GENERAL CHEMISTRY

Chapter 2

Periodic table

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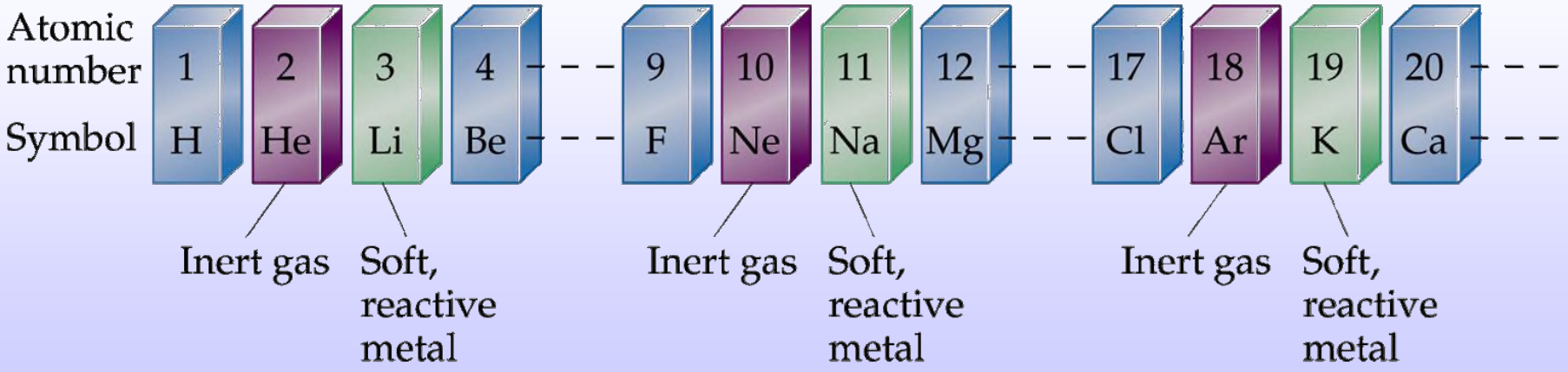
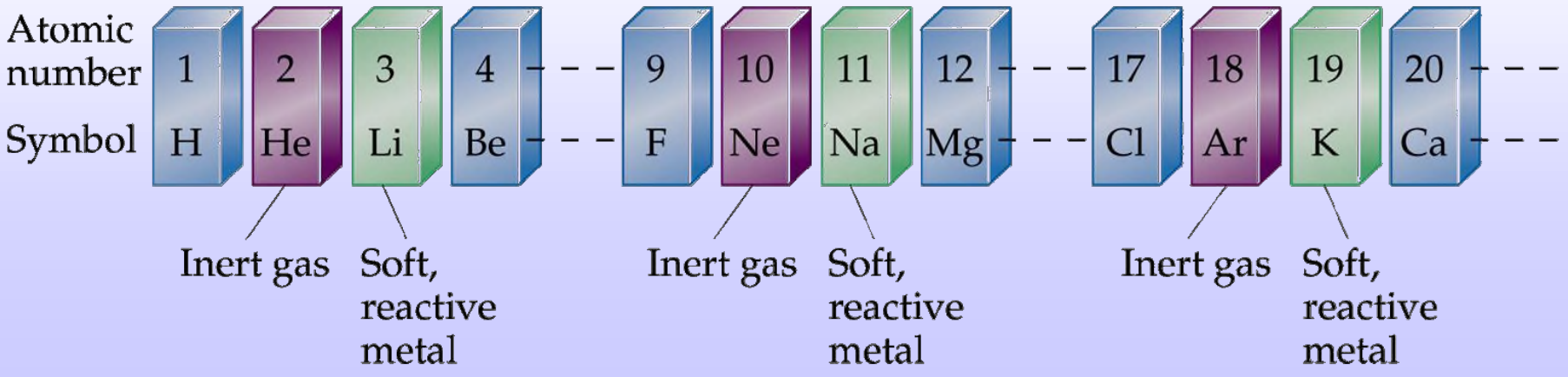
Arrangement of the Periodic Table

- The Periodic Table is used to organize the 114 elements in a meaningful way.
- As a consequence of this organization, there are periodic properties associated with the periodic table.



