# Periodic table of elements

# Periodic Table

- The periodic table organizes the elements in a particular way. A great deal of information about an element can be gathered from its position in the period table.
- For example, you can predict with reasonably good accuracy the physical and chemical properties of the element. You can also predict what other elements a particular element will react with chemically.
- Understanding the organization and plan of the periodic table will help you obtain basic information about each of the 118 known elements.

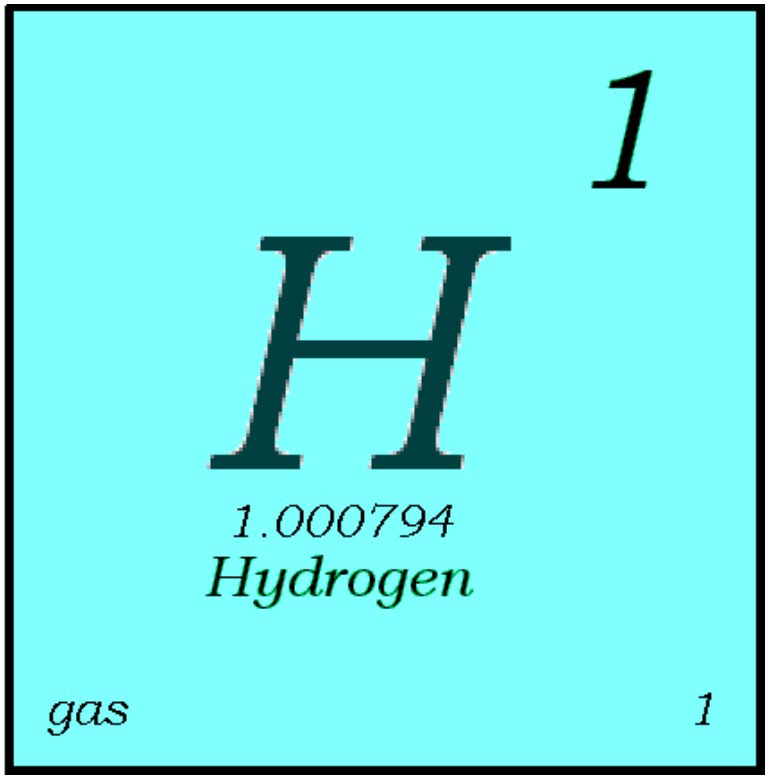
# Dmitri Mendeleev (1869)

In 1869 Mendeleev and Lothar Meyer (Germany) published nearly identical classification schemes for elements known to date. The periodic table is based on the similarity of properties and reactivities exhibited by certain elements. Later, Henri Moseley ( England, 1887-1915) established that each elements has a unique atomic number, which is how the current periodic table is organized.

| Row | Group I — $R_2O$ | Group II — RO | Group III — $R_2O_3$ | Group IV $RH_4$ $RO_2$ | Group V $RH_3$ $R_2O_5$ | Group VI $RH_2$ $RO_3$ | Group VII RH $R_2O_7$ | Group 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 | I = 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.

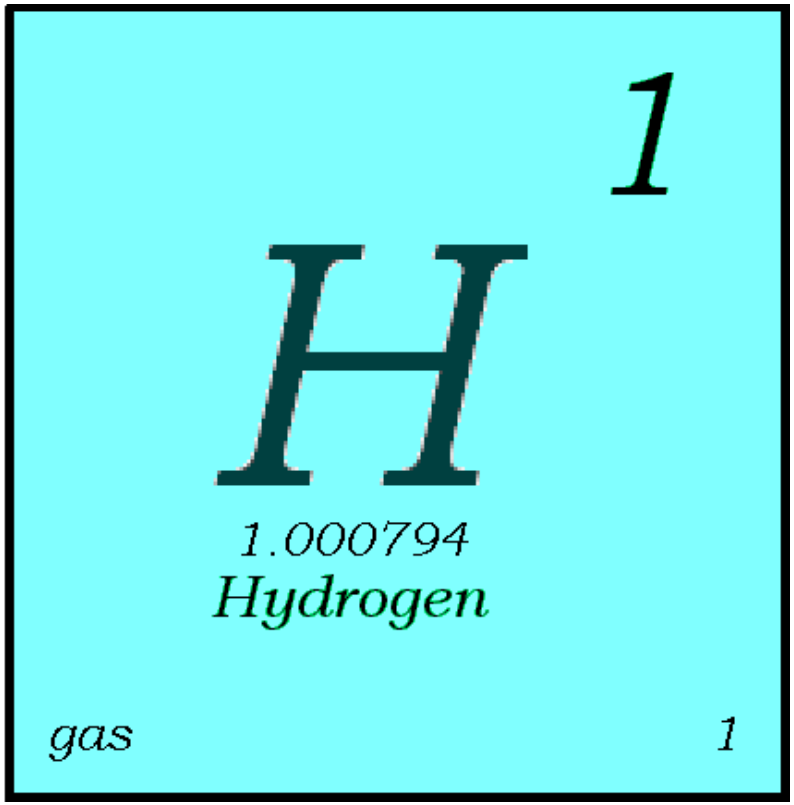
# Key to the Periodic Table




- Elements are organized on the table according to their atomic number, usually found near the top of the square.
  - The atomic number refers to how many protons an atom of that element has.
  - For instance, hydrogen has 1 proton, so it's atomic number is 1.
  - The atomic number is unique to that element. No two elements have the same atomic number.

# What's in a square?

- Different periodic tables can include various bits of information, but usually:
  - atomic number
  - symbol
  - atomic mass
  - number of valence electrons
  - state of matter at room temperature.



# The Periodic Table

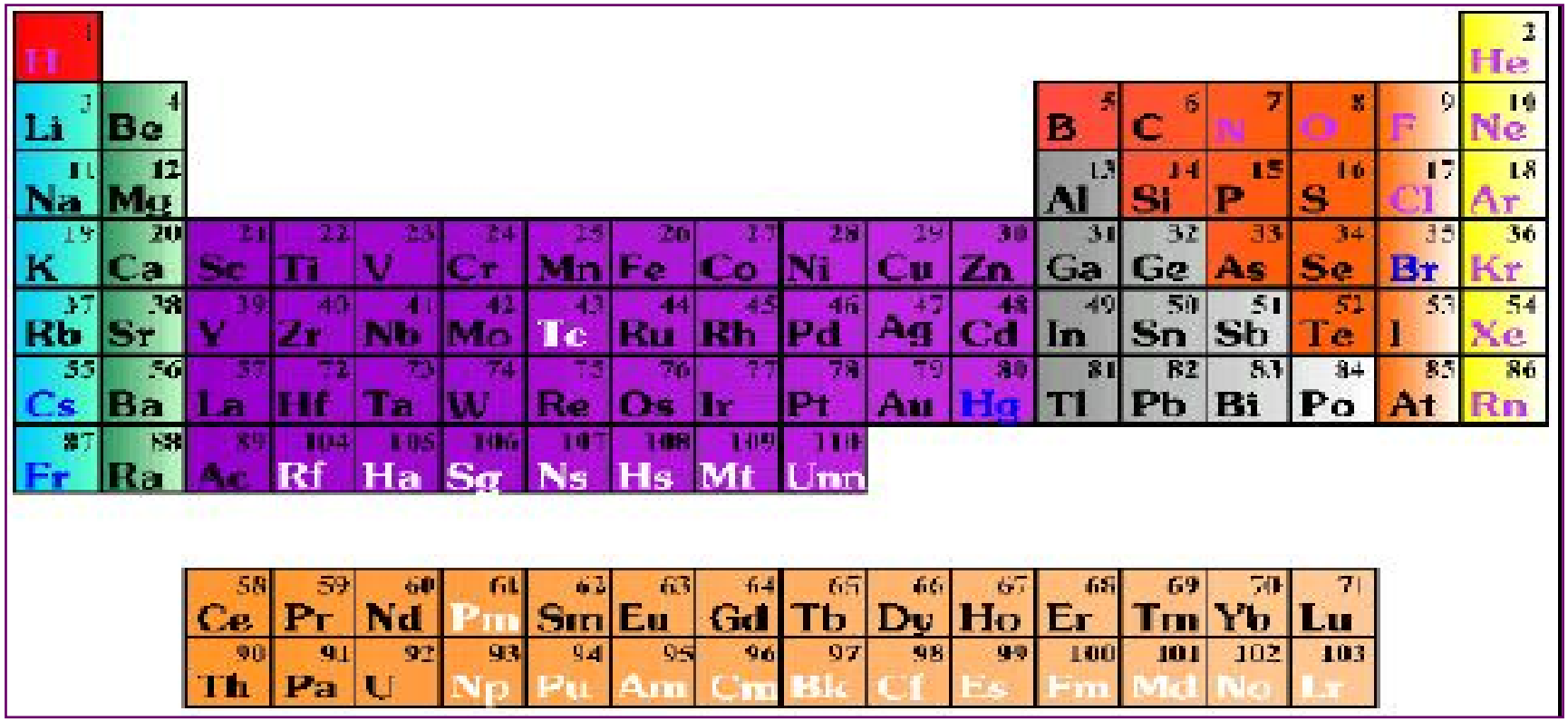
- A map of the building block of matter.

