

## Chapter 6

### The Periodic Table

Organizing the Elements

Classifying the Elements

Periodic Trends



# Periodic Table of Elements



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 <b>H</b> Hydrogen 1.00794																	2 <b>He</b> Helium 4.002602
3 <b>Li</b> Lithium 6.941	4 <b>Be</b> Beryllium 9.012182											5 <b>B</b> Boron 10.811	6 <b>C</b> Carbon 12.011	7 <b>N</b> Nitrogen 14.00643	8 <b>O</b> Oxygen 15.999	9 <b>F</b> Fluorine 18.9984032	10 <b>Ne</b> Neon 20.1797
11 <b>Na</b> Sodium 22.98976928	12 <b>Mg</b> Magnesium 24.304											13 <b>Al</b> Aluminum 26.9815385	14 <b>Si</b> Silicon 28.0855	15 <b>P</b> Phosphorus 30.973761998	16 <b>S</b> Sulfur 32.06	17 <b>Cl</b> Chlorine 35.453	18 <b>Ar</b> Argon 39.948
19 <b>K</b> Potassium 39.0983	20 <b>Ca</b> Calcium 40.078	21 <b>Sc</b> Scandium 44.955912	22 <b>Ti</b> Titanium 47.88	23 <b>V</b> Vanadium 50.9415	24 <b>Cr</b> Chromium 51.9961	25 <b>Mn</b> Manganese 54.938044	26 <b>Fe</b> Iron 55.845	27 <b>Co</b> Cobalt 58.933195	28 <b>Ni</b> Nickel 58.6934	29 <b>Cu</b> Copper 63.546	30 <b>Zn</b> Zinc 65.38	31 <b>Ga</b> Gallium 69.723	32 <b>Ge</b> Germanium 72.64	33 <b>As</b> Arsenic 74.9216	34 <b>Se</b> Selenium 78.96	35 <b>Br</b> Bromine 79.904	36 <b>Kr</b> Krypton 83.798
37 <b>Rb</b> Rubidium 85.4678	38 <b>Sr</b> Strontium 87.62	39 <b>Y</b> Yttrium 88.90584	40 <b>Zr</b> Zirconium 91.224	41 <b>Nb</b> Niobium 92.90638	42 <b>Mo</b> Molybdenum 95.94	43 <b>Tc</b> Technetium (97.90631)	44 <b>Ru</b> Ruthenium 101.07	45 <b>Rh</b> Rhodium 102.90550	46 <b>Pd</b> Palladium 106.42	47 <b>Ag</b> Silver 107.8682	48 <b>Cd</b> Cadmium 112.411	49 <b>In</b> Indium 114.818	50 <b>Sn</b> Tin 118.710	51 <b>Sb</b> Antimony 121.757	52 <b>Te</b> Tellurium 127.6	53 <b>I</b> Iodine 126.90545	54 <b>Xe</b> Xenon 131.29
55 <b>Cs</b> Cesium 132.90545196	56 <b>Ba</b> Barium 137.327	57-71 Lanthanoids	72 <b>Hf</b> Hafnium 178.49	73 <b>Ta</b> Tantalum 180.94788	74 <b>W</b> Tungsten 183.84	75 <b>Re</b> Rhenium 186.207	76 <b>Os</b> Osmium 190.23	77 <b>Ir</b> Iridium 192.222	78 <b>Pt</b> Platinum 195.084	79 <b>Au</b> Gold 196.966569	80 <b>Hg</b> Mercury 200.59	81 <b>Tl</b> Thallium 204.3833	82 <b>Pb</b> Lead 207.2	83 <b>Bi</b> Bismuth 208.980389	84 <b>Po</b> Polonium (209)	85 <b>At</b> Astatine (210)	86 <b>Rn</b> Radon 222.01758
87 <b>Fr</b> Francium (223)	88 <b>Ra</b> Radium (226)	89-103 Actinoids	104 <b>Rf</b> Rutherfordium (261)	105 <b>Db</b> Dubnium (262)	106 <b>Sg</b> Seaborgium (263)	107 <b>Bh</b> Bohrium (264)	108 <b>Hs</b> Hassium (265)	109 <b>Mt</b> Meitnerium (266)	110 <b>Ds</b> Darmstadtium (271)	111 <b>Rg</b> Roentgenium (272)	112 <b>Uub</b> Ununbium (285)	113 <b>Uut</b> Ununtrium (284)	114 <b>Uuq</b> Ununquadium (289)	115 <b>Uup</b> Ununpentium (288)	116 <b>Uuh</b> Ununhexium (285)	117 <b>Uus</b> Ununseptium (286)	118 <b>Uuo</b> Ununoctium (289)

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

Design and Interface Copyright © 1997 Michael Dayah ([michael@dayah.com](mailto:michael@dayah.com)). <http://www.ptable.com/>

57 <b>La</b> Lanthanum 138.9047	58 <b>Ce</b> Cerium 140.12	59 <b>Pr</b> Praseodymium 140.90766	60 <b>Nd</b> Neodymium 144.242	61 <b>Pm</b> Promethium (145)	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.964	64 <b>Gd</b> Gadolinium 157.25	65 <b>Tb</b> Terbium 158.92535	66 <b>Dy</b> Dysprosium 162.50015	67 <b>Ho</b> Holmium 164.930329	68 <b>Er</b> Erbium 167.259	69 <b>Tm</b> Thulium 168.934027	70 <b>Yb</b> Ytterbium 173.054	71 <b>Lu</b> Lutetium 174.967
89 <b>Ac</b> Actinium (227)	90 <b>Th</b> Thorium 232.0377	91 <b>Pa</b> Protactinium 231.036889	92 <b>U</b> Uranium 238.02891	93 <b>Np</b> Neptunium (237)	94 <b>Pu</b> Plutonium (244)	95 <b>Am</b> Americium (243)	96 <b>Cm</b> Curium (247)	97 <b>Bk</b> Berkelium (247)	98 <b>Cf</b> Californium (251)	99 <b>Es</b> Einsteinium (252)	100 <b>Fm</b> Fermium (257)	101 <b>Md</b> Mendelevium (258)	102 <b>No</b> Nobelium (259)	103 <b>Lr</b> Lawrencium (260)

## Topics:

1. The Periodic Table

## Objectives:

1. Explain the history of the Periodic Table (Dobereiner, Newlands, Mendeleev, Moseley).
2. Describe the arrangement of the periodic table (periods, groups, periodic law, classes of elements).
3. Classify elements based on electron configuration for Valence (outer electrons that bond).
4. Explain periodic trends (electronegativity, atomic & ionic size, ionization energy)

# 6.1 Organizing the Elements >



Copy the chart below in your notebook:

*The top row is the order of the EM spectra*

radio	microwave	infrared	Visible ROY	Visible GBIV	ultraviolet	x-rays	gamma

# 6.1 Organizing the Elements >



Observe the items in all 24 squares below in terms of similar characteristics.

Fill in the columns and rows (for the chart you copied) based on a recognizable & sensible pattern of the items.

Meat radio	Seafood microwave	Soup infrared	Dairy Visible ROY	Breads Visible GBIV	Vegetables ultraviolet	Pasta x-rays	Fruit gamma
Pork 0.5 lb radio	Salmon steak microwave	Beans 5 pods ultraviolet	Milk 1 gallon visible ROY	Grapes 1 twig gamma	Beef 0.25 lb radio	Tomato Soup 8 oz infrared	Rye 1 loaf visible GBIV
Stew 32 oz infrared	Spaghetti 1 pot x-rays	Bananas 1 bunch gamma	Clams 1 bushel microwave	Cheese 1 slice visible ROY	Celery 1 stalk ultraviolet	Eggs 1 dozen visible ROY	Barley 1 stalk visible GBIV
Chicken Noodle 16 oz infrared	Wheat flour 2 lbs visible GBIV	Shrimp Cocktail microwave	Rigatoni 1 bite x-rays	Chicken 1 lb radio	Apple 1 bushel gamma	Cucumber 1 plant ultraviolet	Macaroni 1 bowl x-rays

# 6.1 Organizing the Elements >

## Answers



Meat radio	Seafood microwave	Soup infrared	Dairy Visible ROY	Breads Visible GBIV	Vegetables ultraviolet	Pasta x-rays	Fruit gamma
Beef 0.25 lb	Shrimp cocktail	Tomato Soup 8 oz	Cheese 1 slice	Rye 1 loaf	Beans 5 pods	Rigatoni 1 bite	Grapes 1 twig
<b>Pork</b> 0.5 lb	Salmon steak	Chicken Noodle 16 oz	Eggs 1 dozen	Barley 1 stalk	Cucumber 1 plant	Macaroni 1 bowl	Bananas 1 bunch
Chicken 1.0 lb	Clams 1 bushel	Stew 32 oz	Milk 1 gallon	Wheat flour 2 lbs	Celery 1 stalk	Spaghetti 1 pot	Apple 1 bushel

What guidelines did you use to make your Periodic Table of Foods? How did you determine “Groups”?

*Food groups & EM radiation order*

How did you determine “Periods” or “Rows”?

*Amounts within each food group*



# How was the periodic table developed and how is it arranged?

Reihen	Gruppe I. — R <sup>0</sup>	Gruppe II. — R <sup>0</sup>	Gruppe III. — R <sup>0</sup>	Gruppe IV. RH <sup>4</sup> R <sup>0</sup>	Gruppe V. RH <sup>5</sup> R <sup>0</sup>	Gruppe VI. RH <sup>6</sup> R <sup>0</sup>	Gruppe VII. RH R <sup>0</sup>	Gruppe VIII. — R <sup>0</sup>
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	—	— — — —

## 6.1 Organizing the Elements >

### Searching for an Organizing Principle

In 1829, a German chemist, J. W. **Dobereiner**, published a classification system. He grouped known elements into **triads**, sets of three elements with similar properties.

*One triad consisted of chlorine, bromine, and iodine.*



They each look different, but have very **similar chemical properties.**



# 6.1 Organizing the Elements >

## Dobereiner's Triads

*When the 3 elements in a triad are put in the order of their atomic masses, the difference in mass between the first and second elements is about the same as the difference in mass between the second and third elements.*

Example	Triad	Atomic Mass	Difference in Mass
1	chlorine bromine iodine	35.5	44.5 47
		80	
		127	
2	sulfur selenium tellurium	32	47 49
		79	
		128	
3	calcium strontium barium	40	48 49
		88	
		137	
4	lithium sodium potassium	7	16 16
		23	
		39	



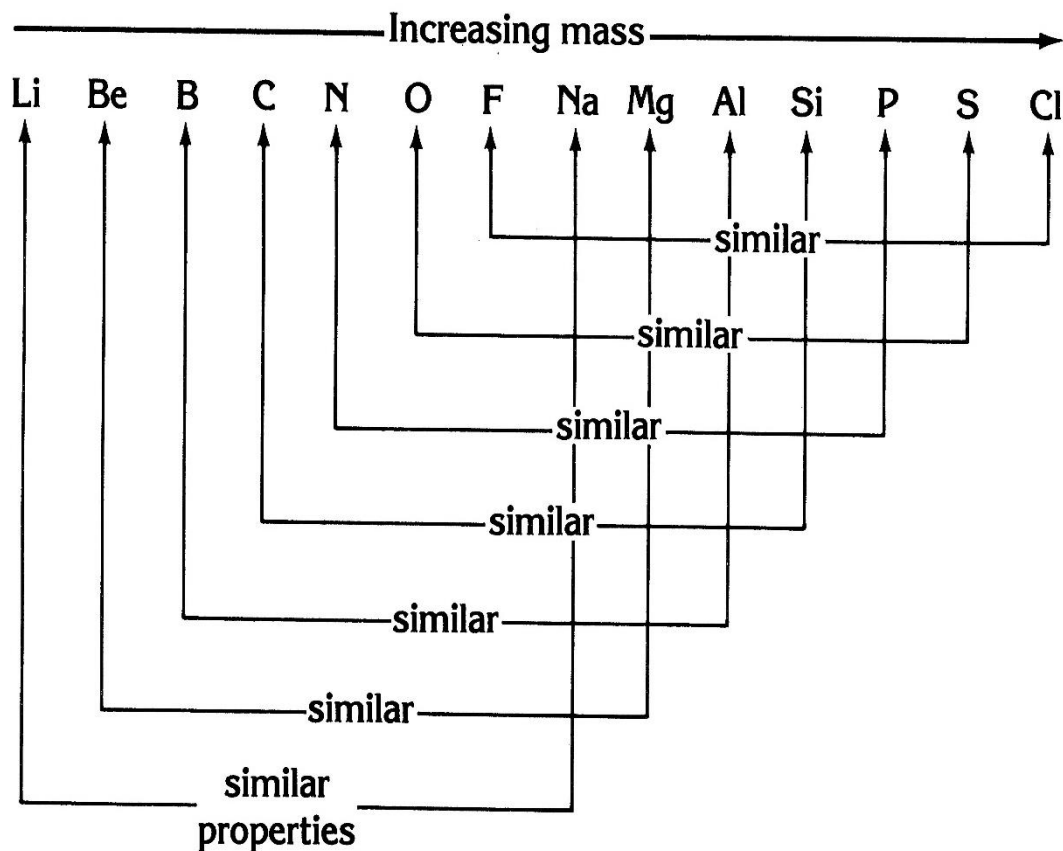
## 6.1 Organizing the Elements >

## Newland's Law of Octaves

### John Newlands (1865)

He arranged the Periodic Table according to increasing atomic mass.

He established the *“Law of Octaves”* → noticing a repeating pattern of similar properties every *eight* elements on the Periodic table.