Arrangement of the Periodic Table

- The Periodic Table is used to organize the 114 elements in a meaningful way.
- As a consequence of this organization, there are periodic properties associated with the periodic table.
- Periodic Law states: When elements are arranged in order of increasing atomic number, there is a periodic repetition of their physical and chemical properties



	I A	II A	III B	IV B	V B	VI B	VII B		VIII B		I B	II B	III A	IV A	V A	VI A	VII A	VIII A
	1																1	2
1	H																H	He
	1.008																1.008	4.0026
	3	4											5	6	7	8	9	10
2	Li	Be											B	C	N	O	F	Ne
	6.939	9.0122											10.811	12.011	14.007	15.999	18.998	20.183
	11	12											13	14	15	16	17	18
3	Na	Mg											Al	Si	P	S	Cl	Ar
	22.99	24.312											26.982	28.086	30.974	32.064	35.453	39.948
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
	39.102	40.08	44.956	47.89	50.942	51.996	54.938	55.847	58.932	58.71	63.54	65.37	69.72	72.59	74.922	78.96	79.909	83.8
	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
	85.468	87.62	88.906	91.224	92.906	95.94	* 98	101.07	102.91	106.42	107.9	112.41	114.82	118.71	121.75	127.61	126.9	131.29
	55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
6	Cs	Ba	**La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
	132.91	137.33	138.91	178.49	180.95	183.85	186.21	190.2	192.22	195.08	196.97	200.29	204.38	207.2	208.98	* 209	* 210	* 222
	87	88	89	104	105	106	107	108	109	110	111	112	113	114	115	116		
7	Fr	Ra	***Ac	Rf	Ha	Sg	Ns	Hs	Mt	Uun	Uuu	Uub	Uut	Uuq	Uup	Uuh		
	* 223	226.03	227.03	* 261	* 262	* 263	* 262	* 265	* 268	* 269	* 272	* 277	*284	*285	*288	*292		

Based on symbols used by ACS — S.M.Condren 2003

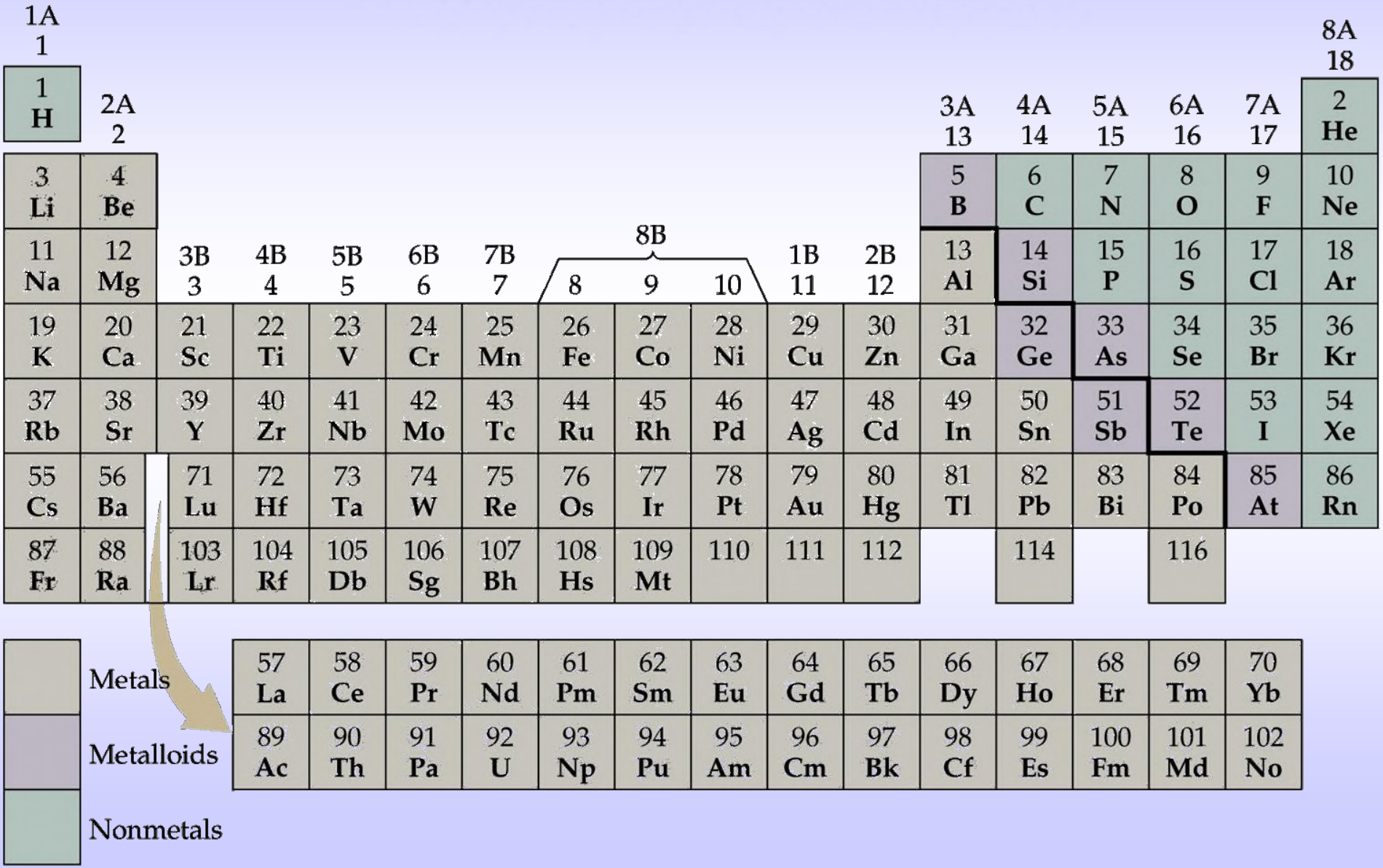
	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
	140.12	140.91	144.24	* 145	150.36	151.96	157.25	158.93	162.51	164.93	167.26	168.93	173.04	174.97
	90	91	92	93	94	95	96	97	98	99	100	101	102	103
	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
	232.04	231.04	238.03	237.05	* 244	* 243	* 247	* 247	* 251	* 252	* 257	* 258	* 259	* 260