## Periodic Table

| | 1 IA | 2 IIA | 3 IIIB | 4 IVB | 5 VB | 6 VIB | 7 VIIB | 8 | 9 VIIIB | 10 | 11 IB | 12 IIB | 13 IIIA | 14 IVA | 15 VA | 16 VIA | 17 VIIA | 18 VIIIA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 **H** 1.00797 | | | | | | | | | | | | | | | | | 2 **He** 4.0026 |
| 2 | 3 **Li** 6.939 | 4 **Be** 9.0122 | | | | | | | | | | | 5 **B** 10.811 | 6 **C** 12.0112 | 7 **N** 14.0067 | 8 **O** 15.9994 | 9 **F** 18.9984 | 10 **Ne** 20.179 |
| 3 | 11 **Na** 22.9898 | 12 **Mg** 24.305 | | | | | | | | | | | 13 **Al** 26.9815 | 14 **Si** 28.086 | 15 **P** 30.9738 | 16 **S** 32.064 | 17 **Cl** 35.453 | 18 **Ar** 39.948 |
| 4 | 19 **K** 39.102 | 20 **Ca** 40.08 | 21 **Sc** 44.956 | 22 **Ti** 47.90 | 23 **V** 50.942 | 24 **Cr** 51.996 | 25 **Mn** 54.9380 | 26 **Fe** 55.847 | 27 **Co** 58.9332 | 28 **Ni** 58.71 | 29 **Cu** 63.54 | 30 **Zn** 65.37 | 31 **Ga** 65.37 | 32 **Ge** 72.59 | 33 **As** 74.9216 | 34 **Se** 78.96 | 35 **Br** 79.909 | 36 **Kr** 83.80 |
| 5 | 37 **Rb** 85.47 | 38 **Sr** 87.62 | 39 **Y** 88.905 | 40 **Zr** 91.22 | 41 **Nb** 92.906 | 42 **Mo** 95.94 | 43 **Tc** [99] | 44 **Ru** 101.07 | 45 **Rh** 102.905 | 46 **Pd** 106.4 | 47 **Ag** 107.870 | 48 **Cd** 112.40 | 49 **In** 114.82 | 50 **Sn** 118.69 | 51 **Sb** 121.75 | 52 **Te** 127.60 | 53 **I** 126.904 | 54 **Xe** 131.30 |
| 6 | 55 **Cs** 132.905 | 56 **Ba** 137.34 | 57 **La** 138.91 | 72 **Hf** 178.49 | 73 **Ta** 180.948 | 74 **W** 183.85 | 75 **Re** 186.2 | 76 **Os** 190.2 | 77 **Ir** 192.2 | 78 **Pt** 195.09 | 79 **Au** 196.967 | 80 **Hg** 200.59 | 81 **Tl** 204.37 | 82 **Pb** 207.19 | 83 **Bi** 208.980 | 84 **Po** [210] | 85 **At** [210] | 86 **Rn** [222] |
| 7 | 87 **Fr** [223] | 88 **Ra** [226] | 89 **Ac** [227] | 104 **Ku** [260] | 105 | 106 | 107 | 108 | 109 | | | | | | | | | |

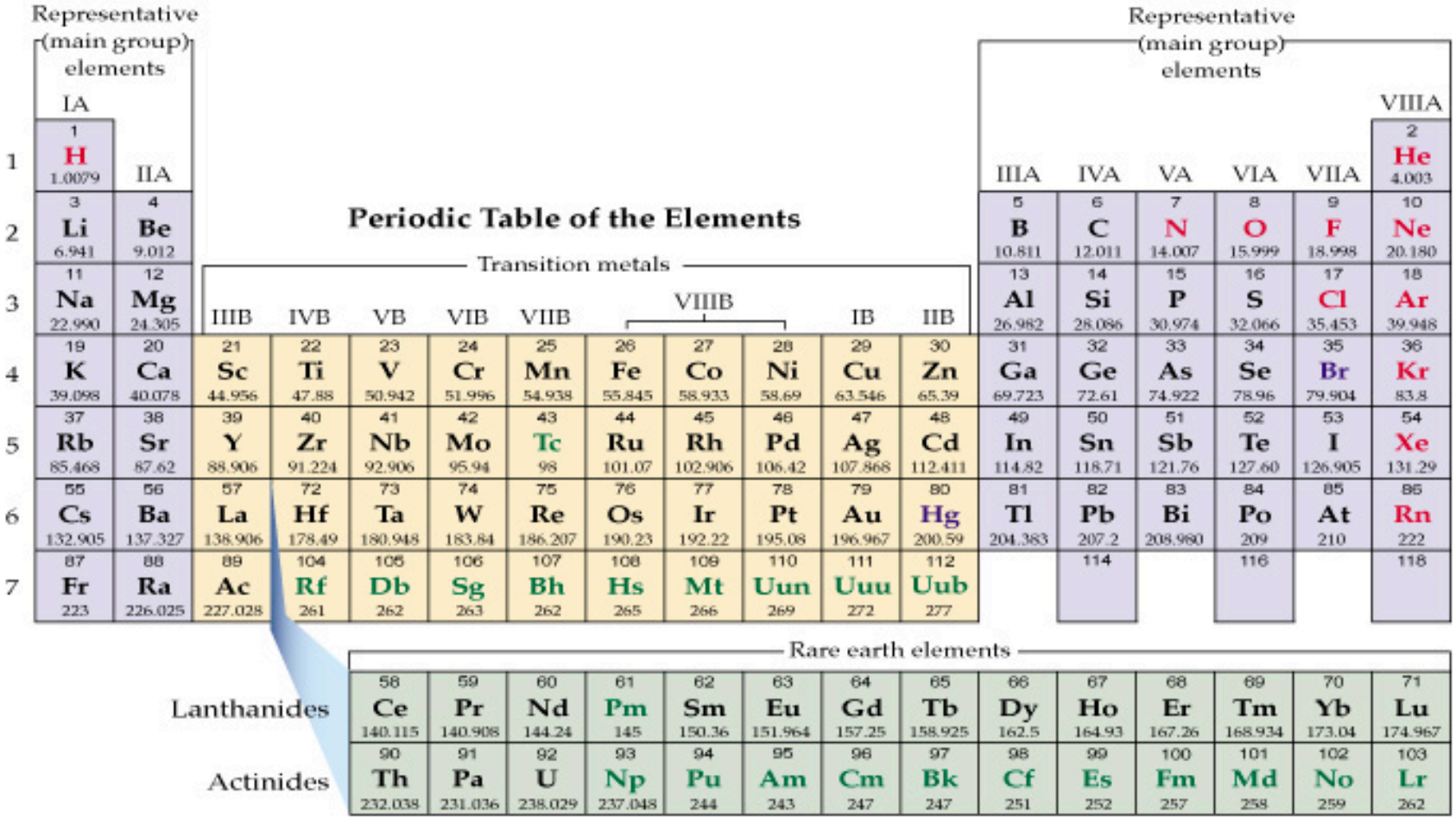
# Periodic Table Expanded View

- The way the periodic table usually seen is a compress view, placing the Lanthanides and actinides at the bottom of the stable.
- The Periodic Table can be arrange by subshells. The s-block is Group IA and IIA, the p-block is Group IIIA - VIIIA. The d-block is the transition metals, and the f-block are the Lanthanides and Actinide metals