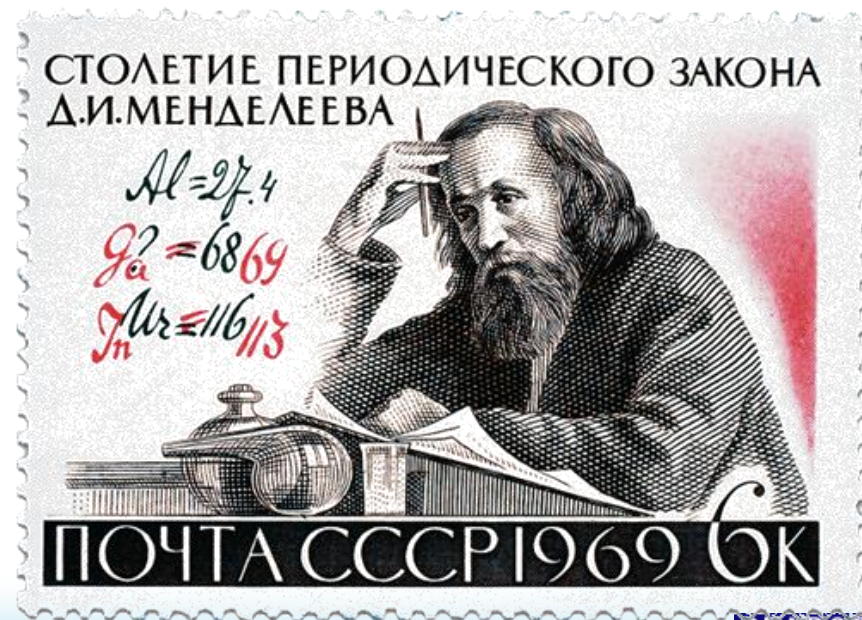
## 6.1 Organizing the Elements >

## Mendeleev's Periodic Table

In 1869, the Russian chemist Dmitri **Mendeleev** produced the first orderly arrangement, or periodic table, of all 63 elements known at the time.

Mendeleev wrote the symbol for each element, along with the **physical** and **chemical properties**.

Mendeleev arranged the elements in order of **increasing atomic mass**.



## 6.1 Organizing the Elements >

Mendeleev's Periodic Table

Mendeleev noticed that similar properties of elements occurred after “**periods**” of varying lengths (rows on Periodic Table).

He established “**Families**” or “**Groups**” (*columns*) on the Periodic Table, possessing **similar chemical properties**.

Mendeleev predicted properties and masses of **unknown elements** that he knew existed. (e.g. scandium, gallium, germanium).

30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904
---------------------------	-------------------------------	--------------------------------	-------------------------------	-------------------------------	-------------------------------

*Mendeleev could NOT account for **Iodine** whose atomic mass was less than Tellurium, but whose chemical properties belonged with Br and Cl's group .*

8 O Oxygen 15.999	9 F Fluorine 18.998
16 S Sulfur 32.06	17 Cl Chlorine 35.453
34 Se Selenium 78.96	35 Br Bromine 79.904
52 Te Tellurium 127.60	53 I Iodine 126.90

# The Modern Periodic Table

## Henry Moseley (1887-1915)

- Contributed to the modern version of the periodic table.
- Arranged all the elements in order of increasing atomic number.
- Accounted for variations resulting from isotopes.



# The Modern Periodic Table

The **periodic table** of elements is an organized display of the chemical elements.

- In order of increasing **atomic number** (protons)
- **Similarities** in chemical properties
- ❖ Similarities in **electron configurations**

## Periodic Table of Elements

Click an element's box for more info.

Element Class    State of Matter    Orbitals (SPDF)

1 H Hydrogen 1.01																	2 He Helium 4.00																		
3 Li Lithium 6.94	4 Be Beryllium 9.01																	10 Ne Neon 20.18																	
11 Na Sodium 22.99	12 Mg Magnesium 24.31																	18 Ar Argon 39.95																	
<div style="border: 1px solid black; padding: 5px;">                 Atomic Number 1 <b>H</b> Hydrogen  (Ave) Atomic Mass 1.01             </div>		<div style="display: flex; justify-content: space-around; font-size: small;"> <div> <p>Non-Metal</p> <p>Semi-Metal</p> <p>Halogen</p> <p>Noble Gas</p> <p>Lanthanide</p> </div> <div> <p>Alkali Metal</p> <p>Alkaline Earth Metal</p> <p>Transition Metal</p> <p>Post-Transition Metal</p> <p>Actinide</p> </div> </div>																																	
5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18	13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80						
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium 98.00	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29	55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.20	83 Bi Bismuth 208.98	84 Po Polonium 209	85 At Astatine 209	86 Rn Radon 222.02
87 Fr Francium 223.00	88 Ra Radium 226.00	89-103 Actinide Series	104 Rf Rutherfordium 261.00	105 Db Dubnium 262.00	106 Sg Seaborgium 266.00	107 Bh Bohrium 264.00	108 Hs Hassium 277.00	109 Mt Meitnerium 268.00	110 Ds Darmstadtium 281.00	111 Rg Roentgenium 272.00	112 Cn Copernicium 285.00	113 Uut Ununtrium 284.00	114 Fl Flerovium 289.00	115 Uup Ununpentium 288.00	116 Lv Livermorium 291.00	117 Uus Ununseptium Unknown	118 Uuo Ununoctium 294.00	119 La Lanthanum 138.91	120 Ce Cerium 140.12	121 Pr Praseodymium 140.91	122 Nd Neodymium 144.24	123 Pm Promethium 145.00	124 Sm Samarium 150.36	125 Eu Europium 151.97	126 Gd Gadolinium 157.25	127 Tb Terbium 158.93	128 Dy Dysprosium 162.50	129 Ho Holmium 164.93	130 Er Erbium 167.26	131 Tm Thulium 168.93	132 Yb Ytterbium 173.04	133 Lu Lutetium 174.97			
119 Ac Actinium 227.00	120 Th Thorium 232.04	121 Pa Protactinium 231.04	122 U Uranium 238.03	123 Np Neptunium 237.00	124 Pu Plutonium 244.00	125 Am Americium 243.00	126 Cm Curium 247.00	127 Bk Berkelium 247.00	128 Cf Californium 251.00	129 Es Einsteinium 252.00	130 Fm Fermium 257.00	131 Md Mendelevium 258.00	132 No Nobelium 259.00	133 Lr Lawrencium 262.00																					

# 6.1 Organizing the Elements >

## Metals, Nonmetals, and Metalloids

### Metals

As one goes across a period, the properties of elements become less metallic and more nonmetallic. About 80% of the elements are metals.

The periodic table is color-coded to show the classification of elements:

- Metals:** Yellow background (left side, including the transition metals).
- Metalloids:** Green background (diagonal line from Boron to Astatine).
- Nonmetals:** Light blue background (right side, including noble gases).

A red circle highlights the Metals region, and a yellow arrow points from the right towards the left across the top of the table, indicating the trend of decreasing metallic character across a period.

1 IA 1A	2 IIA 2A											13 IIIB 3A	14 IVB 4A	15 VB 5A	16 VIB 6A	17 VIIB 7A	18 VIIIB 8A												
1 H	2 He											5 B	6 C	7 N	8 O	9 F	10 Ne												
2 Li	4 Be											11 Na	12 Mg	3 IIIA 3B	4 IVA 4B	5 VA 5B	6 VIA 6B	7 VIIA 7B	8 VIII 8B	9 IX	10 X	11 IB 1B	12 IIB 2B	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
3 Na	4 Mg	3 Sc	4 Ti	5 V	6 Cr	7 Mn	8 Fe	9 Co	10 Ni	11 Cu	12 Zn	13 Ga	14 Ge	15 As	16 Se	17 Br	18 Kr												
4 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 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 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn												
7 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo												
		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb														
		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No														

# Metals

- Good conductors of heat and electric current.
- High **luster**, or sheen ... ability to reflect light.
- Solids at room temperature, except for mercury (Hg).
- **Ductile**, can be drawn into wires.
- **Malleable**, can be hammered into thin sheets without breaking.
- **Hard & Strong**



# 6.1 Organizing the Elements >

## Metals, Nonmetals, and Metalloids

### Nonmetals

- Tend to have properties opposite of metals.
- Usually **poor conductors & brittle**.

The periodic table is color-coded to show the classification of elements:

- Metals:** Yellow background (Groups 1-10, 11-12, and the lanthanide/actinide series).
- Metalloids:** Green background (Groups 13-16).
- Nonmetals:** Teal background (Groups 17-18, and Groups 14-16 in periods 2 and 3).

A red circle highlights the Nonmetals box, and a blue arrow points from it towards the right side of the table.

1 IA 1A	2 IIA 2A											13 IIIB 3A	14 IVB 4A	15 VB 5A	16 VIB 6A	17 VIIB 7A	18 VIIIB 8A
1 H	2 He											5 B	6 C	7 N	8 O	9 F	10 Ne
3 Li	4 Be	3 IIIA 3B	4 IVA 4B	5 VA 5B	6 VIA 6B	7 VIIA 7B	8 VIII 8B	9 VIII 8B	10 VIII 8B	11 IB 1B	12 IIB 2B	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 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo
		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb		
		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No		



# 6.1 Organizing the Elements >

## Metals, Nonmetals, and Metalloids

### Metalloids

- “Staircase Elements” that sometimes behave like metals.
- Under other conditions, they may behave like nonmetals.
- Silicon is also present as the compound silicon dioxide in glass items and the earth’s crust (*silica*).

1 IA 1A	2 IIA 2A											13 IIIB 3A	14 IVB 4A	15 VB 5A	16 VIB 6A	17 VIIB 7A	18 VIIIB 8A
1 H																	2 He
2 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3 Na	12 Mg	3 IIIA 3B	4 IVA 4B	5 VA 5B	6 VIA 6B	7 VIIA 7B	8 VIII 8B		10 10	11 IB 1B	12 IIB 2B	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4 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 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 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo
		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb		
		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No		



# Information for Each Element

Atomic Number

11

**Na**

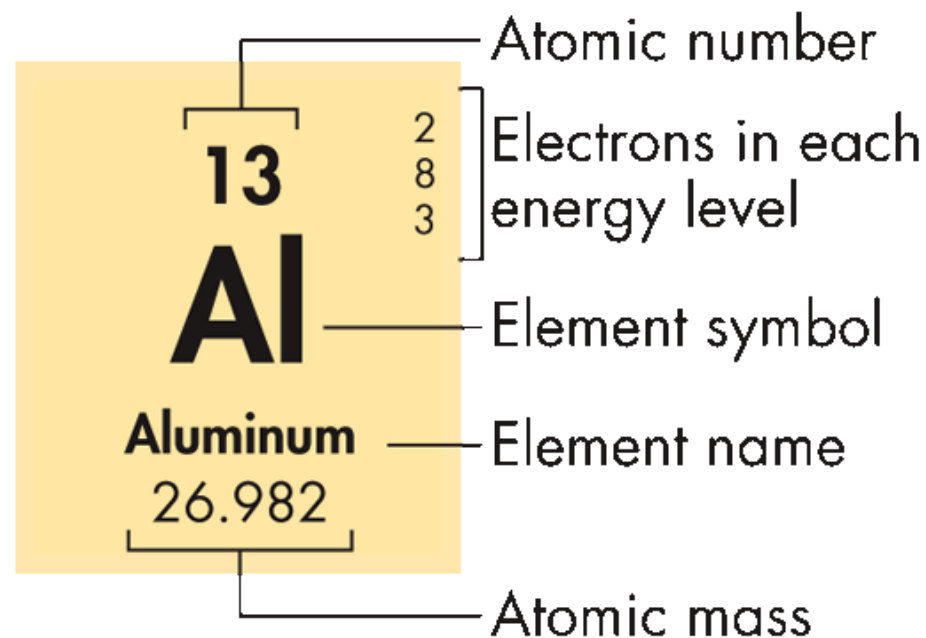
Sodium

Average Atomic Mass

22.99

Each element's entry on the periodic table shows:

- Chemical symbol
- Element name
- Atomic number
- Average atomic mass
- Electron configuration





# Periods

Periodic Table of the Elements


	IA	IIA											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	III B	IV B	V B	VI B	VII B	— VII —		IB	IIB	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	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	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn

## Horizontal rows on the periodic table

- Indicate **principal energy level** of valence electrons (Quantum number 1, n).
- Atomic number increases from left to right across the period.
- In each period the number of **valence** electrons increases from left to right.
- Chemical properties change systematically across the periodic table.

# Groups or Families

Periodic Table of the Elements



1	2											10	11	
1	IA	IIA											0	2
1	H												He	
2	3	4											10	
2	Li	Be											Ne	
3	11	12	III B	IV B	V B	VI B	VII B	VIII			IB	IIB	18	
3	Na	Mg											Ar	
4	19	20	21	22	23	24	25	26	27	28	29	30	36	
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Kr	
5	37	38	39	40	41	42	43	44	45	46	47	48	54	
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	Xe	

**Groups:** columns or **families** on the periodic table

- Elements within a group have the same chemical properties.
- Groups contain the same number of electrons in outermost level (valence electrons), which explains why groups have the same properties.
- “A” groups → electrons filling s and p valence orbitals.

