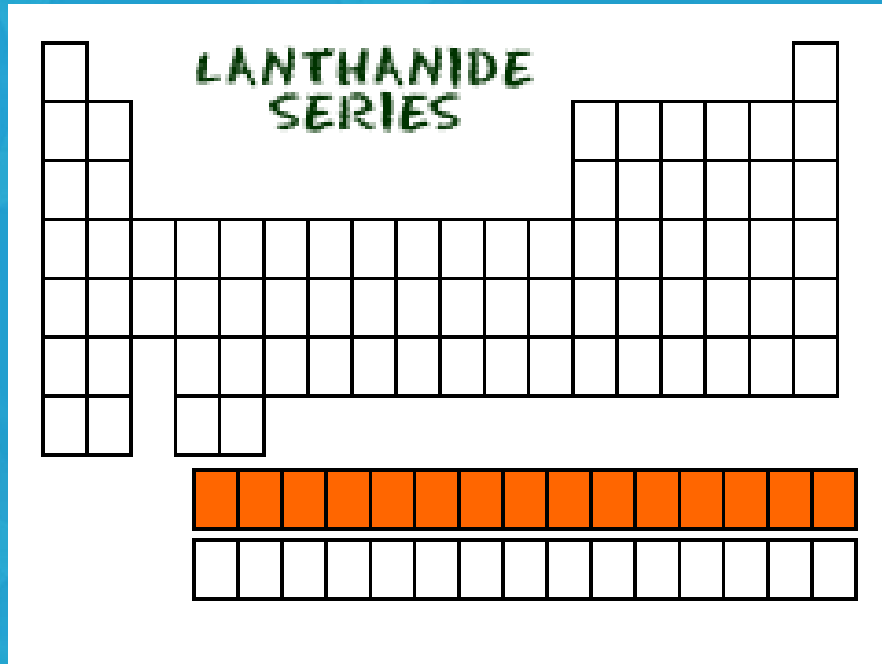
Periodic Table Families

- Hydrogen can behave as a metal (Alkali family) or nonmetal (Halogen family)
- It can form a cation with a +1 charge or an anion with a -1 charge



Periodic Table Families

- Inner Transition Metals (Lanthanide & Actinide Series)
- Most are radioactive
- Also called the rare earth elements



Periodic Table Trends

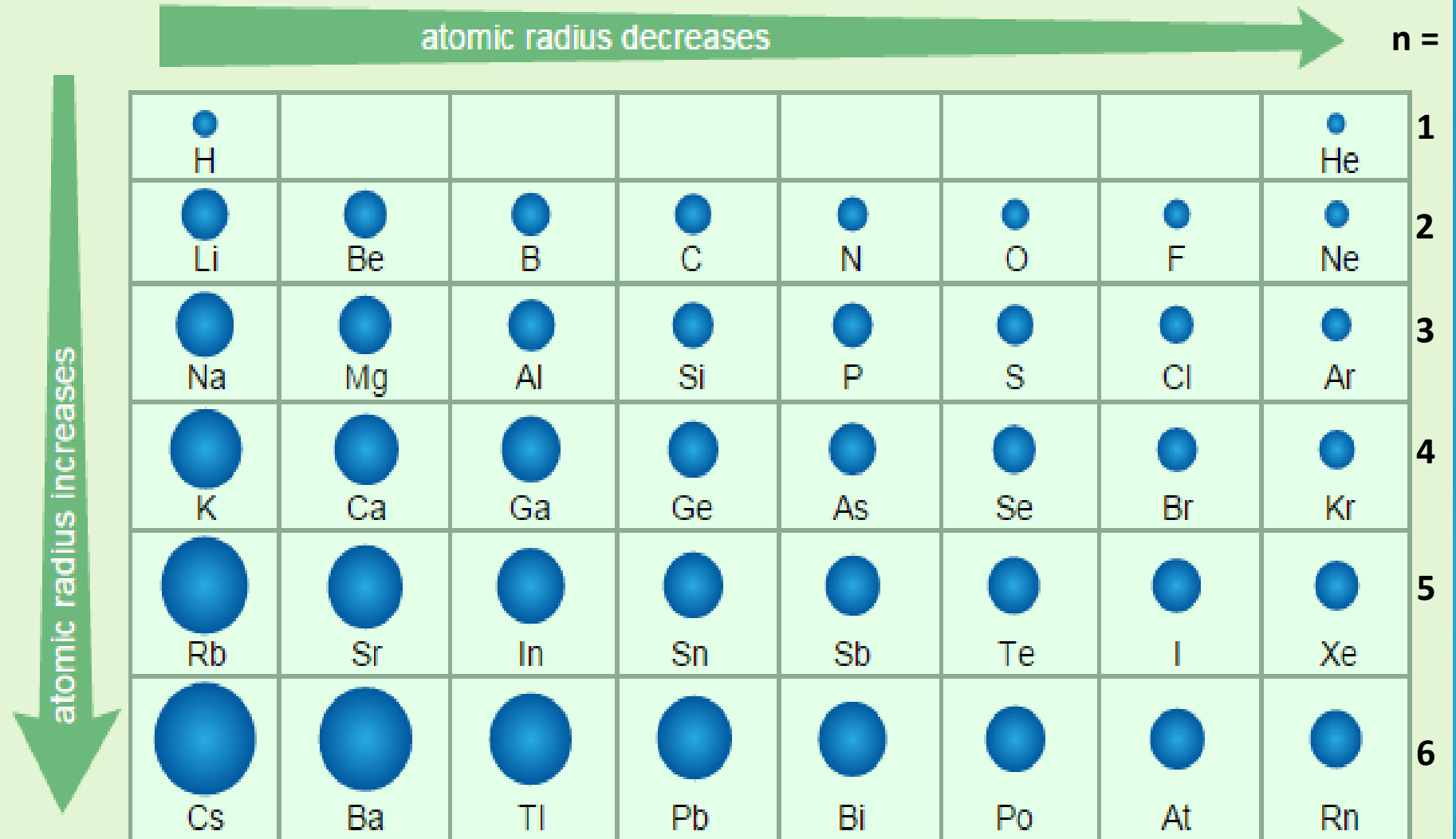
- **Certain patterns seen usually in the main group elements related to particular properties.**