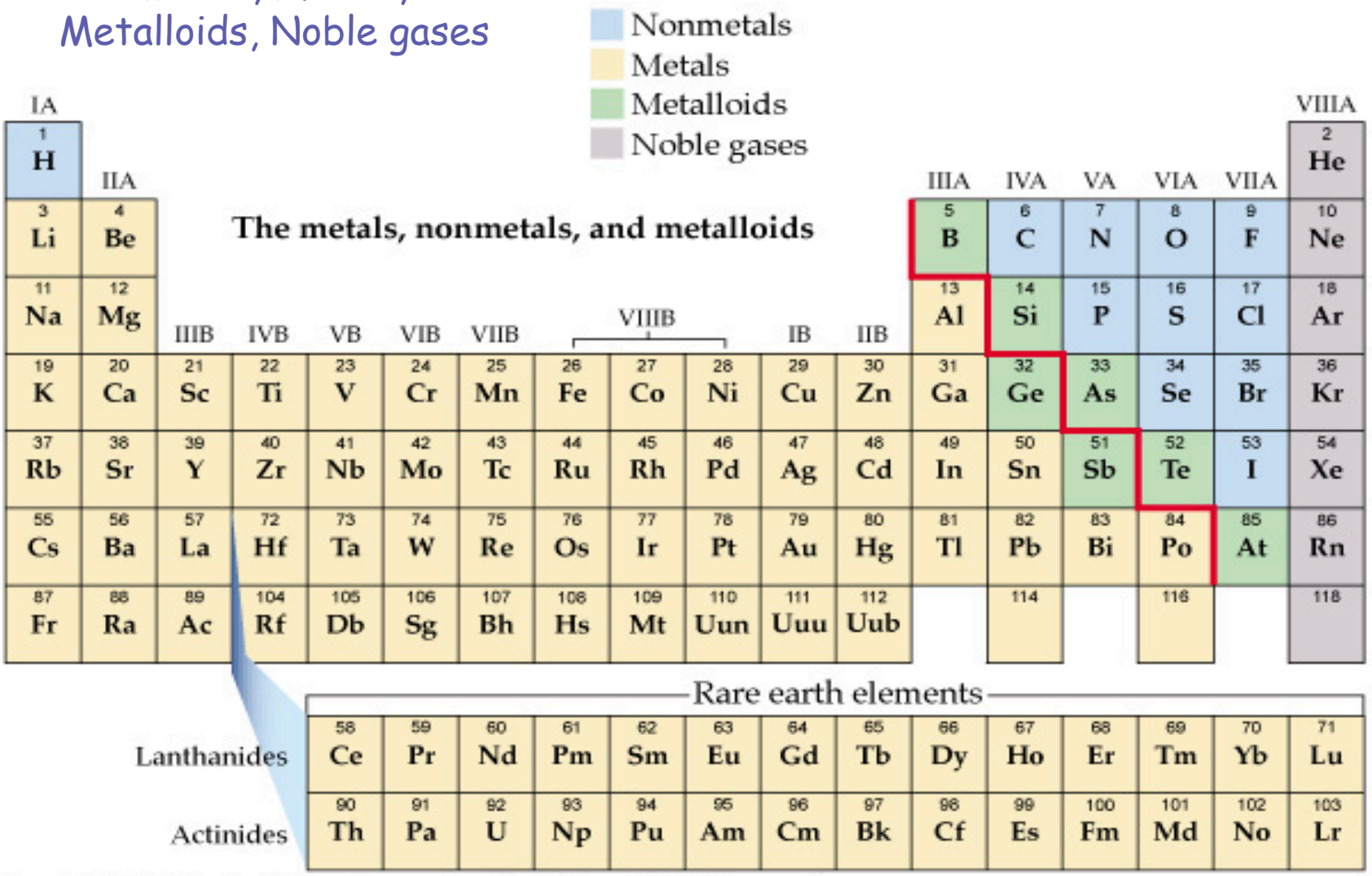
# Periodic Table: The three broad Classes Main, Transition, Rare Earth

- Main (Representative), Transition metals, lanthanides and actinides (rare earth)



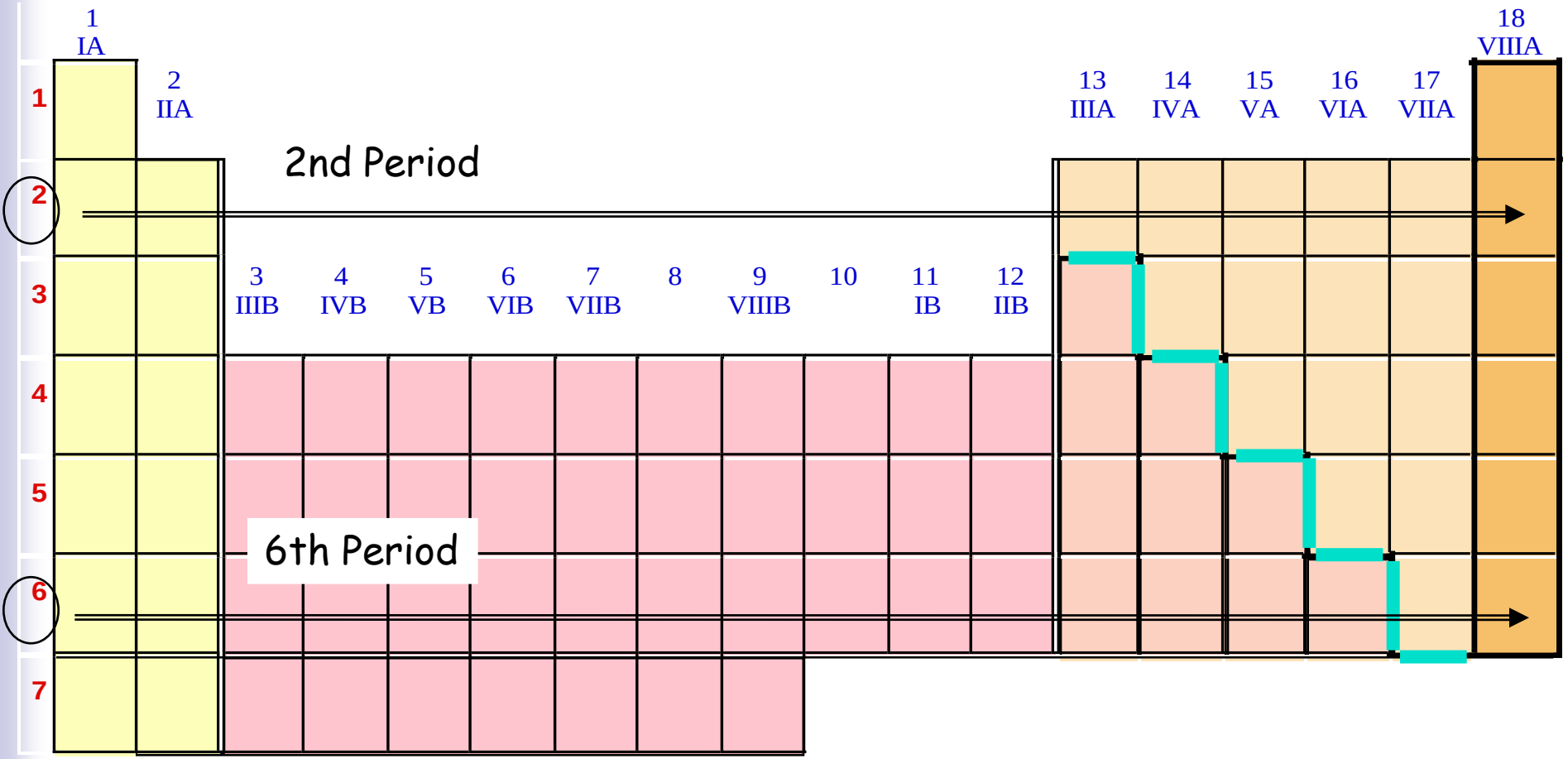
# Reading the Periodic Table: Classification