**Magic number is “8” ...  $s^2 + p^6$**

# Periodic Table of the Elements

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	III B	IV B	V B	VI B	VII B	VIII			IB	IIB	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	*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
87 Fr	88 Ra	+Ac	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110	111	112	113					

*S<sup>1</sup>*  
valence

\* Lanthanide 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

# Alkali Metals

# Alkali Metals (Group IA)

- Group 1 or IA
- Easily lose an electron to form a **+1 cation** *in order to gain ideal electron configuration*
- Typical properties:
  - Silver in color
  - Soft (can be cut with a knife)
  - Highly reactive with oxygen and water
  - Able to oxidize in air



# Alkali Metals (Group IA)

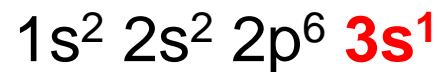
- Group 1 or IA
- Easily lose an electron to form a **+1 cation** *in order to gain ideal electron configuration*



$$+11 \text{ p}$$

$$\frac{-11 \text{ e}}{0}$$

$$0$$



- “Magic number is “8” ... s2 + p6
- *Is it easier for the metals to gain 7 electrons to make 8 or to lose 1 electron to have a full valence in the next lowest energy level?*

$$+11 \text{ p}$$

$$\frac{-10 \text{ e}}{0}$$

**+1 charge**





# Alkaline Earth Metals (**Group IIA**)

- Group 2 or IIA
- Lose two electrons to form a **+2 cation** *in order to gain ideal electron configuration*
- Typical properties:
  - Silver in color
  - More brittle than alkali metals
  - Somewhat reactive
  - Low in density, with low melting and boiling points



# Alkaline Earth Metals (**Group IIA**)

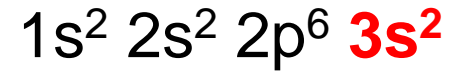
- Group 2 or IIA
- Lose two electrons to form a **+2 cation** *in order to gain ideal electron configuration*
- **“Magic number is “8” ... s<sup>2</sup> + p<sup>6</sup>**
- *Is it easier for the metals to gain 6 electrons to make 8 or to lose 2 electron to have a full valence in the next lowest energy level?*



$$+12 \text{ p}$$

$$\underline{-12 \text{ e}}$$

$$0$$



$$+12 \text{ p}$$

$$\underline{-10 \text{ e}}$$

**+2 charge**

# Periodic Table of the Elements

1A																				0	
1	2																				2
3	4																				10
11	12																				18
19	20	III B	IV B	V B	VI B	VII B	— VII —					IB	IIB	5	6	7	8	9			
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54				
55	56	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	81	82	83	84	85	86				
87	88	+Ac	Rf	Ha	Sg	Ns	Hs	Mt	110	111	112	113									

*B Groups*

* Lanthanide Series	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
+ Actinide Series	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*

# Transition Metals (B Groups)

- Characterized by the presence of electrons in **d** orbitals
- E.g. Copper, silver, gold, iron
- Form colored compounds
- May have unusual properties:
  - Magnetism
  - High conductivity



These elements are also called the **rare-earth elements**.

# Periodic Table of the Elements

1	2											3	4	5	6	7	8	9	10
1	2											3	4	5	6	7	8	9	10
3	4											5	6	7	8	9	10		
11	12	13	14	15	16	17	18												
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54		
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86		
87	88	89	104	105	106	107	108	109	110	111	112	113							

**B Groups**



\* Lanthanide Series  
+ Actinide Series

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
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

# Inner Transition Metals

# Inner Transition Metals (B Groups)

- Characterized by the presence of electrons in **f** orbitals
- **Lanthanides**: *elements 57-71*
- **Actinides**: *elements 89-103*
- Radioactive (e.g. U-92)
- Present in only trace amounts on Earth



# Periodic Table of the Elements

1	2											3	4	5	6	7	8	9	10
1	2											3	4	5	6	7	8	9	10
3	4											5	6	7	8	9	10		
11	12	13	14	15	16	17	18												
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54		
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86		
87	88	89	104	105	106	107	108	109	110	111	112	113							

$s^2 p^5$   
valence

\* Lanthanide Series

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

+ Actinide Series

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



# Halogens



# Halogens (Group VIIA)

- Group 17 or VIIA
- Easily gain an electron to form a **-1 anion** *in order to gain ideal electron configuration*
- Typical properties
  - **Highly reactive with metals**
  - Toxic to organisms
  - Most occur as diatomic molecules ( $F_2$ ,  $Cl_2$ ,  $Br_2$ ,  $I_2$ )
  - **React with metals to form salts**



# Halogens (Group VIIA)

- Group 17 or VIIA
- Easily gain an electron to form a **-1 anion** *in order to gain ideal electron configuration*
- “Magic number is “8” ... s<sup>2</sup> + p<sup>6</sup>
- *Is it easier for the non-metal to gain 1 electron to make 8 or to lose 7 electrons to have a full valence in the energy level?*



$$+17 \text{ p}$$

$$\underline{-17 \text{ e}}$$

$$0$$



$$+17 \text{ p}$$

$$\underline{-18 \text{ e}}$$

**-1 charge**

# Periodic Table of the Elements

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	III B	IV B	V B	VI B	VII B	VIII			IB	IIB	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	*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
87 Fr	88 Ra	+Ac	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110	111	112	113					

$s^2 p^6$   
valence



\* 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
----------	----------	---------	----------	----------	----------	----------	----------	----------	----------	-----------	-----------	-----------	-----------

# Noble Gases

# Noble Gases (Group VIII A)

- Group 18 or VIII A
- **Inert gases** (nonreactive)  
*have ideal electron configuration*
- Typical properties
  - Odorless and tasteless
  - Nonreactive and nonflammable
  - Have extremely low boiling points (i.e. gases)
  - Produce characteristic colors when excited electrically



# Songs

The Periodic Table Song (2:44)

<http://somup.com/cF6QFinnyQ>

Tom Lehrer (1970 ... 1:47)

[The Elements Song](#)

<http://somup.com/cFQ22hVSKJ>

# Octet Rule – Stability of Atoms When Bonding

The stability of an atom is associated with electron configuration:

The maximum number of electrons in outer level is  $8e^-$   
[  $s$  orbital holds up to  $2 e^-$ ,  
 $p$  orbitals hold up to  $6 e^-$  ]

**$8e^-$**  represents a very stable arrangement (noble gas configuration)

Helium ( ${}_2\text{He}^4$ ) has only  $2e^-$  but a complete outer shell.

Atoms tend to combine with other atoms in such a way that each atom has eight electrons in its valence shell, giving it the same electron configuration as a noble gas.

## 6.1 Organizing the Elements >

## Electron Configurations in Groups

# Valence Electrons

The number of electrons in the highest occupied energy level (n) level (valence electrons.)

Lithium (Li)	$1s^2 2s^1$
Sodium (Na)	$1s^2 2s^2 2p^6 3s^1$
Potassium (K)	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

Carbon (C)	$1s^2 2s^2 2p^2$
Silicon (Si)	$1s^2 2s^2 2p^6 3s^2 3p^2$

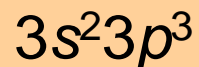
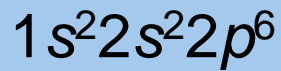
Helium (He)	$1s^2$
Neon (Ne)	$1s^2 2s^2 2p^6$
Argon (Ar)	$1s^2 2s^2 2p^6 3s^2 3p^6$
Krypton (Kr)	$1s^2 2s^2 2p^6 3s^2 3p^6 2d^{10} 4s^2 4p^6$

# Kernel & Valence Electrons in **A** Groups

Example:

Phosphorus (P)

- Highest  $n$  orbitals = valence electrons



Core  
kernel

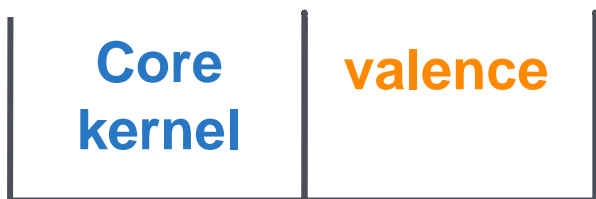
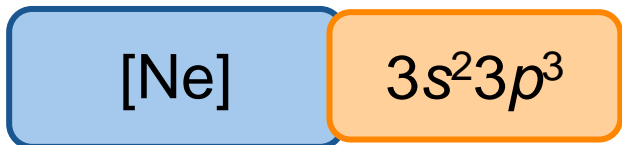
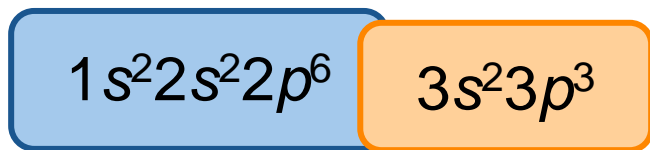




# Kernel & Valence Electrons in **A** Groups

Example:

Phosphorus (P)

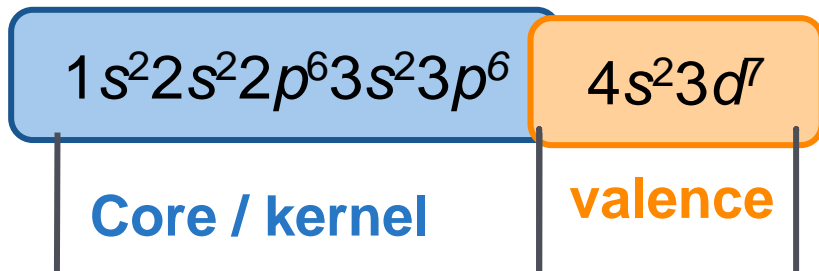


- Highest  $n$  orbitals = valence electrons.
- All other orbitals = kernel electrons (use [Ne]).
- Group number relates to the number of valence electrons.
- Noble gases (group VIII or 18): full valence shell.

# Kernel & Valence Electrons in **B** Groups

Examples:

Cobalt (Co)

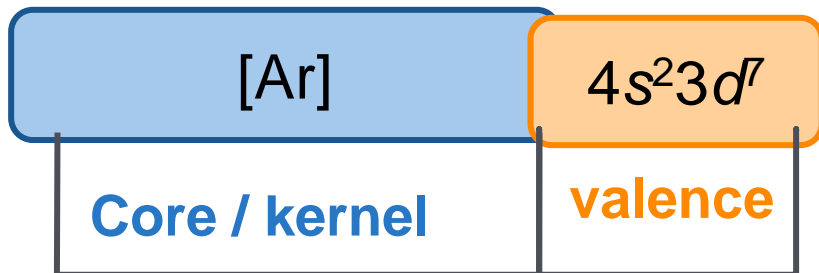


- *NOTICE that valence electrons are still in the highest “n” s and p orbitals.*
- Partially filled *d* and *f* orbitals = valence electrons

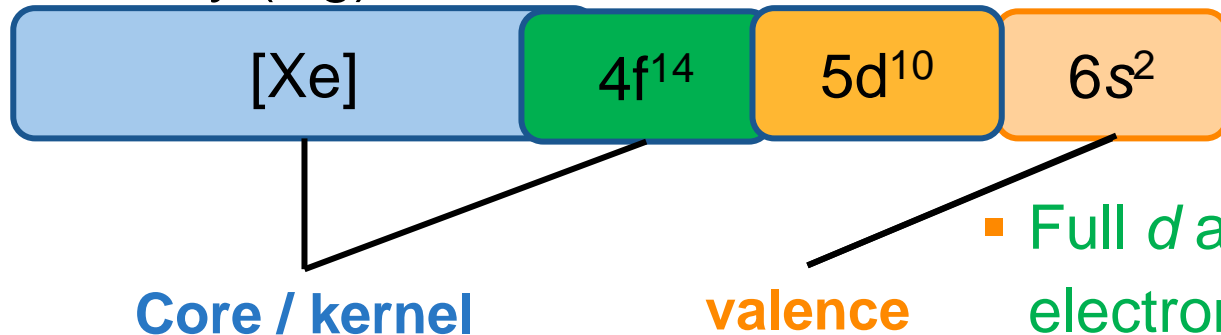
# Core and Valence Electrons in **B** Groups

Examples:

Cobalt (Co)



Mercury (Hg)



- *NOTICE that valence electrons are still in the highest "n" s and p orbitals*
- Partially filled *d* and *f* orbitals = valence electrons
- Full *d* and *f* orbitals = Core electrons