Periodic Table Trends

- Atomic radius one half the distance between the nuclei of identical atoms that are bonded together
- Atoms get larger going down a group because each period down adds one energy level (n).
- Atoms get smaller going across a period because more protons pull the electrons closer to the nucleus.

-

Periodic Table Trends



Periodic Table Trends

Electronegativity

- An atom's ability, in a chemical compound, to attract electrons from another atom in a compound.
- Most electronegative → **F** Least electronegative → **Fr**
- The more electrons an element has in its valence shell the higher the electronegativity.
- As you move down groups, valence electrons get further away from the positive nucleus.

Periodic Table Trends

- Increases across periods left to right
- Decreases down a group

Directions of increasing electronegativity

1A		2A												3A	4A	5A	6A	7A	
1	H																		
3	Li	4	Be											5	6	7	8	9	
11	Na	12	Mg	3B	4B	5B	6B	7B	8B		1B	2B	13	14	15	16	17		
19	K	20	Ca	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
37	Rb	38	Sr	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	
55	Cs	56	Ba	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	
87	Fr	88	Ra	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	

Noble Gases not included

Periodic Table Trends

Ionization energy

- Energy required to remove an electron to create an ion.
- The higher the IE, the harder it is to remove an electron
- Small atoms have a large IE because the electrons are very close to the positive nucleus
- Atoms with a large EN have a large IE because if it is easy for the atom to grab electrons it will be very difficult to remove the electrons it has.

Chemical Bonding

- **Chemical bond:** A mutual electrical attraction between the nuclei & valence electrons of different atoms that bind the atoms together.

Two Types

- **Ionic** results from the electrical attraction between cations and anions
- **Covalent** results from the sharing of electron pairs between two atoms