- Nonmetals, Metals, Metalloids, Noble gases



# Across the Periodic Table

- Periods: Are arranged horizontally across the periodic table (rows 1-7)
- These elements have **the same number of valence shells**.



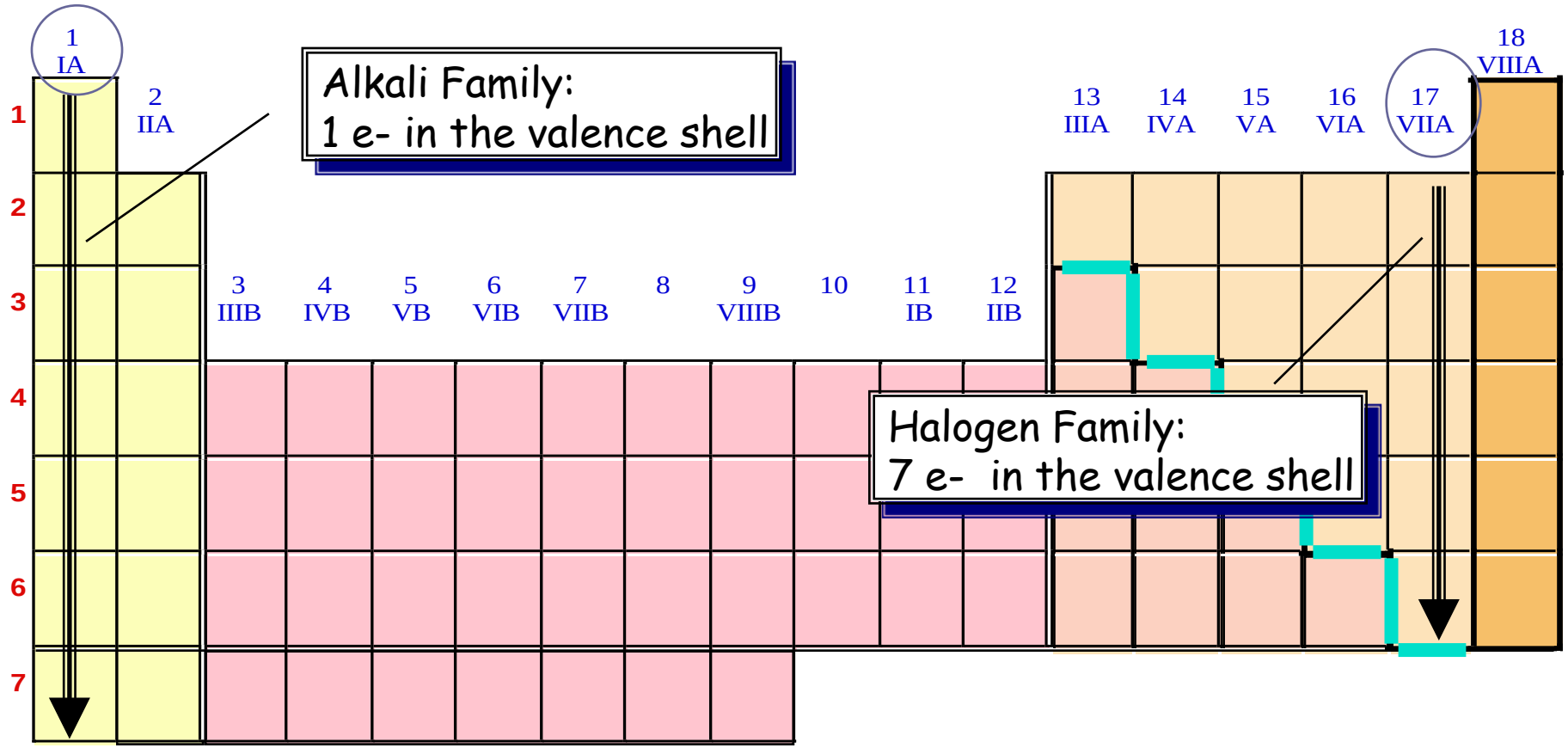
# Reading the Periodic Table: Categorization

## Periods

- Each horizontal row of elements is called a period.
- The elements in a period are not alike in properties.
- In fact, the properties change greatly across even given row.
- The first element in a period is always an extremely active solid. The last element in a period, is always an inactive gas.

# Down the Periodic Table

- Family: Are arranged vertically down the periodic table (columns or group, 1- 18 or 1-8 A,B)
- These elements have **the same number of electrons in the outer most shells**, the valence shell.



# Reading the Periodic Table: Categorization

## Families

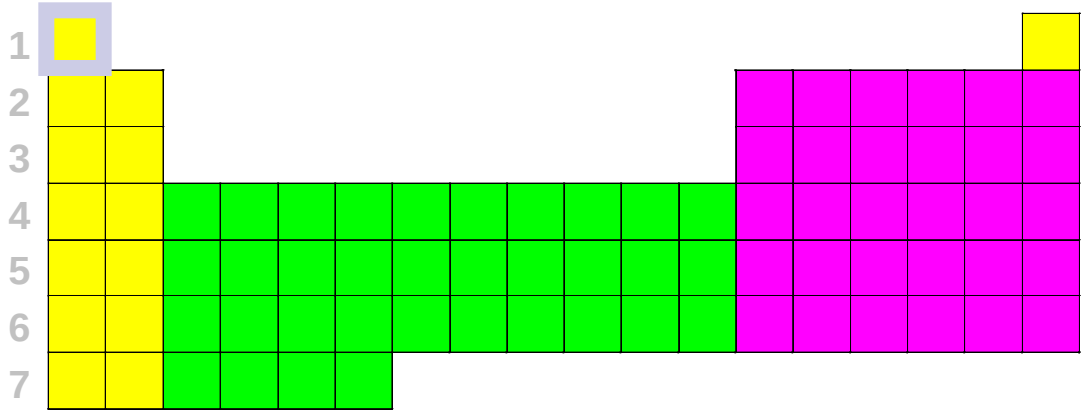
- Columns of elements are called groups or families.
- Elements in each family have similar but not identical properties.
- For example, lithium (Li), sodium (Na), potassium (K), and other members of family IA are all soft, white, shiny metals.
- All elements in a family have the same number of valence electrons.