# Group “A” & “B” Elements distinguished by sublevels

## A Groups

*s block*

1s	1s <sup>1</sup>	
2s	2s <sup>1</sup>	2s <sup>2</sup>
3s	3s <sup>1</sup>	3s <sup>2</sup>
4s	4s <sup>1</sup>	4s <sup>2</sup>
5s	5s <sup>1</sup>	5s <sup>2</sup>
6s	6s <sup>1</sup>	6s <sup>2</sup>
7s	7s <sup>1</sup>	7s <sup>2</sup>

nd<sup>1-10</sup>

3d										
4d										
5d										
6d										

**B Groups**  
*Transition d block*

## A Groups

*p block*

						1s <sup>2</sup>
2p	2p <sup>1</sup>	2p <sup>2</sup>	2p <sup>3</sup>	2p <sup>4</sup>	2p <sup>5</sup>	2p <sup>6</sup>
3p	3p <sup>1</sup>	3p <sup>2</sup>	3p <sup>3</sup>	3p <sup>4</sup>	3p <sup>5</sup>	3p <sup>6</sup>
4p	4p <sup>1</sup>	4p <sup>2</sup>	4p <sup>3</sup>	4p <sup>4</sup>	4p <sup>5</sup>	4p <sup>6</sup>
5p	5p <sup>1</sup>	5p <sup>2</sup>	5p <sup>3</sup>	5p <sup>4</sup>	5p <sup>5</sup>	5p <sup>6</sup>
6p	6p <sup>1</sup>	6p <sup>2</sup>	6p <sup>3</sup>	6p <sup>4</sup>	6p <sup>5</sup>	6p <sup>6</sup>

nf<sup>1-14</sup>

5f													
6f													

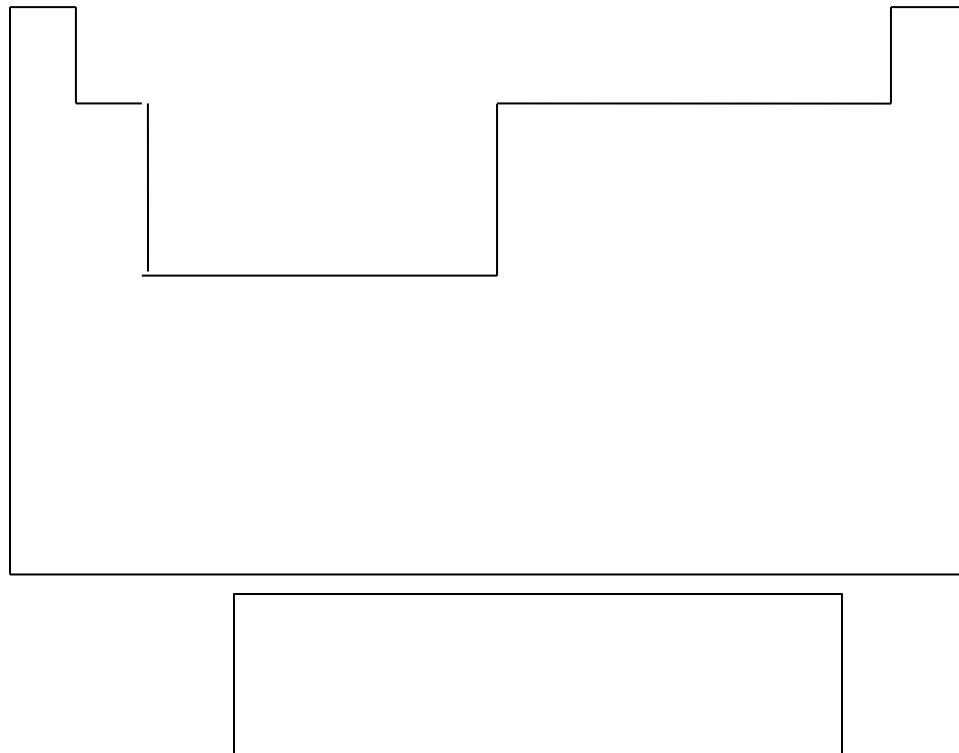
**B Groups – f block**

# Review of the Periodic Table

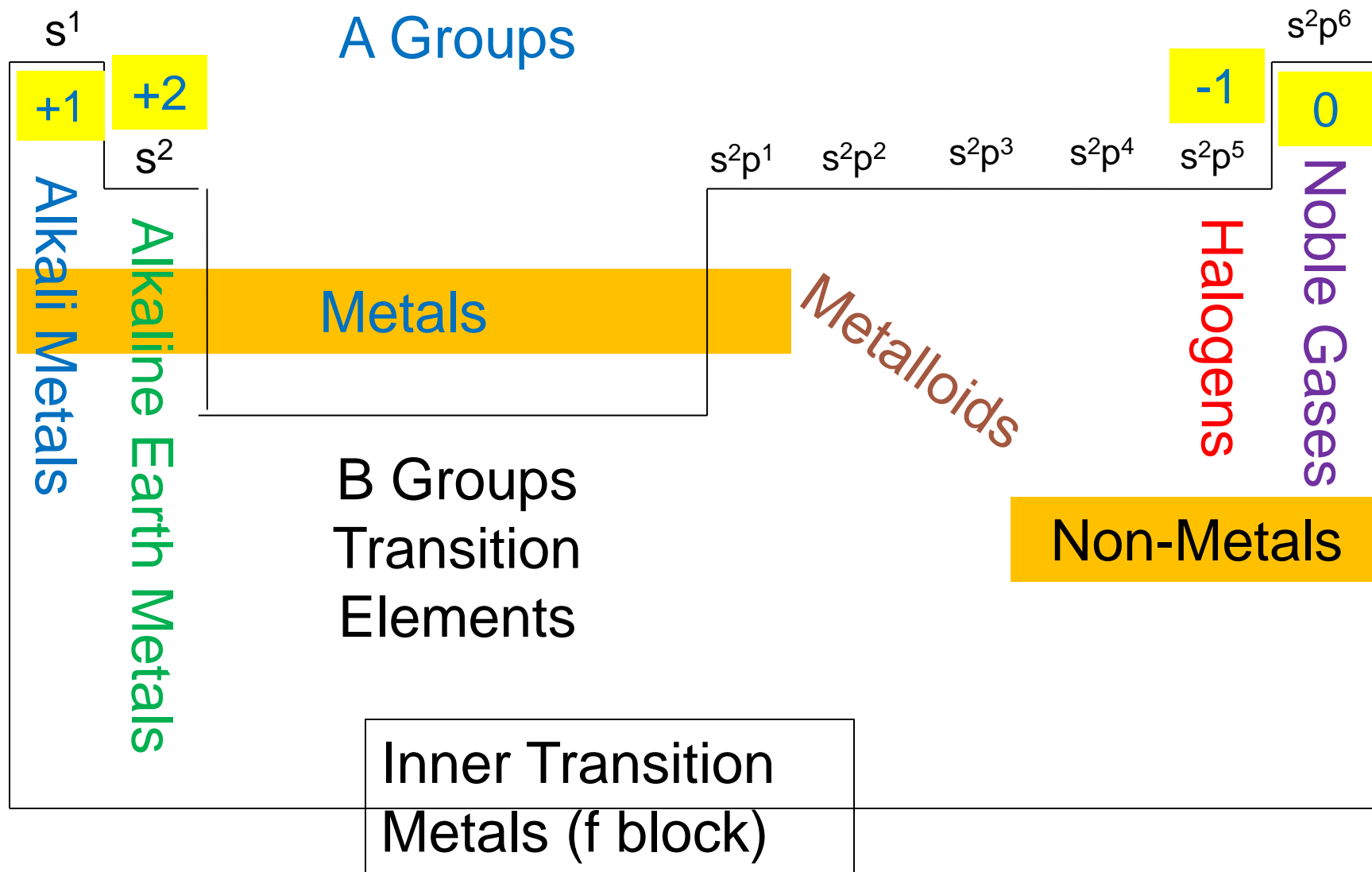
## Copy the Blank table and LABEL



- **A** Groups with valence electron configuration
- **B** Groups (transition elements, inner transition)
- Metals, non-metals, metalloids
- Alkali & Alkaline Earth Metals, Halogens, Noble Gases
- What ion would the major groups form?



# Review of the Periodic Table





## Periodic trends

Atomic and ionic radii

Ionization energy

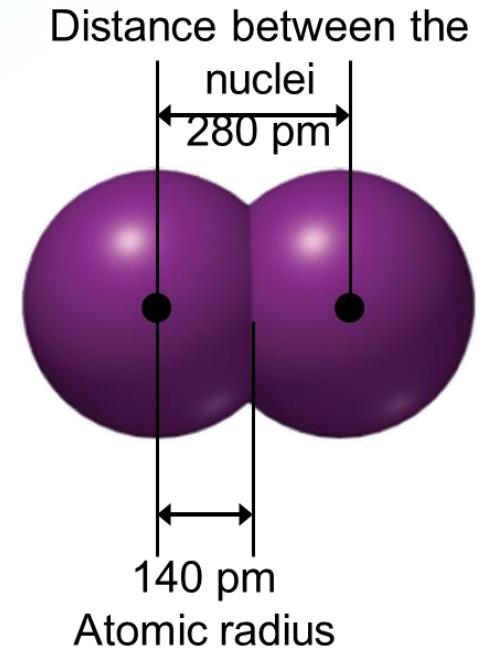
Electron affinity and electronegativity

What **trends** become apparent from the arrangement of electrons in the periodic table?

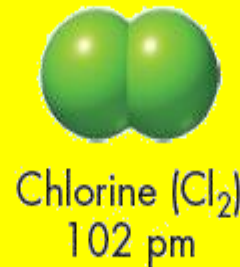
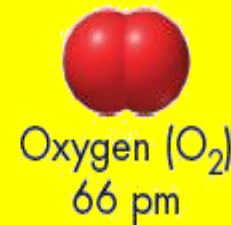
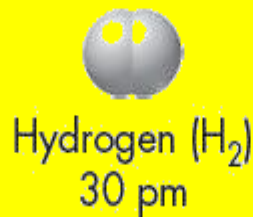
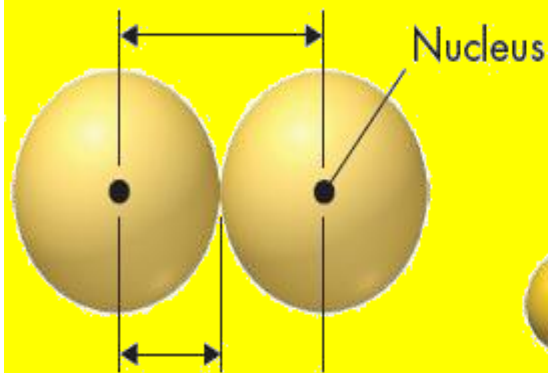


## Atomic Radii (Size)

This size is expressed as an atomic radius, and is one-half of the distance between the nuclei of two atoms of the same element when the atoms are joined. (picometers or  $10^{-12}$  m)



Distance between nuclei

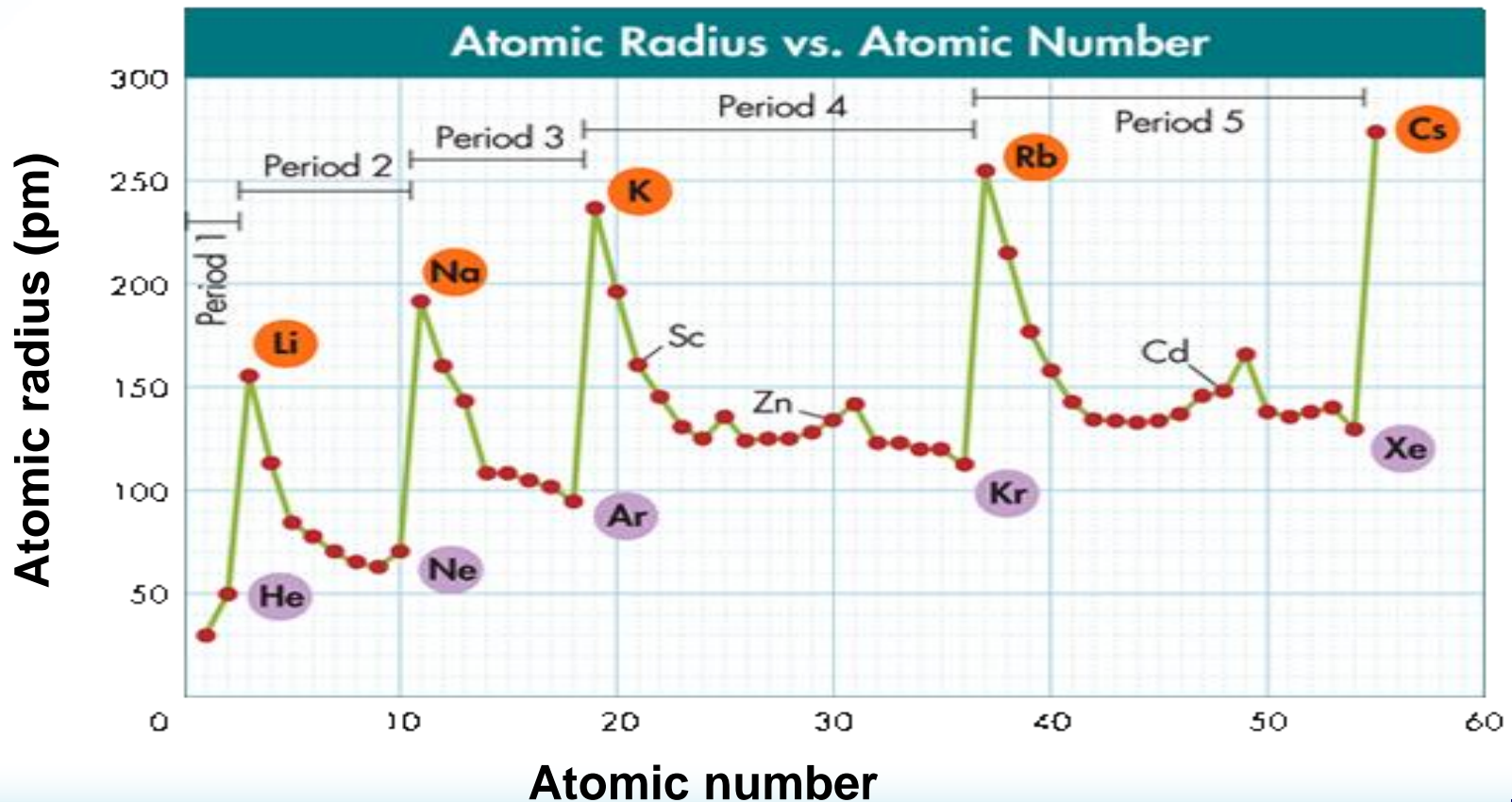




# Trends in Atomic Size

In general, atomic size

- decreases from left to right across a **period**.
- increases going down a **group**.