Chemical Bonding

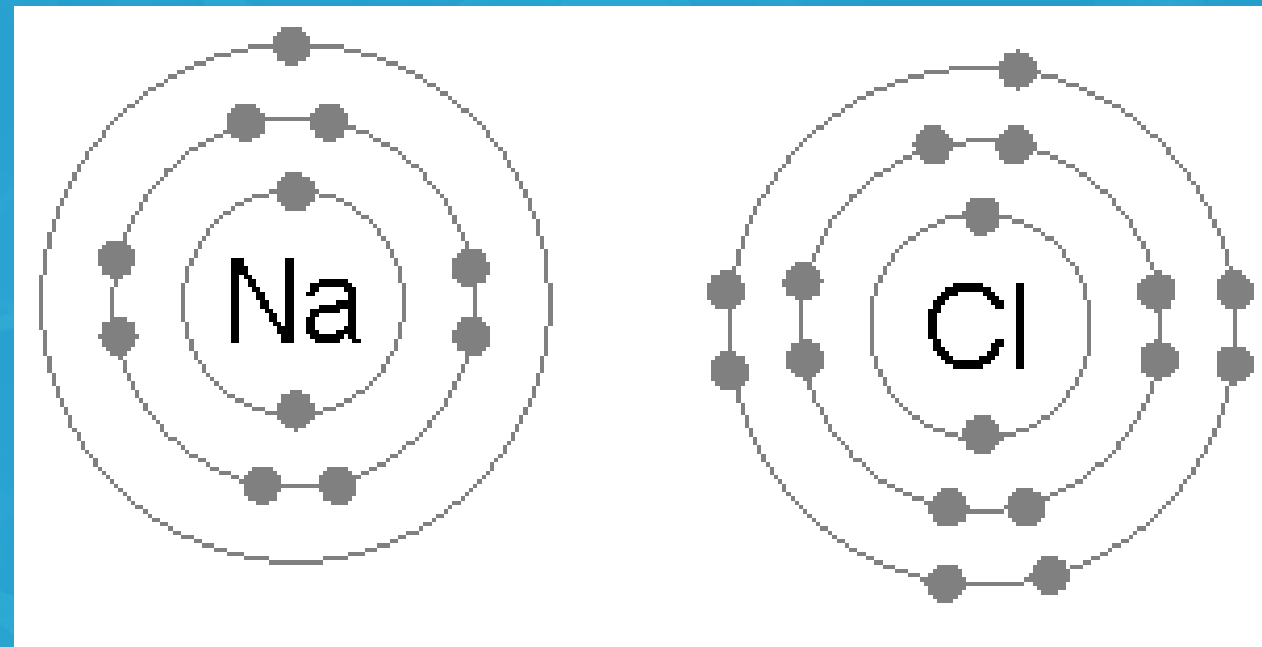
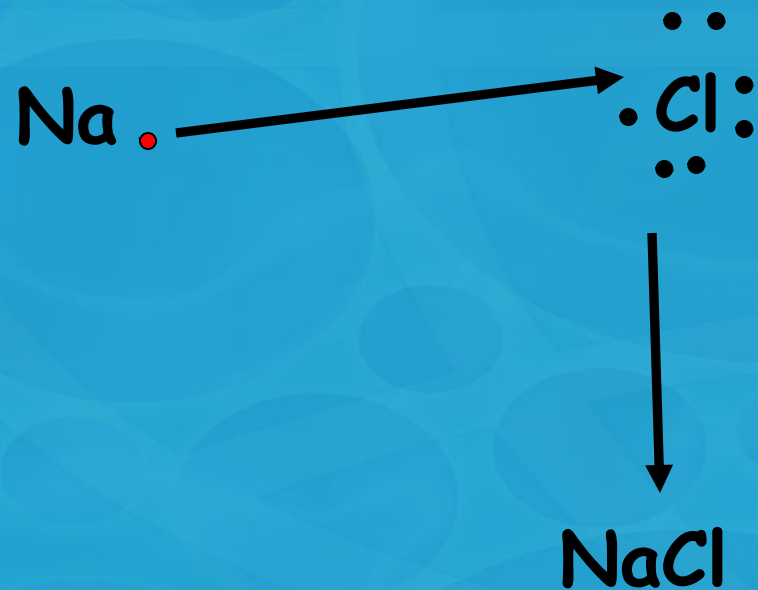
Ionic Bonding

- Atoms are stable when their outermost shell is full (8 electrons)
- Atoms need to gain or lose electrons in order to gain the octet
- Results in formation of cations (metals), losing electrons and anions (non-metals), gaining electrons

Chemical Bonding

Ionic Bonding

- Valence electrons are lost by the metal and gained by the non-metal



Ionic Bonds Properties

- High melting and boiling points
- Good conductors of heat and electricity
- Form crystalline structures
- Ionic bonds are usually strong and stable

Covalent Bonds

- Occurs between two non-metals
- Electrons are shared by both atoms to attain an octet
- A molecule forms when two or more atoms bond covalently
- Atoms may not share electrons equally

Covalent Bonds

- When this occurs the bond formed between them is a polar covalent bond
- If the covalent bond formed is shared equally between the two atoms it is non-polar covalent

Covalent Bonds Properties

- **Low melting and boiling points**
- **Most are liquids and gases at room temperature**
- **Non-conductors of heat and electricity**