# Reading the Periodic Table: Periodic Patterns

- **Period #**
  - energy level (subtract for d & f)
- **A/B Group #**
  - total # of valence $e^-$
- **Column within sublevel block**
  - # of $e^-$ in sublevel

# Periodic Patterns

- **Example** - Hydrogen




$1s^1$ ← 1st column of s-block

1st Period

s-block

# Periodic Table

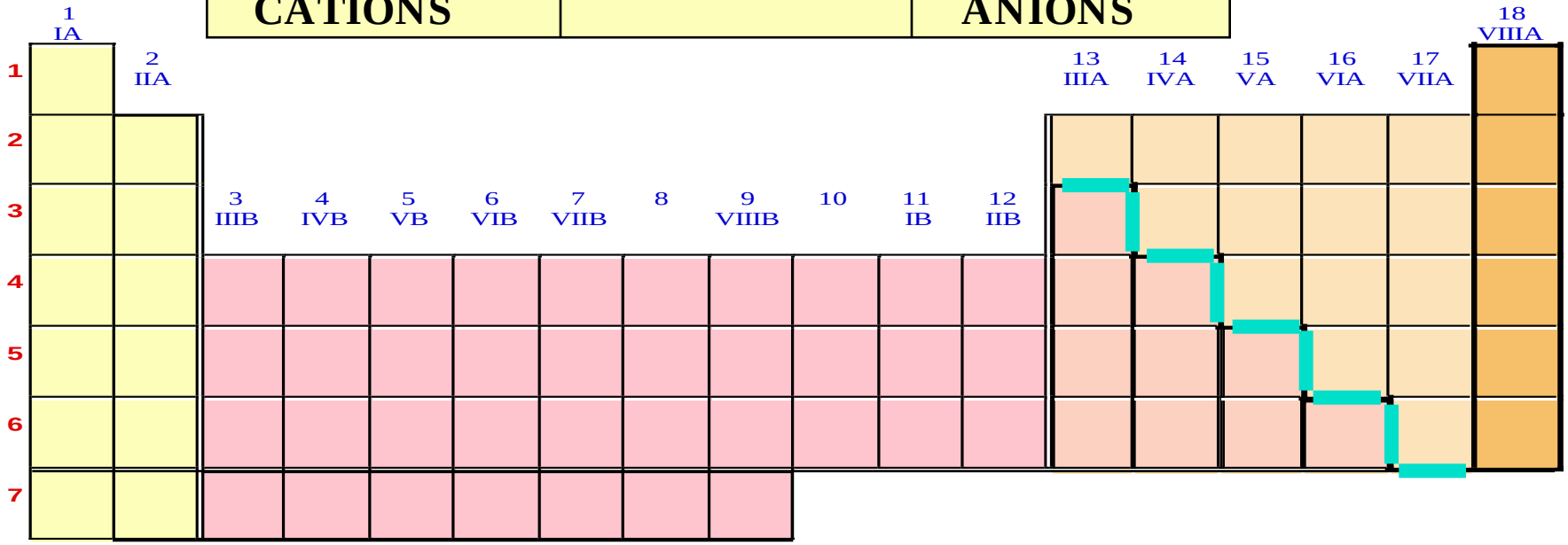
## e⁻ configuration from the periodic table

| | 1 IA | 2 IIA | 3 IIIB | 4 IVB | 5 VB | 6 VIB | 7 VIIB | 8 | 9 VIIIB | 10 | 11 IB | 12 IIB | 13 IIIA | 14 IVA | 15 VA | 16 VIA | 17 VIIA | 18 VIIIA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | H $1s^1$ | | | | | | | | | | | | | | | | | He $1s^2$ |
| 2 | Li $2s^1$ | Be $2s^2$ | | | | | | | | | | | B $2p^1$ | C $2p^2$ | N $2p^3$ | O $2p^4$ | F $2p^5$ | Ne $2p^6$ |
| 3 | Na $3s^1$ | Mg $3s^2$ | | | | | | | | | | | Al $3p^1$ | Si $3p^2$ | P $3p^3$ | S $3p^4$ | Cl $3p^5$ | Ar $3p^6$ |
| 4 | K $4s^1$ | Ca $4s^2$ | Sc $3d^1$ | Ti $3d^2$ | V $3d^3$ | Cr $4s^1 3d^5$ | Mn $3d^5$ | Fe $3d^6$ | Co $3d^7$ | Ni $3d^8$ | Cu $4s^1 3d^{10}$ | Zn $3d^{10}$ | Ga $4p^1$ | Ge $4p^2$ | As $4p^3$ | Se $4p^4$ | Be $4p^5$ | Kr $4p^6$ |
| 5 | Rb $5s^1$ | Sr $5s^2$ | Y $4d^1$ | Zr $4d^2$ | Nb $4d^3$ | Mo $5s^1 4d^5$ | Tc $4d^5$ | Ru $4d^6$ | Rh $4d^7$ | Ni $4d^8$ | Ag $5s^1 4d^{10}$ | Cd $4d^{10}$ | In $5p^1$ | Sn $5p^2$ | Sb $5p^3$ | Te $5p^4$ | I $5p^5$ | Xe $5p^6$ |
| 6 | Cs $6s^1$ | Ba $6s^2$ | La $5d^1$ | Hf $5d^2$ | Ta $5d^3$ | W $6s^1 5d^5$ | Re $5d^5$ | Os $5d^6$ | Ir $5d^7$ | Ni $5d^8$ | Au $6s^1 5d^{10}$ | Hg $5d^{10}$ | Tl $6p^1$ | Pb $6p^2$ | Bi $6p^3$ | Po $6p^4$ | At $6p^5$ | Rn $6p^6$ |
| 7 | Fr $7s^1$ | Ra $7s^2$ | Ac $6d^1$ | Rf $6d^2$ | Db $6d^3$ | Sg $7s^1 6d^5$ | Bh $6d^5$ | Hs $6d^6$ | Mt $6d^7$ | | | | | | | | | |

# Periodic Table: electron behavior

- The periodic table can be classified by the behavior of their electrons

| West (South)<br>**METALS** | Mid-plains<br>**METALLOID** | East (North)<br>**NON-METALS** |
|---|---|---|
| Alkali<br>Alkaline | | Noble gas<br>Halogens |
| Transition<br>These elements tend to **give up** $e^-$ and form | These elements will give up $e^-$ or accept $e^-$ | Calcogens<br>These elements tend to **accept** $e^-$ and form |
| **CATIONS** | | **ANIONS** |



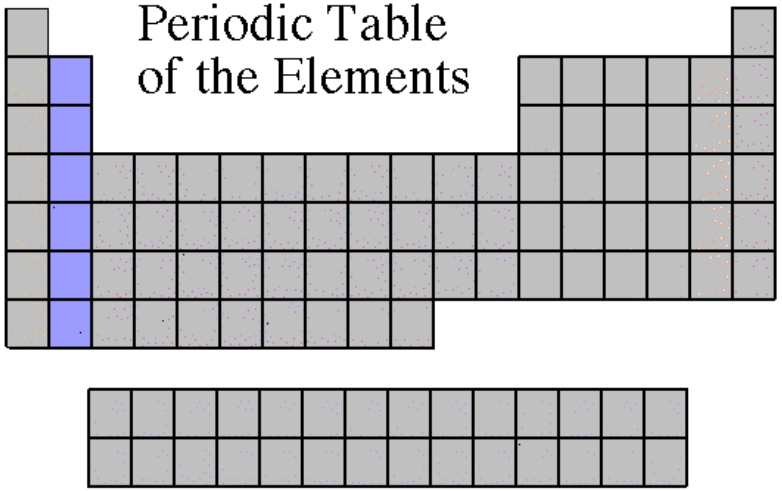
# Metals

# Alkali Metals

- They are the most reactive metals.
- They react violently with water.
- Alkali metals are never found as free elements in nature. They are always bonded with another element.