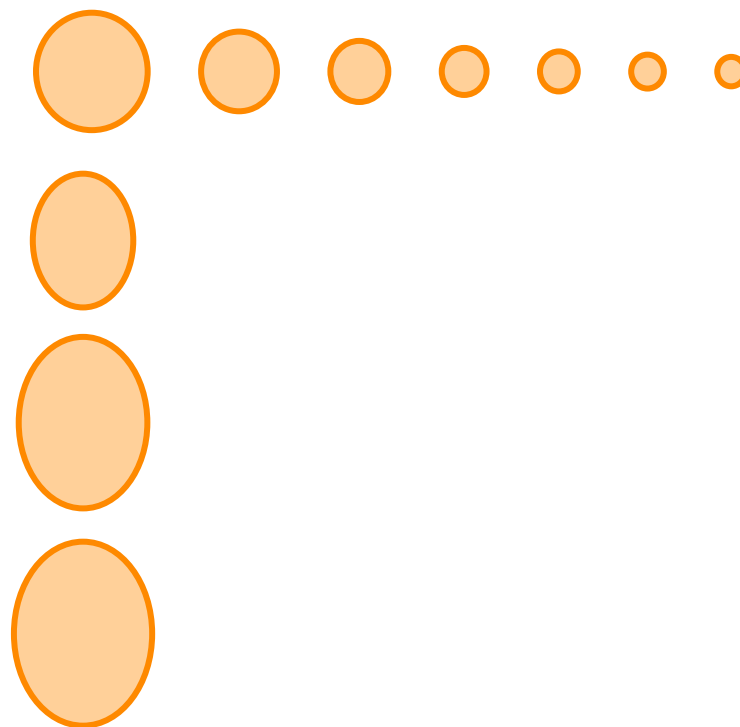
# Trends of Atomic Radii

Electrons are added:

- To the same energy level across a period (*stronger nuclear charge draws them in*).
  - E.g. using a larger magnet to pick up metals.
- To a higher energy level down a group (*the atom is much larger and electrons more energetic*).
  - E.g. placing the electrons in a bigger room to accommodate the larger atom.

Atomic radii tend to:

- Decrease across a period.
- Increase down a group.



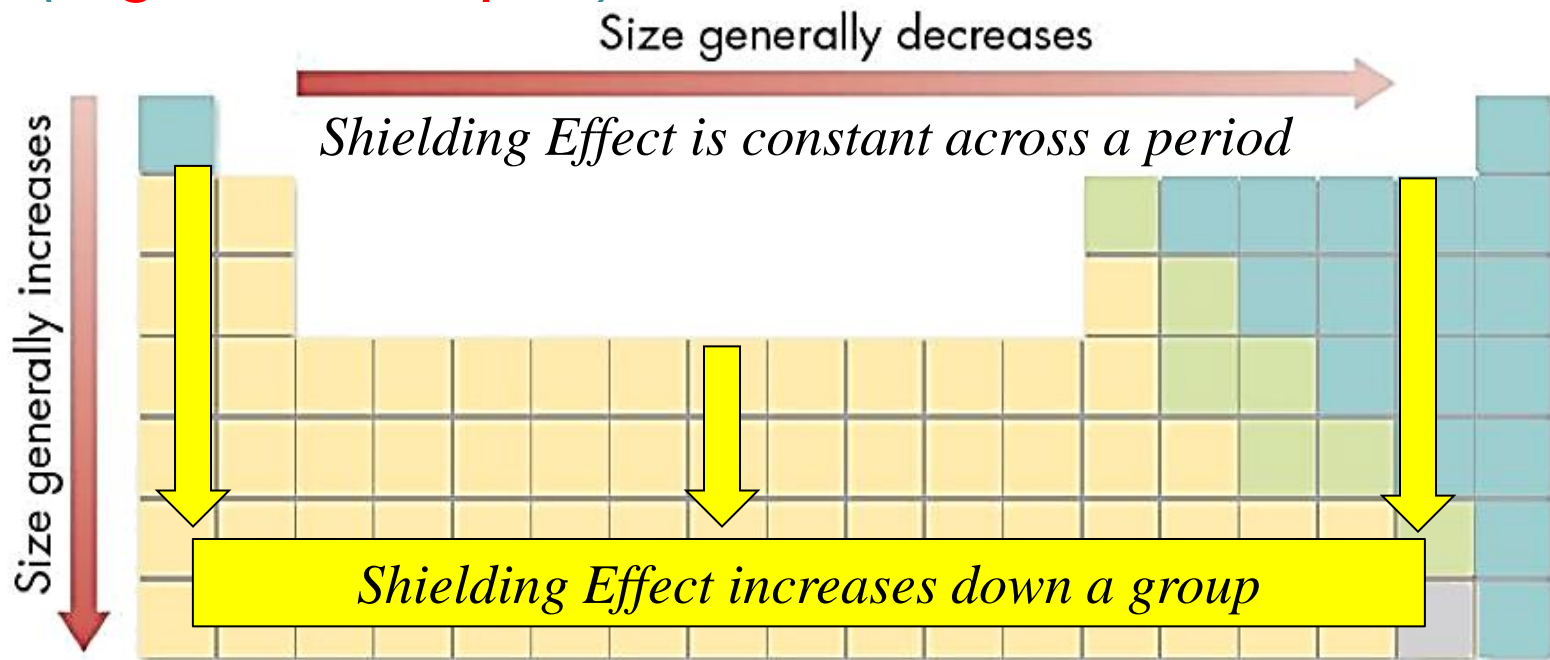
# 6.3 Periodic Trends

## Trends in Atomic Size



# The Shielding Effect

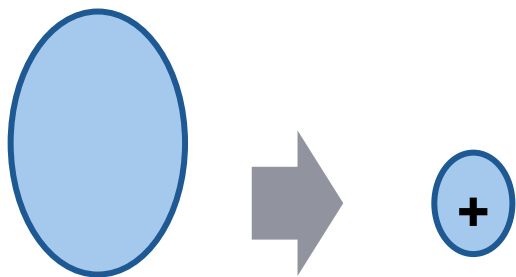
*The increase in the number of occupied orbitals **shields** electrons in the highest occupied energy level from the attraction of protons in the nucleus (e.g. solar eclipse).*



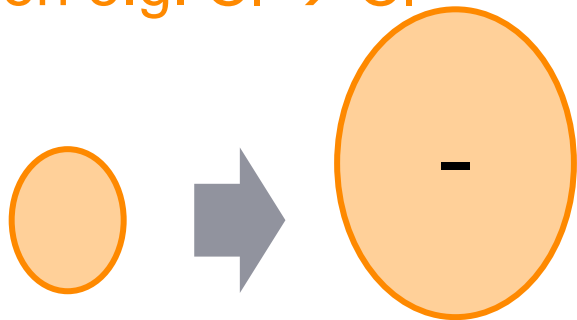
# Trends of **Ionic Radii**

**Ionic radius** is a measure of the size of an ion.

Cation e.g.  $\text{Na} \rightarrow \text{Na}^+$

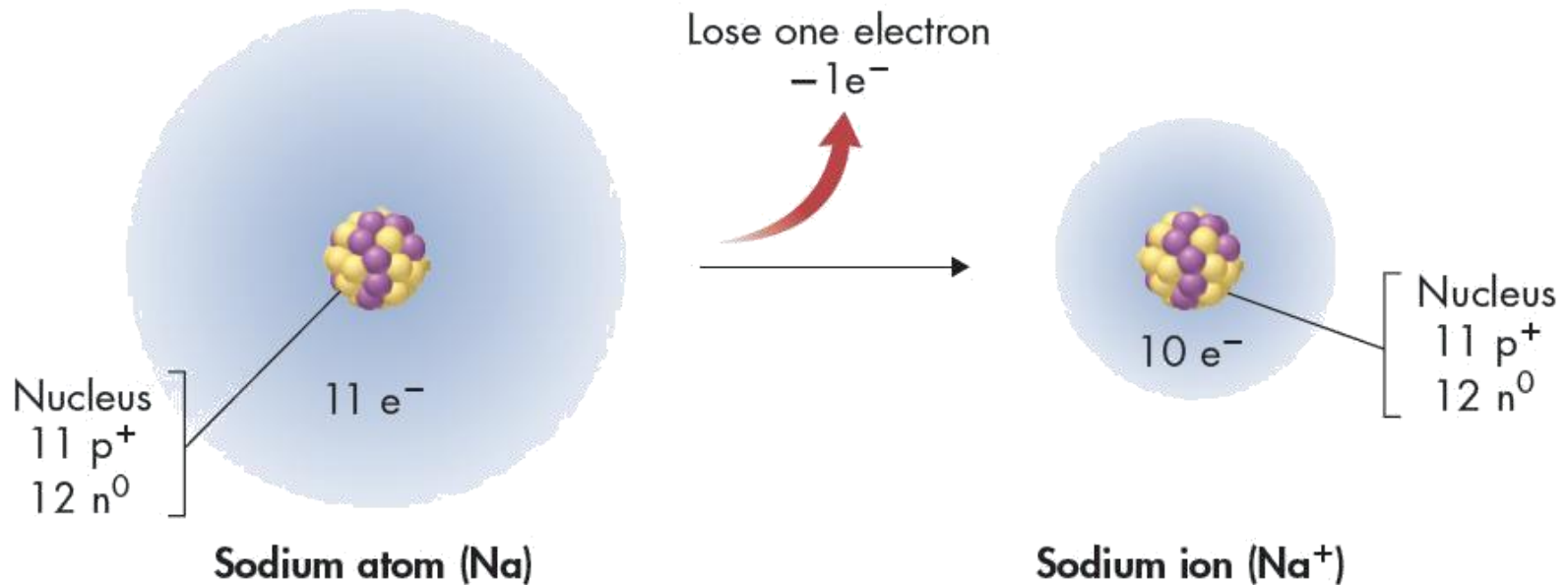


Anion e.g.  $\text{Cl} \rightarrow \text{Cl}^-$

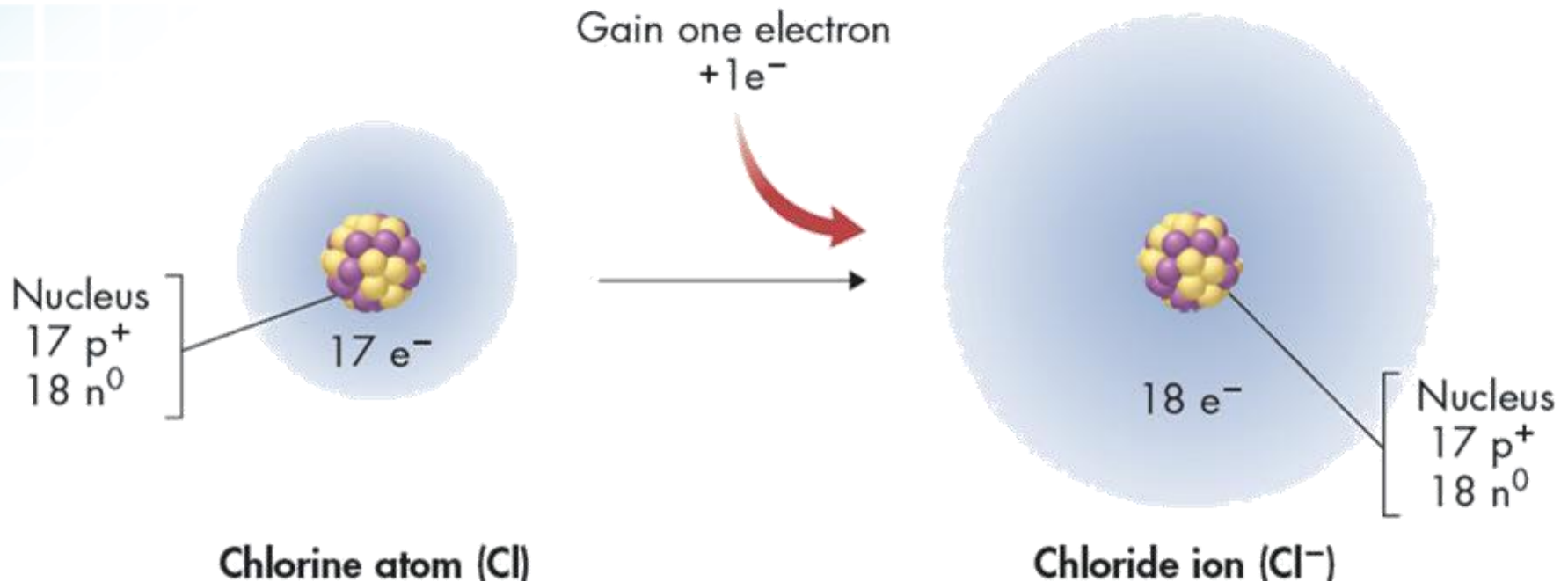


- **DECREASE** for cations across a period.
  - *Groups 1A – 3A elements lose electrons to become cations.*
- **INCREASE** for anions across a period.
  - *Groups 4A – 8A elements gain electrons to become anions.*
- **Increase down a group.**

Metals, such as Sodium lose electrons when bonding, **giving the sodium ion a net positive charge (11 protons - 10 electrons)**. The positive ion is called a **cation** and is written as  $\text{Na}^+$ . The **ionic size is SMALLER than the atomic size**.



Nonmetals, such as chlorine, *gain* electrons when bonding, producing an **anion** (negative ion): (+17 p – 18 e<sup>-</sup>). This is written: Cl<sup>-</sup>. The **ionic size is GREATER** than the atomic size.