* Designates that all isotopes are radioactive

**Lanthanum Series

*** Actinium Series

The Periodic Table



Reading the Periodic Table

- Columns in the periodic table are called *groups* (numbered from 1A to 8A or 1 to 18).
- Elements in each column have the same number of valence electrons
- Elements in each group have similar but not identical properties.
- Rows in the periodic table are called *periods*.
- Periods reflect the periodic recurrence of similar properties

Reading the Periodic Table

- Metals are located on the left hand side of the periodic table (most of the elements are metals).
- Non-metals are located in the top right hand side of the periodic table.
- Elements with properties similar to both metals and non-metals are called metalloids and are located at the interface between the metals and non-metals.

Group A (representative elements)

- Group IA – ns^1 Alkali Metals (except Hydrogen)
- Group IIA – ns^2 Alkaline Earth Metals
- Group IIIA – ns^2np^1 Aluminum Group/Boron Family
- Group IVA – ns^2np^2 Carbon Family
- Group VA – ns^2np^3 Nitrogen Family
- Group VIA – ns^2np^4 Oxygen Family/Chalcogens
- Group VIIA – ns^2np^5 Halogens
- Group VIIIA – ns^2np^6 Noble Gases

Group B (transition elements)

- d: start from period 4 and f elements: period 6: subgroup (B)
- 8 main groups → 8 subgroups 3B to 8B, 1B, 2B
- Transition metals: group IIIB – IIB: referred to as the d-block
- Inner transition elements (lanthanides and actinides) are found at the bottom of the table and referred to as the f-block: group 3B
- d: elements: last filled e fall in d orbital
- $ns^2\ (n-1)d^{1,2,3}$: 3, 4, 5 valence e → group 3B 4B 5B
- $ns^2\ (n-1)d^4$ → $ns^1\ (n-1)d^5$: 6B
- $ns^2\ (n-1)d^5$: 7B
- $ns^2\ (n-1)d^{6,7,8}$: 8,9,10 e → 8B (3 columns) (no 9B, 10B)
- $ns^2\ (n-1)d^9$ → $ns^1\ (n-1)d^{10}$: 1B, $ns^2\ (n-1)d^{10}$: 2B
- ns^1 1A ns^2 : 2A

f elements

- $ns^2\ (n-2)f^x$: (n-2)f $(n-1)d^{0,1}$ ns^2 : distance from the nucleus
- 3B $ns^2\ (n-1)d^1$: all f-elements : 3B
- f electron: difficult to take part in chemical rxn

Position and electron configuration

- From atomic number (Z) ⇄ Electron configuration ⇄ Position in periodic table
- The Number of electrons in the outermost energy level or the valence electrons resembles to the group number.
- Main group: ns and np
- Subgroup: ns and (n-1)d
- The highest main energy level occupied by the electrons of the atom corresponds to the period.