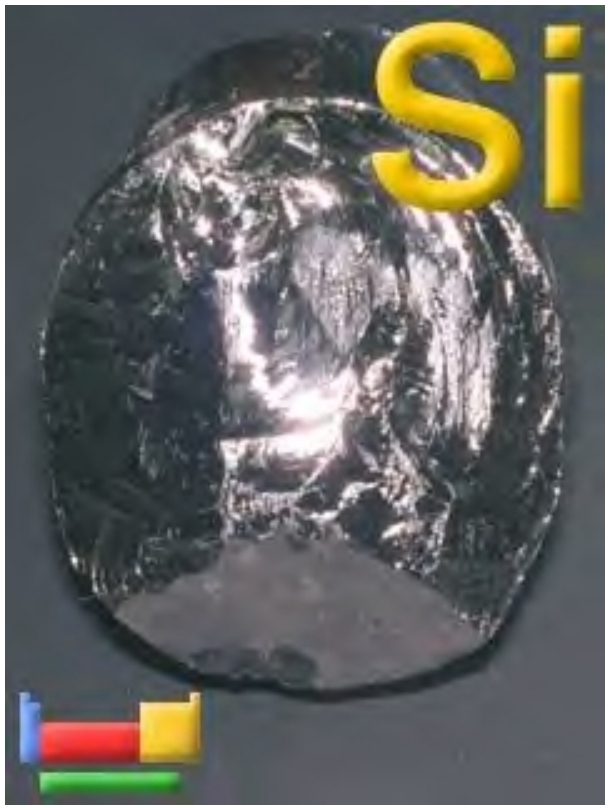

sodium(Na)

# Alkaline Earth Metals




- They are never found uncombined in nature.
- They have two valence electrons.
- Alkaline earth metals include magnesium and calcium, among others.

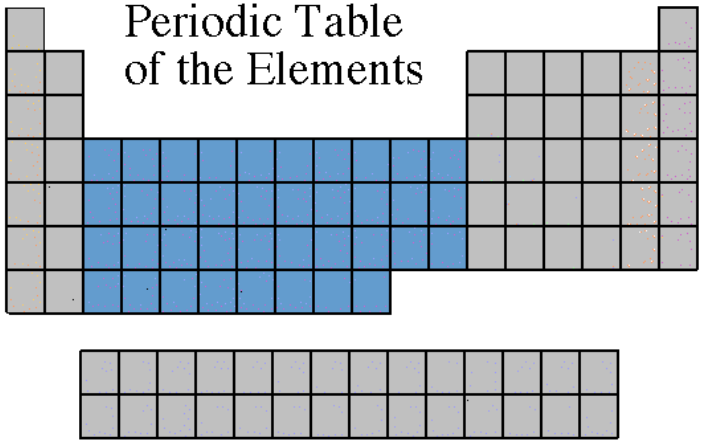
# Properties of Metalloids




Silicon

- Metalloids (metal-like) have properties of both metals and non-metals.
- They are solids that can be shiny or dull.
- They conduct heat and electricity better than non-metals but not as well as metals.
- They are ductile and malleable.

# Transition Metals



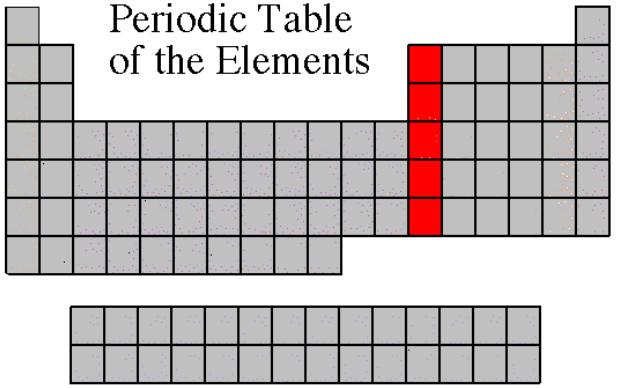

- Transition Elements include those elements in the B families.
- These are the metals you are probably most familiar: copper, tin, zinc, iron, nickel, gold, and silver.
- They are good conductors of heat and electricity.

# Transition Elements

- Transition elements have properties similar to one another and to other metals, but their properties do not fit in with those of any other family.
- Many transition metals combine chemically with oxygen to form compounds called oxides.

# Boron Family

- The Boron Family is named after the first element in the family.
- Atoms in this family have 3 valence electrons.
- This family includes a metalloid (boron), and the rest are metals.
- This family includes the most abundant metal in the earth's crust (aluminum).

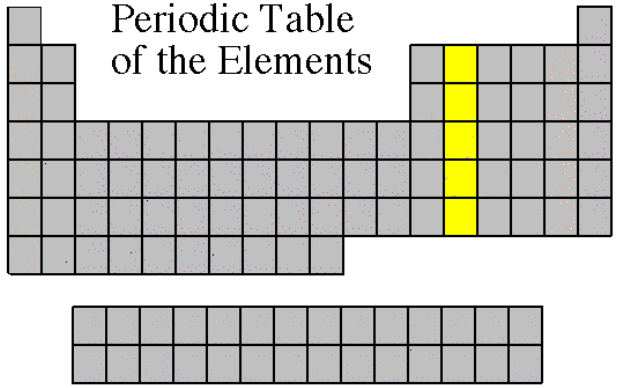
# Properties of Non-Metals

Sulfur

- Non-metals are poor conductors of heat and electricity.
- Non-metals are not ductile or malleable.
- Solid non-metals are brittle and break easily.
- They are dull.
- Many non-metals are gases.

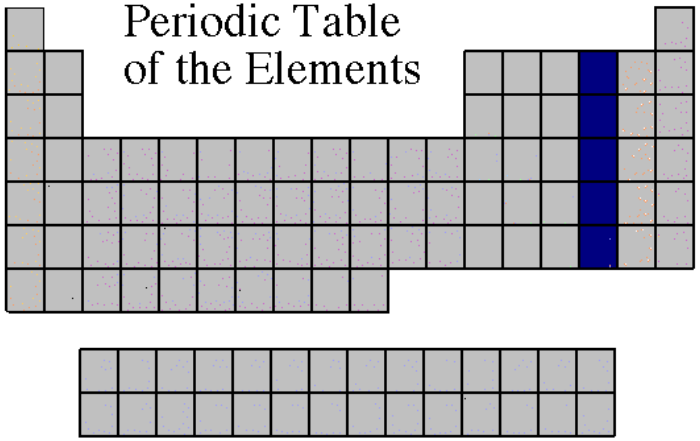
# Carbon Family

- Atoms of this family have 4 valence electrons.
- This family includes a non-metal (carbon), metalloids, and metals.
- The element carbon is called the "basis of life." There is an entire branch of chemistry devoted to carbon compounds called organic chemistry.



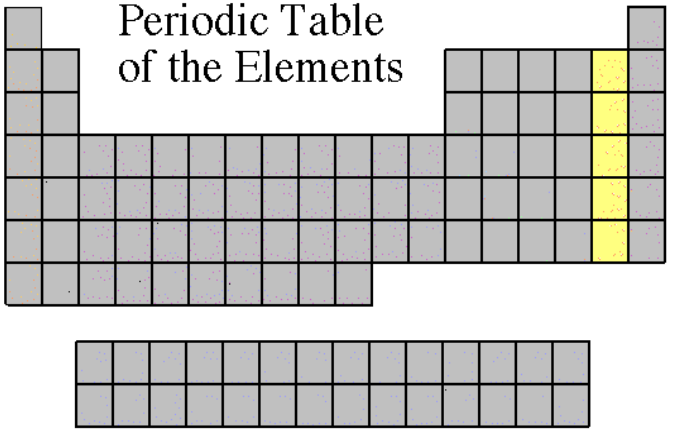
# Oxygen Family

- Atoms of this family have 6 valence electrons.
- Most elements in this family share electrons when forming compounds.
- Oxygen is the most abundant element in the earth's crust. It is extremely active and combines with almost all elements.