*In general, metals tend to form cations. Nonmetals tend to form anions.*

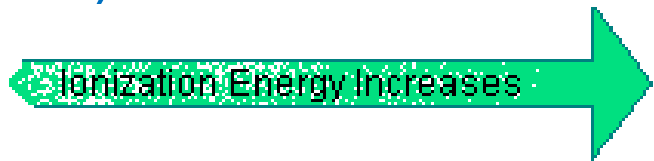
# Ionization Energy

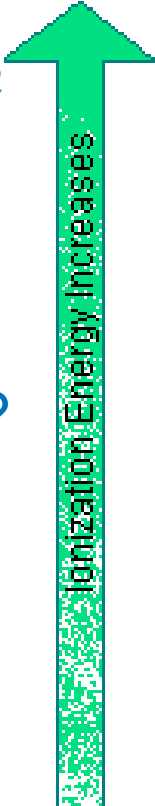
The energy required to remove an electron from an atom.

The **tendency to lose electrons** is evidence of **????** character (*to gain ideal electron configuration*).

*The energy required to remove the first electron from an atom is called the first ionization energy.*

Ionization energy **????** across a period & **????** down a group.

Ionization Energy Increases 

 Ionization Energy Increases

IA						VIIA		VIII A	
H						H	He		
1312.0	IIA					1312.0	2372.3		
Li	Be					F	Ne		
520.2	899.4					1681.0	2080.6		
Na	Mg					Cl	Ar		
495.8	737.7					1251.1	1520.5		
K	Ca					B	Kr		
418.8	589.8					1139.9	1360.7		
Rb	Sr					I	Xe		
403.0	549.5					1008.4	1170.4		
Cs	Ba					At	Rn		
375.7	508.1					--	1047.8		
Fr	Ra								
--	514.6								



# Ionization Energy

The energy required to remove an electron from an atom.

The **tendency to lose electrons** is evidence of **metallic** character (*to gain ideal electron configuration*).

*The energy required to remove the first electron from an atom is called the first ionization energy.*

Ionization energy increases across a period & decreases down a group.

IA						VIIA		VIII A	
H						H	He		
1312.0						1312.0	2372.3		
	IIA		IIIA	IVA	VA	VIA			
Li	Be	B	C	N	O	F	Ne		
520.2	899.4	800.6	1086.4	1420.3	1313.9	1681.0	2080.6		
Na	Mg	Al	Si	P	S	Cl	Ar		
495.8	737.7	577.6	786.4	1011.7	999.6	1251.1	1520.5		
K	Ca	Ga	Ge	As	Se	Br	Kr		
418.8	589.8	578.8	762.1	947	940.9	1139.9	1360.7		
Rb	Sr	In	Sn	Sb	Te	I	Xe		
403.0	549.5	558.3	708.6	833.7	869.2	1008.4	1170.4		
Cs	Ba	Tl	Pb	Bi	Po	At	Rn		
375.7	508.1	595.4	722.9	710.6	821	--	1047.8		
Fr	Ra								
--	514.6								

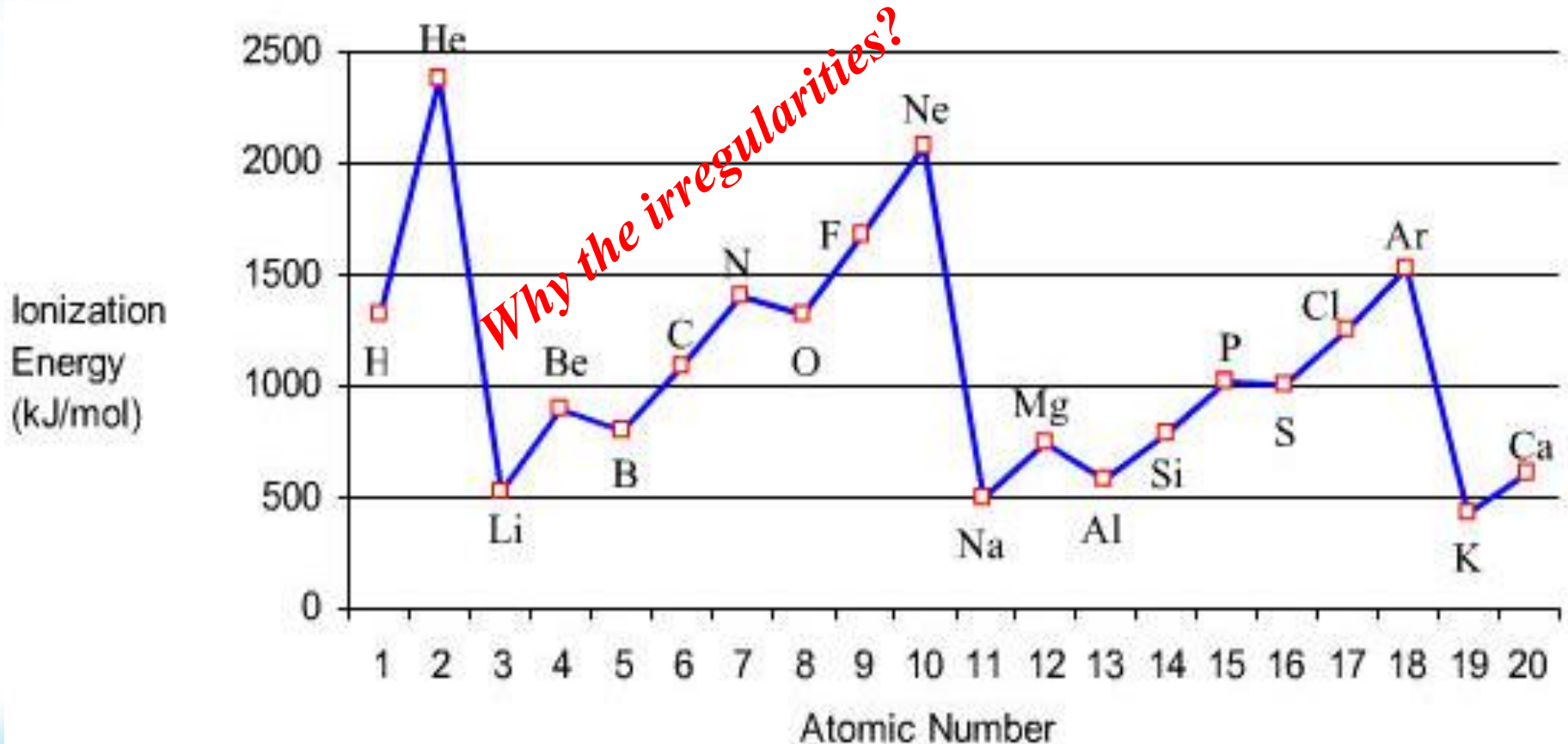
## 6.3 Periodic Trends

## Trends in Ionization Energy



Metals tend to lose/gain electrons, meaning it takes less/more energy (lower/higher I.E.)?

Non-metals tend to lose/gain electrons, meaning it would require less/more energy (lower/higher I.E.)?

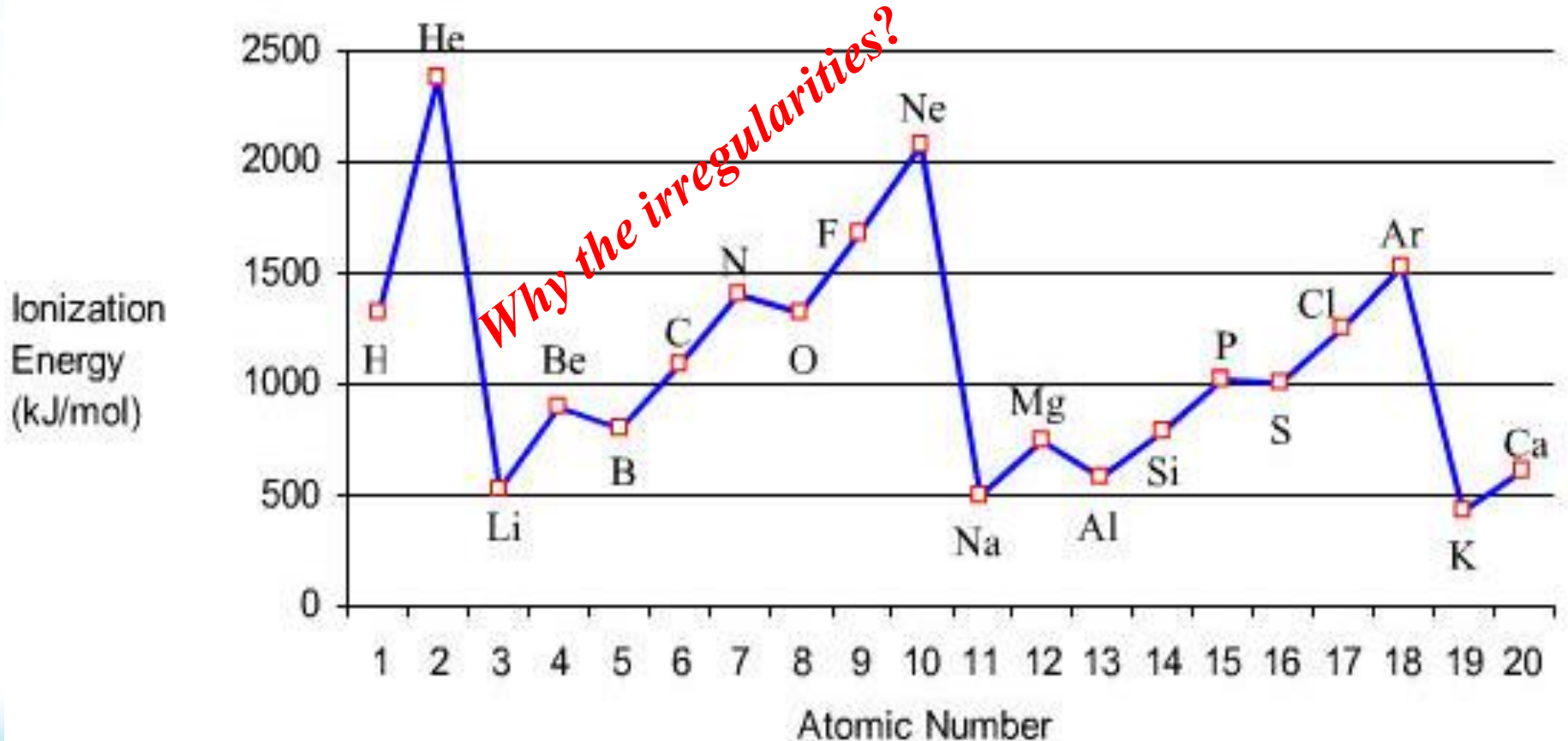


## 6.3 Periodic Trends

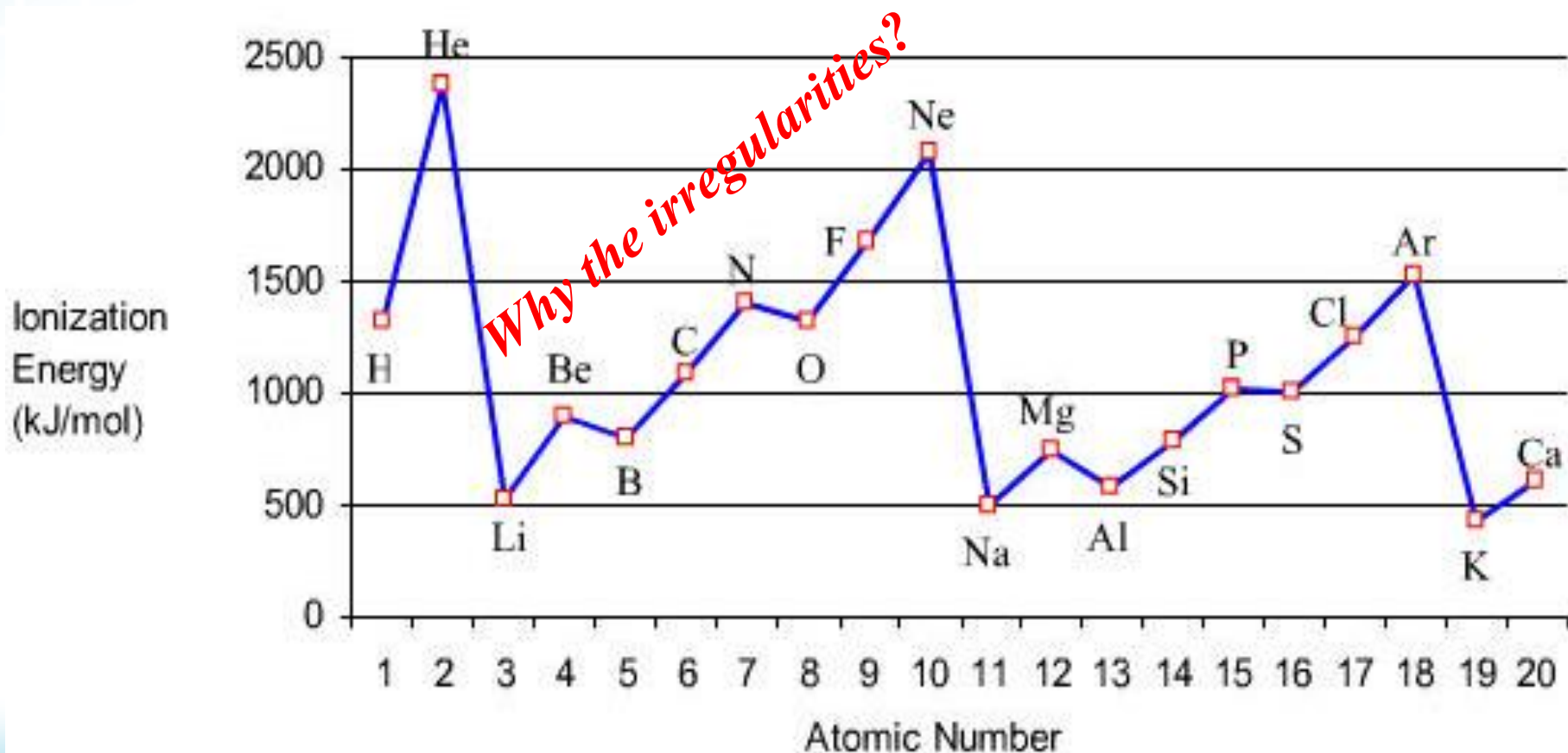
## Trends in Ionization Energy

Metals tend to lose electrons, meaning it takes LESS energy (lower I.E.)