Position and electron configuration

- S, p elements: ns + np → group No.
- d elements: ns + (n-1)d : 3-7: 3B- 7B;
  8,9,10: 8B;
  11,12: 1B, 2B
- f- elements: 3B

Exercises

- Find the position (period, group) of the elements of the last week homework
- Z=13, 27, 41, 36, 46, 52, 71, 80, 91, 87

[?] ns (n-2)f (n-1)d np

Exercises

- Find the Z of the elements

Group	Period	Group
	2	7A
	3	6A
5B	4	5A
4B	5	4A
3B	6	3A
2B	7	2A

Trends in the Periodic Table

- atomic radius
- ionic radius
- ionization energy
- electron affinity
- electronegativity

Atomic Radius

- decrease left to right across a period
  - Same No. of shells (same n) → distance from the valence e to the nucleus
  - as nuclear charge increases, number of electrons increase; however, the nucleus acts as a unit charge while the electrons act independently, pulling electrons towards the nucleus, decreasing size

Atomic Radius

- increase top to bottom down a group
  - More shell → distance increase
  - each additional electron "shell" shields the outer electrons from the nuclear charge

$Z_{eff} = Z - S$

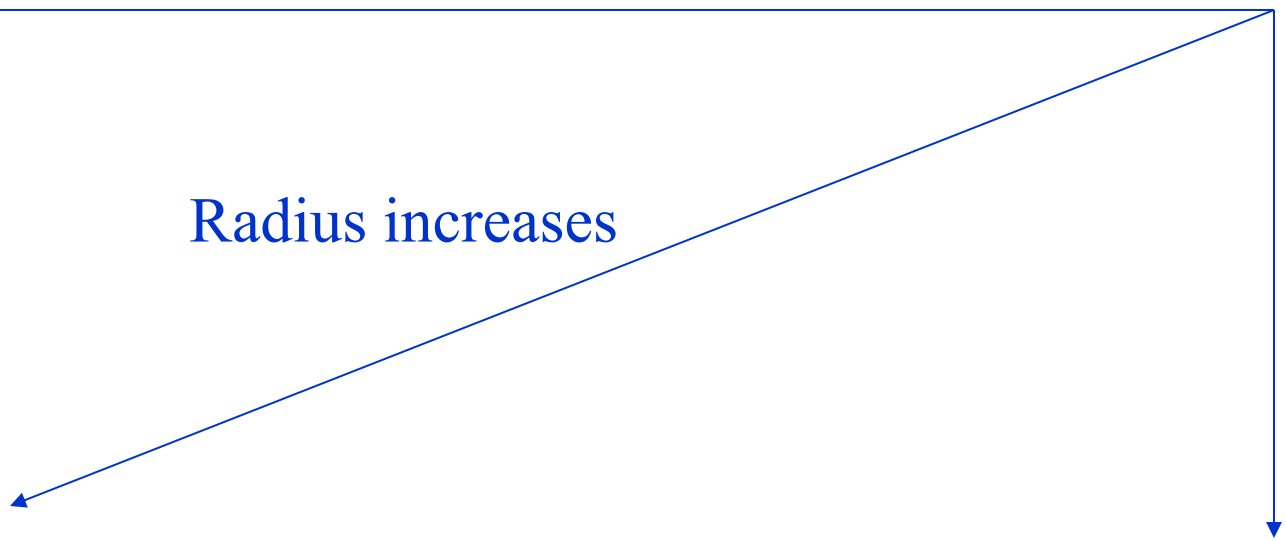
where Z_{eff} => effective nuclear charge