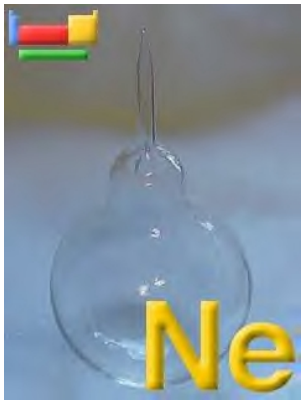


# Halogen Family

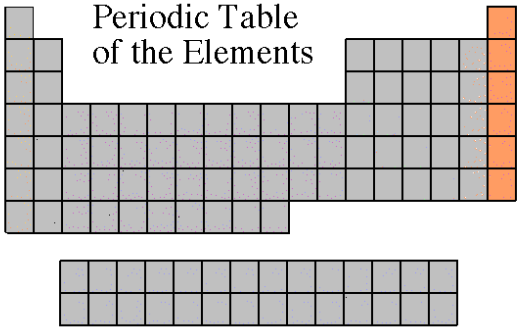
- The elements in this family are fluorine, chlorine, bromine, iodine, and astatine.
- Halogens have 7 valence electrons, which explains why they are the most active non-metals. They are never found free in nature.




Halogen atoms only need to gain 1 electron to fill their outermost energy level. They react with alkali metals to form salts.

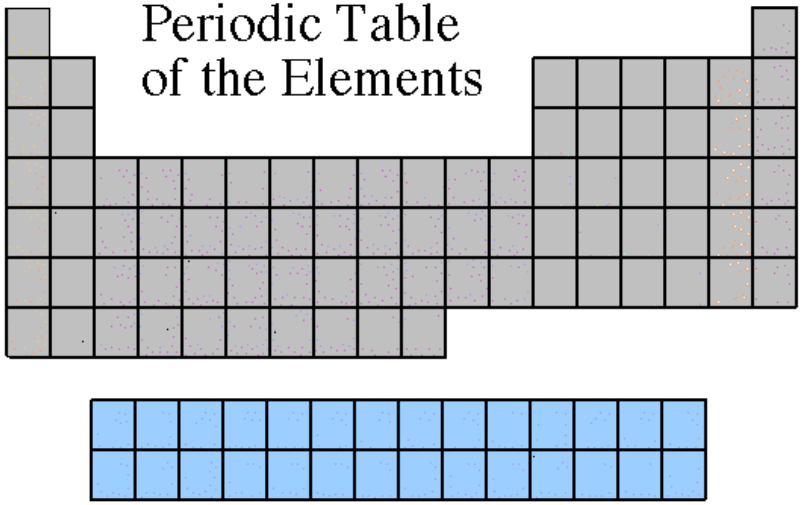



# Noble Gases




- Noble Gases are colorless gases that are extremely un-reactive.
- One important property of the noble gases is their inactivity. They are inactive because their outermost energy level is full.
- Because they do not readily combine with other elements to form compounds, the noble gases are called inert.
- The family of noble gases includes helium, neon, argon, krypton, xenon, and radon.
- All the noble gases are found in small amounts in the earth's atmosphere.

# Rare Earth Elements




- The thirty rare earth elements are composed of the lanthanide and actinide series.
- One element of the lanthanide series and most of the elements in the actinide series are called trans-uranium, which means synthetic or man-made.

# Periodic Trends

**Electronegativity** – a chemical property describing an atom's ability to attract and bind with electrons.

**Atomic Radius** - a term used to describe the size of the atom. There is no standard definition for this value - it may refer to the ionic radius, covalent radius, metallic radius, or van der Waals radius.

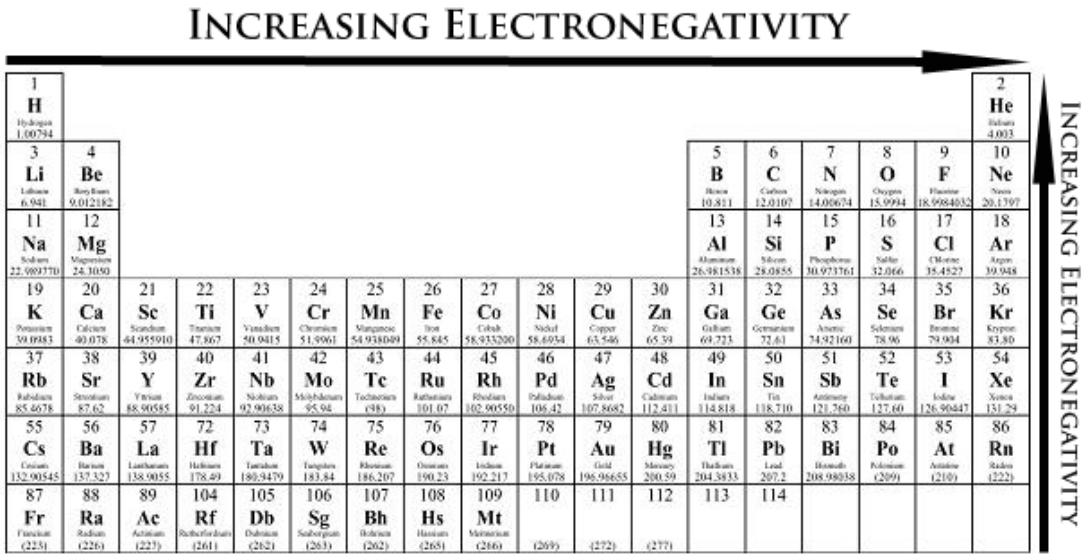
**Ionization potential** (**ionization energy** ($E_i$)) - is qualitatively defined as the minimum amount of energy required to remove the most loosely bound electron, the valence electron, of an isolated neutral gaseous atom to form a cation.

**Electron Affinity** - the **electron affinity** ($E_{ea}$) of an atom or molecule is defined as the amount of energy *released* or *spent* when an electron is added to a neutral atom or molecule in the gaseous state to form a negative ion.

**Melting Point** - the amount of energy required to break a bond(s) to change the solid phase of a substance to a liquid.