Non-metals tend to gain electrons, meaning it would require MORE energy (higher I.E.)



The irregularities are produced when electrons **enter the “p” sublevel** (e.g. Be, Mg) and again when the electrons **fill the first “p” orbital** (Hund’s Rule) [e.t. N, P]

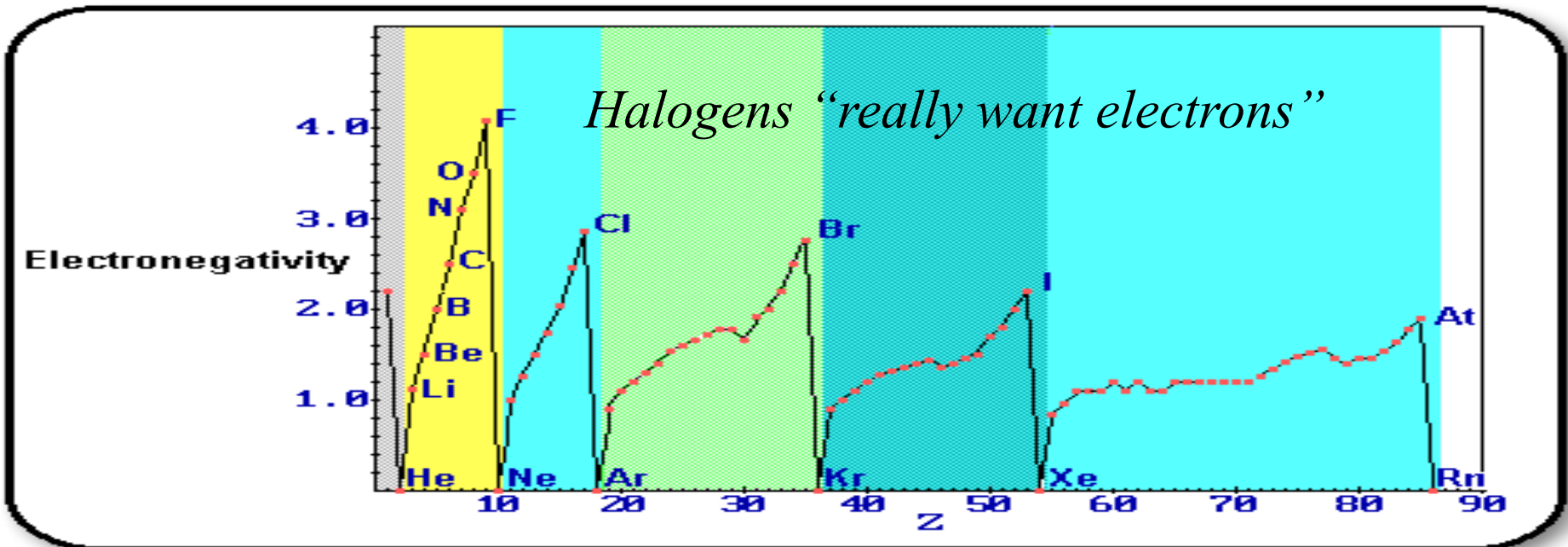


# Electronegativity

The measure of the **electron attracting power** (ELECTRON AFFINITY) of an atom when it bonds with another atom (*to gain ideal electron configuration*).

A property used to predict Bonding type during a reaction.

- Increase/decrease along a period or row?
- Increase/decrease down a group or family?

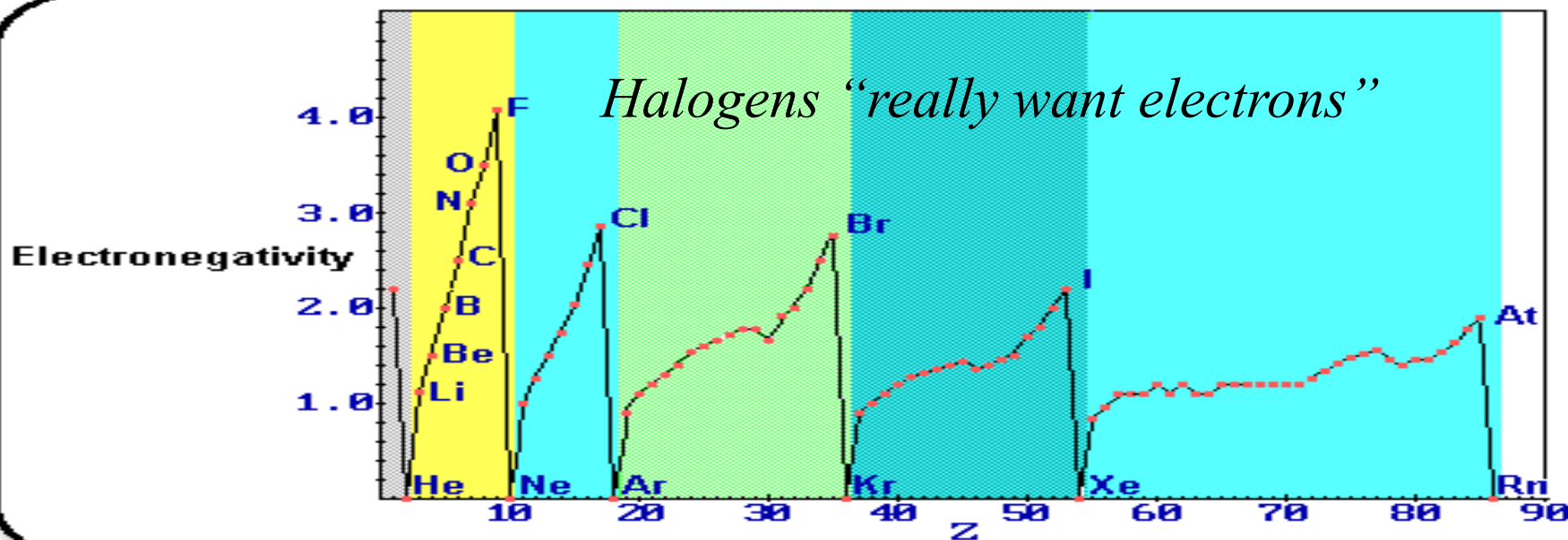


# Electronegativity

The measure of the **electron attracting power** (ELECTRON AFFINITY) of an atom when it bonds with another atom (*to gain ideal electron configuration*).

A property used to predict Bonding type during a reaction.

- **INCREASES** along a period or row.
- **DECREASES** down a group or family.



Describe metals in terms of electrons and electronegativity.

Describe non-metals in terms of electrons and electronegativity.



Electronegativity Values for Selected Elements

<b>H</b> 2.1						
<b>Li</b> 1.0	<b>Be</b> 1.5	<b>B</b> 2.0	<b>C</b> 2.5	<b>N</b> 3.0	<b>O</b> 3.5	<b>F</b> 4.0
<b>Na</b> 0.9	<b>Mg</b> 1.2	<b>Al</b> 1.5	<b>Si</b> 1.8	<b>P</b> 2.1	<b>S</b> 2.5	<b>Cl</b> 3.0
<b>K</b> 0.8	<b>Ca</b> 1.0	<b>Ga</b> 1.6	<b>Ge</b> 1.8	<b>As</b> 2.0	<b>Se</b> 2.4	<b>Br</b> 2.8
<b>Rb</b> 0.8	<b>Sr</b> 1.0	<b>In</b> 1.7	<b>Sn</b> 1.8	<b>Sb</b> 1.9	<b>Te</b> 2.1	<b>I</b> 2.5
<b>Cs</b> 0.7	<b>Ba</b> 0.9	<b>Tl</b> 1.8	<b>Pb</b> 1.9	<b>Bi</b> 1.9		

Metals do not “gain” electrons, meaning LESS electronegativity.

Non-metals DO gain electrons, meaning MORE electronegativity.



Electronegativity Values for Selected Elements

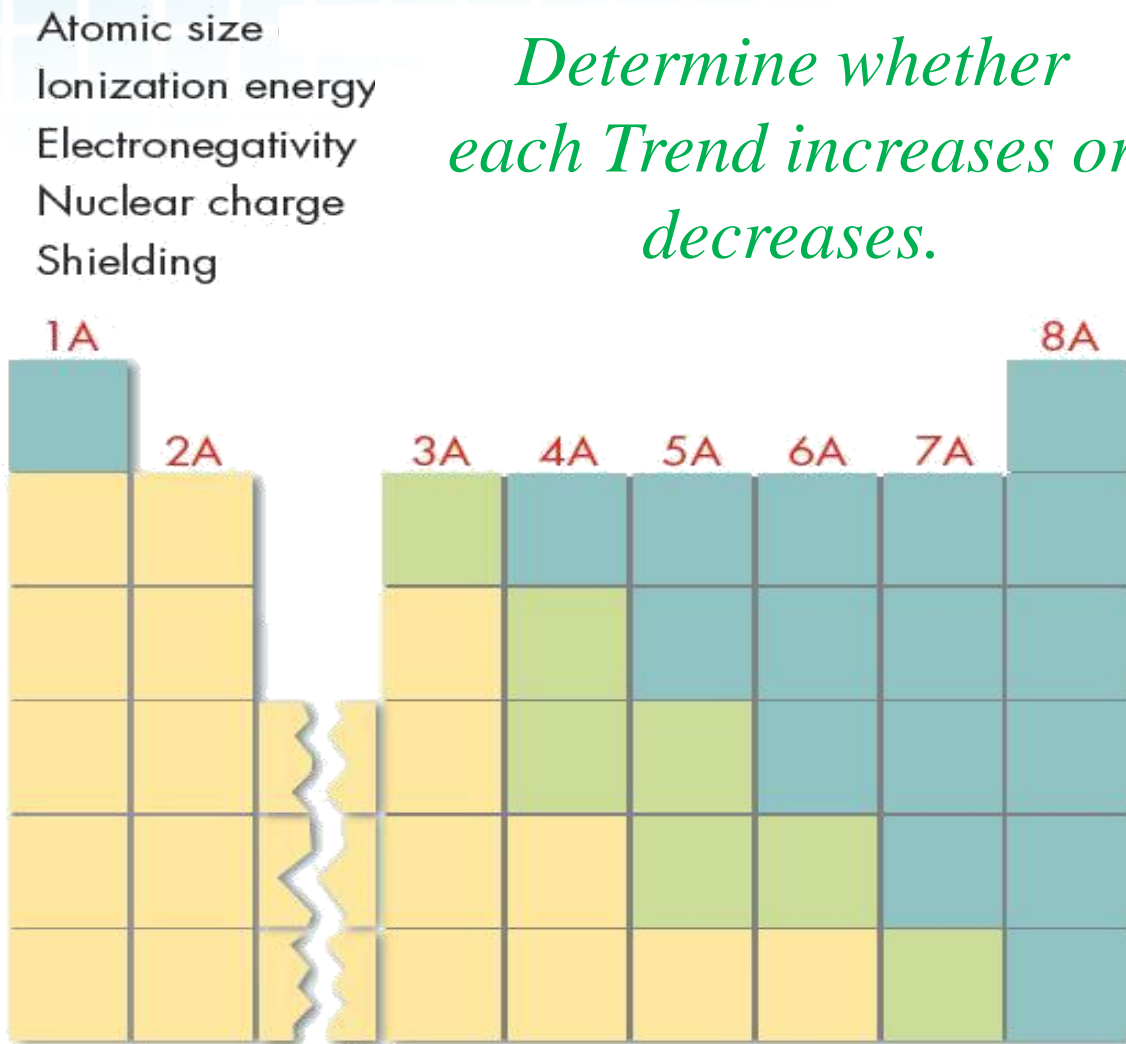
<b>H</b> 2.1						
<b>Li</b> 1.0	<b>Be</b> 1.5	<b>B</b> 2.0	<b>C</b> 2.5	<b>N</b> 3.0	<b>O</b> 3.5	<b>F</b> 4.0
<b>Na</b> 0.9	<b>Mg</b> 1.2	<b>Al</b> 1.5	<b>Si</b> 1.8	<b>P</b> 2.1	<b>S</b> 2.5	<b>Cl</b> 3.0
<b>K</b> 0.8	<b>Ca</b> 1.0	<b>Ga</b> 1.6	<b>Ge</b> 1.8	<b>As</b> 2.0	<b>Se</b> 2.4	<b>Br</b> 2.8
<b>Rb</b> 0.8	<b>Sr</b> 1.0	<b>In</b> 1.7	<b>Sn</b> 1.8	<b>Sb</b> 1.9	<b>Te</b> 2.1	<b>I</b> 2.5
<b>Cs</b> 0.7	<b>Ba</b> 0.9	<b>Tl</b> 1.8	<b>Pb</b> 1.9	<b>Bi</b> 1.9		





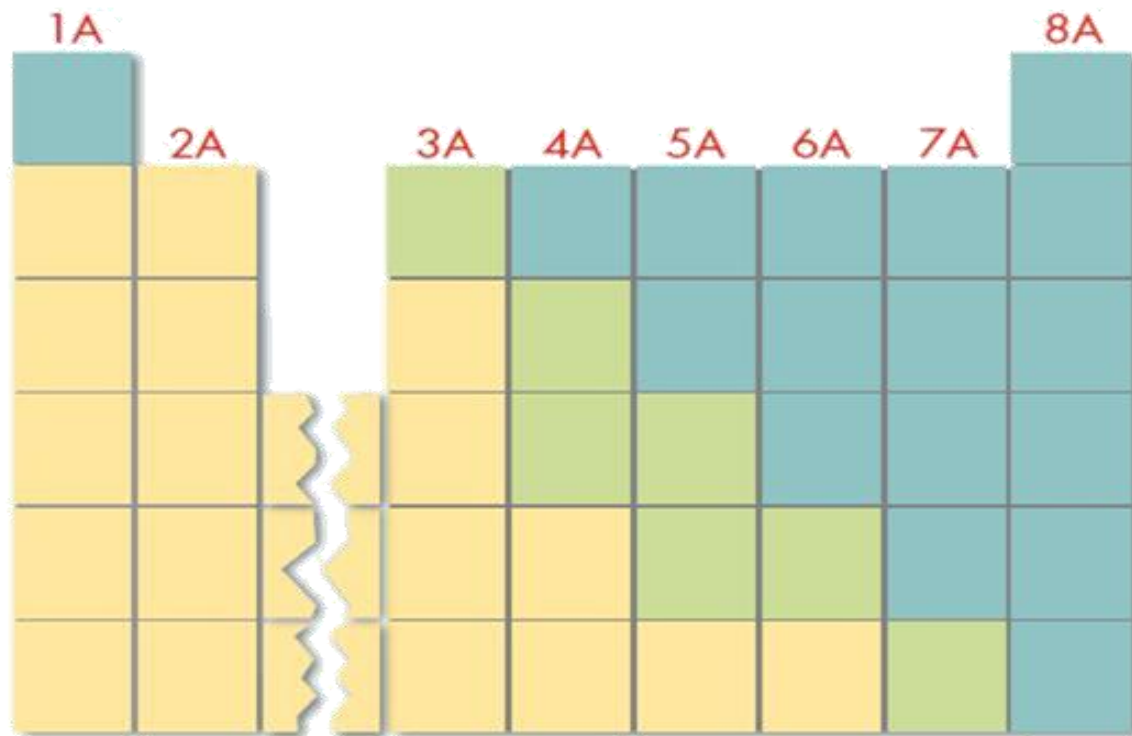
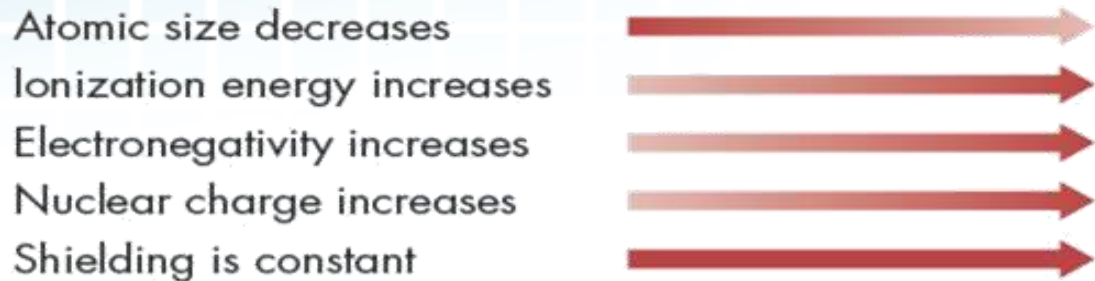
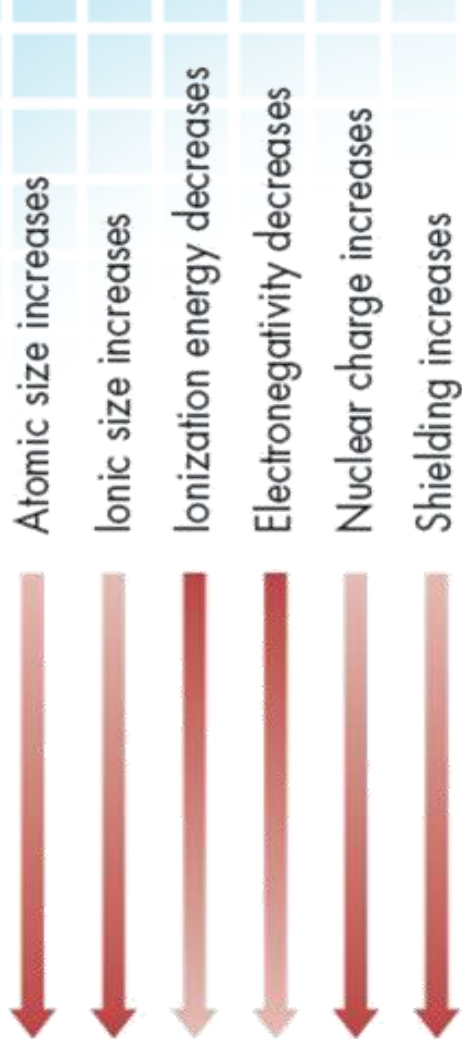
*Determine whether each Trend increases or decreases.*

Atomic size  
 Ionic size  
 Ionization energy  
 Electronegativity  
 Nuclear charge  
 Shielding



*... going across a period →*

*... going down a group ↓*



# The Arrangement of the Periodic Table



The periodic table contains a great deal of information on the elements.

- *Periods* refer to horizontal rows of the periodic table.
- *Groups* or *families* refer to vertical columns of the periodic table.
- Cells of the periodic table contain information such as the atomic symbol, atomic number, atomic mass, name of the element, electron configuration, and possible oxidation numbers.
- Elements can be categorized broadly as metals, nonmetals, or semimetals (metalloids).

# Classifying the Elements



## Groups

- Alkali metals: most reactive metals, soft, oxidize quickly.
- Alkaline earth metals: not as reactive as alkali metals, brittle, shiny.
- Transition metals: form colored compounds, good conductors of electricity.
- Halogens: most reactive nonmetals.
- Noble gases: lowest chemical reactivity, used in lighting.
- Inner transition metals: radioactive, used in nuclear power plants.

Period	s-block	
	1 IA	
1	1.00794 <b>H</b> 1 1s <sup>1</sup>	+1 -1

**KEY**

Atomic Mass → 12.0111

Symbol → **C**

Atomic Number → 6

Electron Configuration → 1s<sup>2</sup>2s<sup>2</sup>2p<sup>2</sup>

Selected Oxidation States → -4, +2, +4

Relative atomic masses are based on <sup>12</sup>C = 12.00000

s-block  
**GROUP**

1 IA      2 IIA

New Designation

Former Designation (prior to 1984 IUPAC decision)

2	6.941 <b>Li</b> 3 1s <sup>2</sup> 2s <sup>1</sup>	9.01218 <b>Be</b> 4 1s <sup>2</sup> 2s <sup>2</sup>										
3	22.98977 <b>Na</b> 11 [Ne]3s <sup>1</sup>	24.305 <b>Mg</b> 12 [Ne]3s <sup>2</sup>	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII		9	10	
4	39.0983 <b>K</b> 19 [Ar]4s <sup>1</sup>	40.08 <b>Ca</b> 20 [Ar]4s <sup>2</sup>	44.9559 <b>Sc</b> 21 [Ar]3d <sup>1</sup> 4s <sup>2</sup>	47.88 <b>Ti</b> 22 [Ar]3d <sup>2</sup> 4s <sup>2</sup>	50.9415 <b>V</b> 23 [Ar]3d <sup>3</sup> 4s <sup>2</sup>	51.996 <b>Cr</b> 24 [Ar]3d <sup>5</sup> 4s <sup>1</sup>	54.9380 <b>Mn</b> 25 [Ar]3d <sup>5</sup> 4s <sup>2</sup>	55.847 <b>Fe</b> 26 [Ar]3d <sup>6</sup> 4s <sup>2</sup>	58.9332 <b>Co</b> 27 [Ar]3d <sup>7</sup> 4s <sup>2</sup>	58.69 <b>Ni</b> 28 [Ar]3d <sup>8</sup> 4s <sup>2</sup>	63.546 <b>Cu</b> 29 [Ar]3d <sup>10</sup> 4s <sup>1</sup>	
5	85.4678 <b>Rb</b> 37 [Kr]5s <sup>1</sup>	87.62 <b>Sr</b> 38 [Kr]5s <sup>2</sup>	88.9059 <b>Y</b> 39 [Kr]4d <sup>1</sup> 5s <sup>2</sup>	91.224 <b>Zr</b> 40 [Kr]4d <sup>2</sup> 5s <sup>2</sup>	92.9064 <b>Nb</b> 41 [Kr]4d <sup>4</sup> 5s <sup>1</sup>	95.94 <b>Mo</b> 42 [Kr]4d <sup>5</sup> 5s <sup>1</sup>	(98) <b>Tc</b> 43 [Kr]4d <sup>5</sup> 5s <sup>1</sup>	101.07 <b>Ru</b> 44 [Kr]4d <sup>7</sup> 5s <sup>1</sup>	102.906 <b>Rh</b> 45 [Kr]4d <sup>8</sup> 5s <sup>1</sup>	106.42 <b>Pd</b> 46 [Kr]4d <sup>10</sup> 5s <sup>0</sup>	107.86 <b>Ag</b> 47 [Kr]4d <sup>10</sup> 5s <sup>1</sup>	
6	132.905 <b>Cs</b> 55 [Xe]6s <sup>1</sup>	137.33 <b>Ba</b> 56 [Xe]6s <sup>2</sup>	La-Lu 57 71		178.49 <b>Hf</b> 72 [Xe]4f <sup>14</sup> 5d <sup>2</sup> 6s <sup>2</sup>	180.948 <b>Ta</b> 73 [Xe]4f <sup>14</sup> 5d <sup>3</sup> 6s <sup>2</sup>	183.85 <b>W</b> 74 [Xe]4f <sup>14</sup> 5d <sup>4</sup> 6s <sup>2</sup>	186.207 <b>Re</b> 75 [Xe]4f <sup>14</sup> 5d <sup>5</sup> 6s <sup>2</sup>	190.2 <b>Os</b> 76 [Xe]4f <sup>14</sup> 5d <sup>6</sup> 6s <sup>2</sup>	192.22 <b>Ir</b> 77 [Xe]4f <sup>14</sup> 5d <sup>7</sup> 6s <sup>2</sup>	195.08 <b>Pt</b> 78 [Xe]4f <sup>14</sup> 5d <sup>9</sup> 6s <sup>1</sup>	196.96 <b>Au</b> 79 [Xe]4f <sup>14</sup> 5d <sup>10</sup> 6s <sup>1</sup>
7	(223) <b>Fr</b> 87 [Rn]7s <sup>1</sup>	226.025 <b>Ra</b> 88 [Rn]7s <sup>2</sup>	Ac-Lr 89 103		(261) <b>Unq*</b> 104	(262) <b>Unp</b> 105	(263) <b>Unh</b> 106	(262) <b>Uns</b> 107	<b>Uno</b> 108	<b>Une</b> 109	* The sys 103 wil	

d-block

Transition Elements

**GROUP**

\* The sys  
103 wil

masses are  
2.00000

s-block  
18  
0

ation States

4.00260	0
<b>He</b>	
2	
$1s^2$	

p-block  
**GROUP**

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

# IONIZATION ENERGIES AND ELECTRONEGATIVITIES

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

# Polyatomic Ions

Name	Formula	Name	Formula
perPhosphate	$(\text{PO}_5)^{-3}$	perCarbonate	$(\text{CO}_4)^{-2}$
<b>Phosphate</b>	$(\text{PO}_4)^{-3}$	<b>Carbonate</b>	$(\text{CO}_3)^{-2}$
Phosphite	$(\text{PO}_3)^{-3}$	Carbonite	$(\text{CO}_2)^{-2}$
hypoPhosphite	$(\text{PO}_2)^{-3}$	hypocarbonite	$(\text{CO})^{-2}$
perChlorate	$(\text{ClO}_4)^{-1}$	perNitrate	$(\text{NO}_4)^{-}$
<b>Chlorate</b>	$(\text{ClO}_3)^{-1}$	<b>Nitrate</b>	$(\text{NO}_3)^{-}$
Chlorite	$(\text{ClO}_2)^{-1}$	Nitrite	$(\text{NO}_2)^{-}$
hypoChlorite	$(\text{ClO})^{-1}$	Hyponitrite	$(\text{NO})^{-}$
perSulfate	$(\text{SO}_5)^{-2}$	perChromate	$(\text{CrO}_5)^{-2}$
<b>Sulfate</b>	$(\text{SO}_4)^{-2}$	<b>Chromate</b>	$(\text{CrO}_4)^{-2}$
Sulfite	$(\text{SO}_3)^{-2}$	Chromite	$(\text{CrO}_3)^{-2}$
hyposulfite	$(\text{SO}_2)^{-2}$	Hypochromite	$(\text{CrO}_2)^{-2}$
<b>Acetate</b>	$(\text{C}_2\text{H}_3\text{O}_2)^{-1}$	<b>Cyanide</b>	$(\text{CN})^{-1}$
<b>Hydroxide</b>	$(\text{OH})^{-1}$	<b>Manganate</b>	$(\text{MnO}_4)^{-2}$

<b>Ammonium</b> $(\text{NH}_4)^{+1}$
---