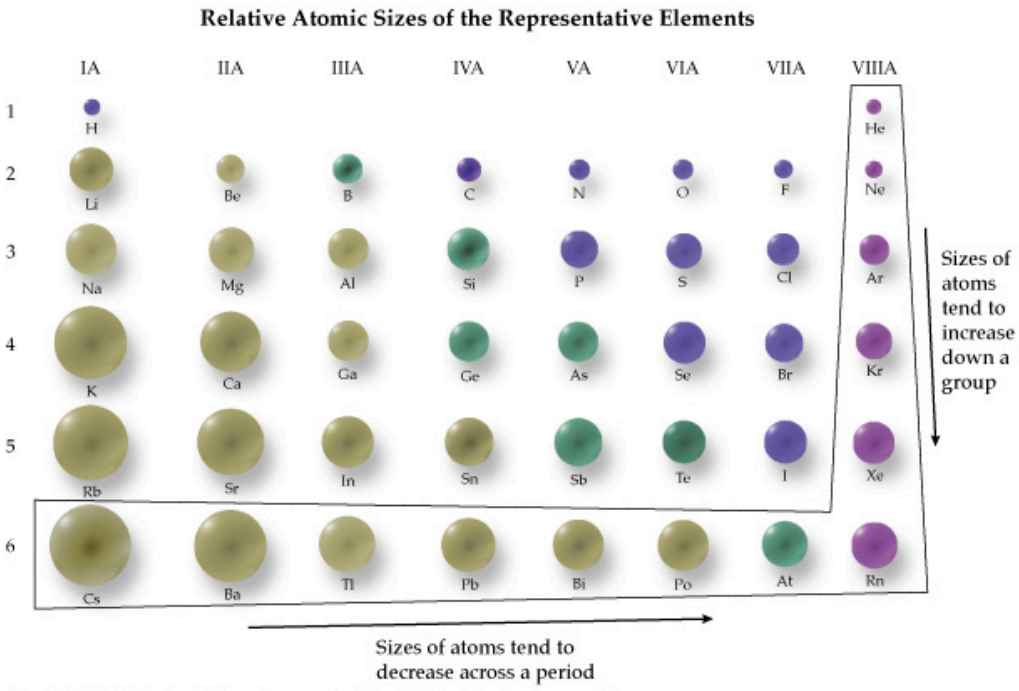
# 1. Trend in Electronegativity

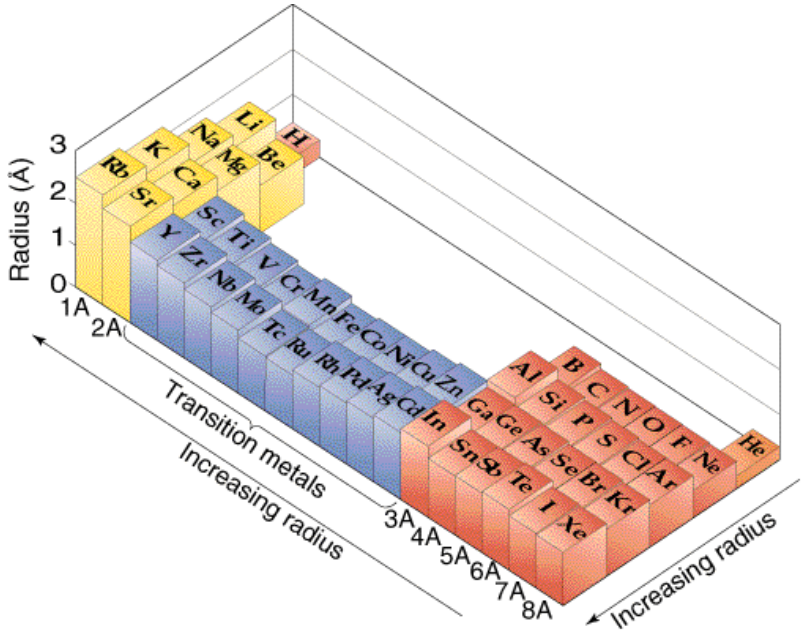
- From **left to right across** a period of elements, electronegativity increases.
- From **top to bottom down** a group, electronegativity decreases.
- Important exceptions of the above rules include the noble gases, lanthanides, and actinides.
- As for the **transition metals**, although they have electronegativity values, there is little variance among them across the period and up and down a group.



# 2. Trend in Atomic Radius

- Atomic Radius:
- The size of an atomic specie as determined by the boundaries of the valence e-. Largest atomic species are those found in the SW corner since these atoms have the largest n, but the smallest $Z_{eff}$.

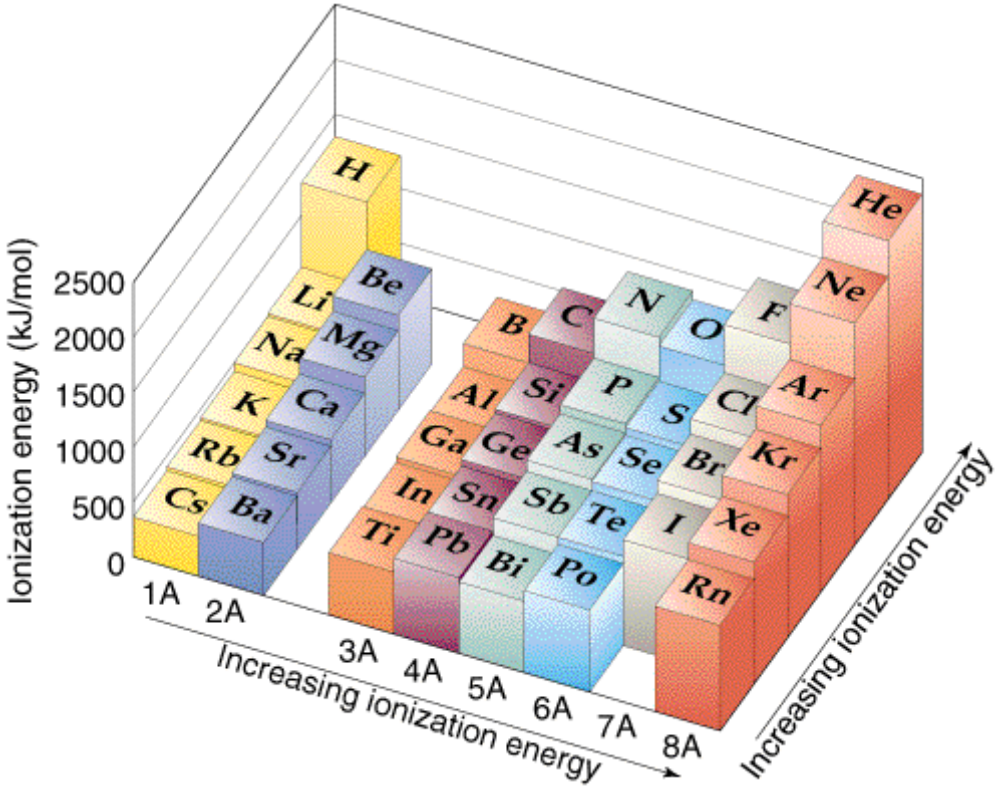


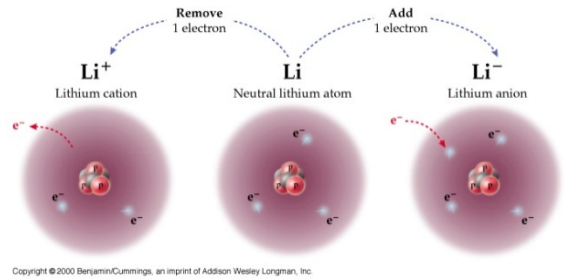
# 3. Trend in Ionization Potential

Ionization potential:

The energy required to remove the valence electron from an atomic specie. Largest toward NE corner of PT since these atoms hold on to their valence e- the tightest.




| | IA | | | | | | | VIIIA |
|---|---|---|---|---|---|---|---|---|
| 1 | H 1312 | IIA | IIIA | IVA | VA | VIA | VIIA | He 2372 |
| 2 | Li 520 | Be 899 | B 801 | C 1086 | N 1402 | O 1314 | F 1681 | Ne 2081 |
| 3 | Na 496 | Mg 738 | Al 578 | Si 786 | P 1012 | S 1000 | Cl 1251 | Ar 1521 |
| 4 | K 419 | Ca 590 | Ga 579 | Ge 762 | As 947 | Se 941 | Br 1140 | Kr 1351 |
| 5 | Rb 403 | Sr 549 | In 558 | Sn 709 | Sb 834 | Te 869 | I 1008 | Xe 1170 |
| 6 | Cs 376 | Ba 503 | Tl 589 | Pb 716 | Bi 703 | Po 812 | At 926 | Rn 1037 |



# 4. Trend in Electron Affinity

Electron Affinity:

The energy release when an electron is added to an atom. Most favorable toward NE corner of PT since these atoms have a great affinity for e-.

| 1A | 2A | 3A | 4A | 5A | 6A | 7A | 8A |
|---|---|---|---|---|---|---|---|
| H –73 | | | | | | | He >0 |
| Li –60 | Be >0 | B –27 | C –122 | N >0 | O –141 | F –328 | Ne >0 |
| Na –53 | Mg >0 | Al –43 | Si –134 | P –72 | S –200 | Cl –349 | Ar >0 |
| K –48 | Ca –4 | Ga –30 | Ge –119 | As –78 | Se –195 | Br –325 | Kr >0 |
| Rb –47 | Sr –11 | In –30 | Sn –107 | Sb –103 | Te –190 | I –295 | Xe >0 |

# 5. Trend in Melting point

Melting points are varied and do not generally form a distinguishable trend across the periodic table. However, certain conclusions can be drawn from the graph below.

- Metals generally possess a *high melting point*.
- Most non-metals possess *low melting points*.
- The non-metal **carbon** possesses *the highest boiling point of all the elements*. The semi-metal boron also possesses a high melting point.

# Summary of Trend

- Periodic Table and Periodic Trends