Z => nuclear charge, atomic number

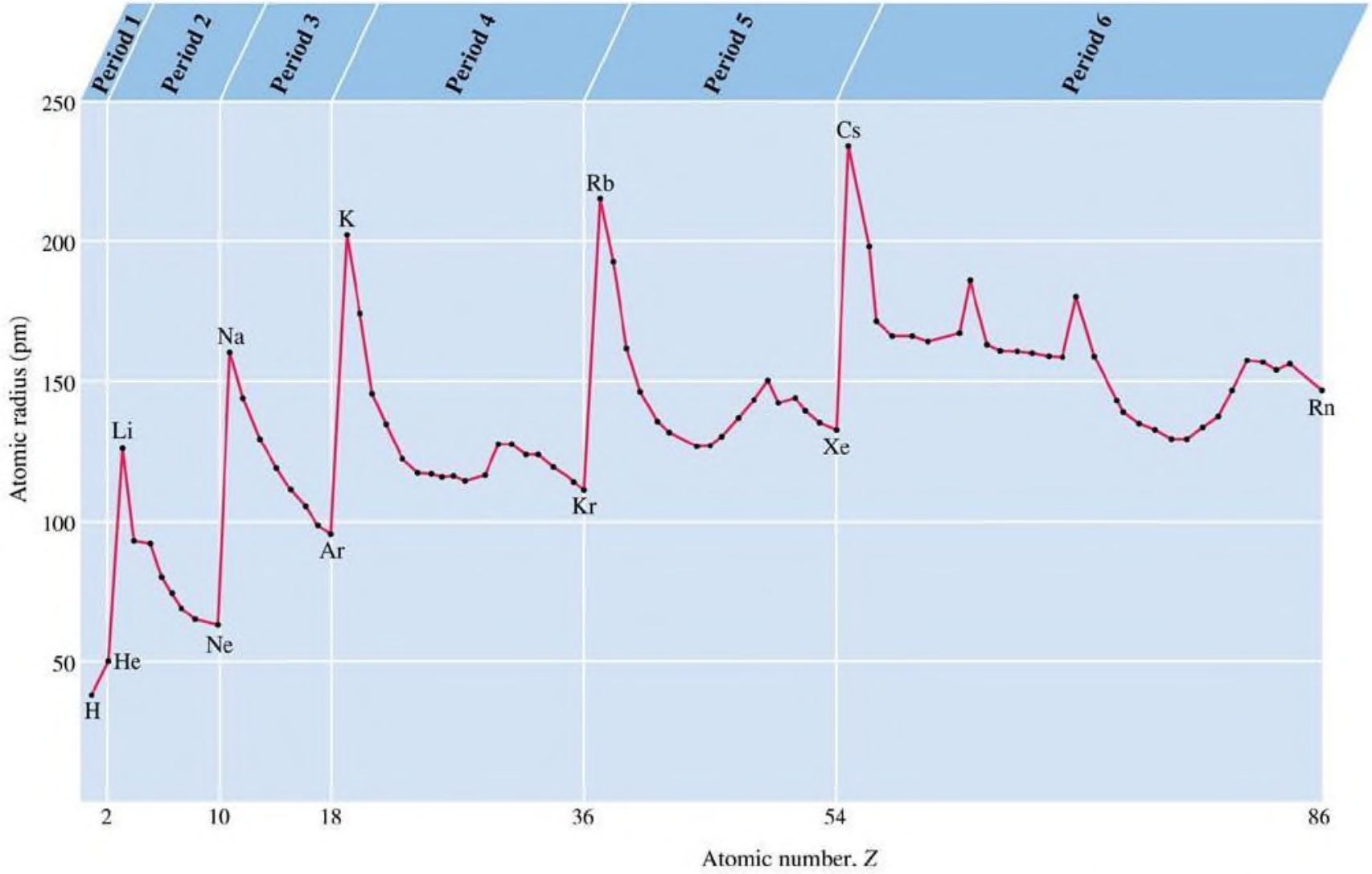
S => shielding constant

Atomic Radius

- increases from upper right corner to the lower left corner



Atomic Radius vs. Atomic Number



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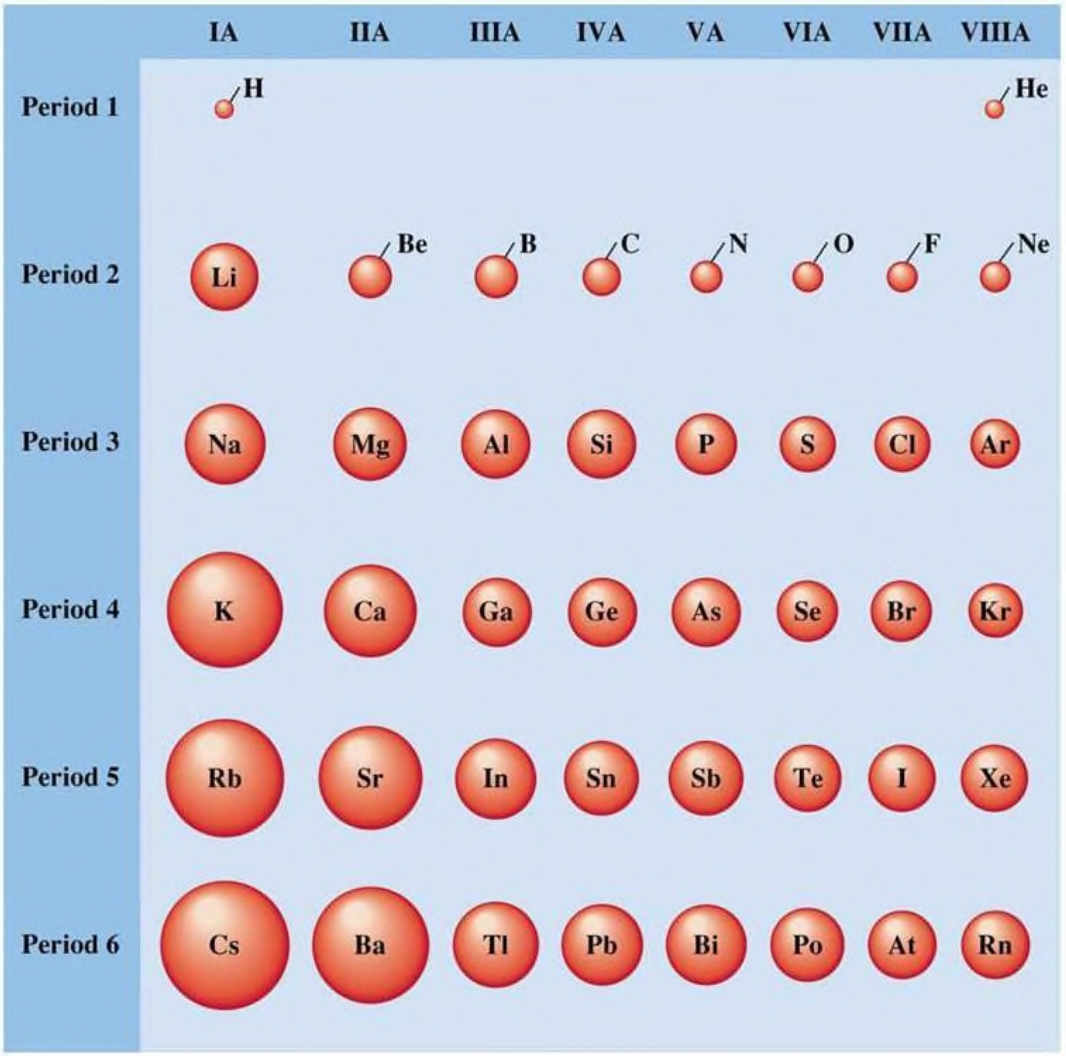
Atomic Radius



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Ionic Radius

- **same trends** as for atomic radius

if X>Y

then $X^{n+} > Y^{n+}$, $X^{n-} > Y^{n-}$ (same charge)

- positive ions smaller than atom

Less No. of electron → less repulsion (e-e)

Lose e → lose 1 shell [18]$4s^1$ → [18]

Size decreases $Na^+ < Na$

- negative ions larger than atom

More electron → more repulsion → size increases $F^- > F$

- ….<X^{2+} < X^{+} <X< X^{-}<X^{2-} < …
- Fe^{3+} < Fe^{2+} < Fe

Ionic Radius

Isoelectronic Series

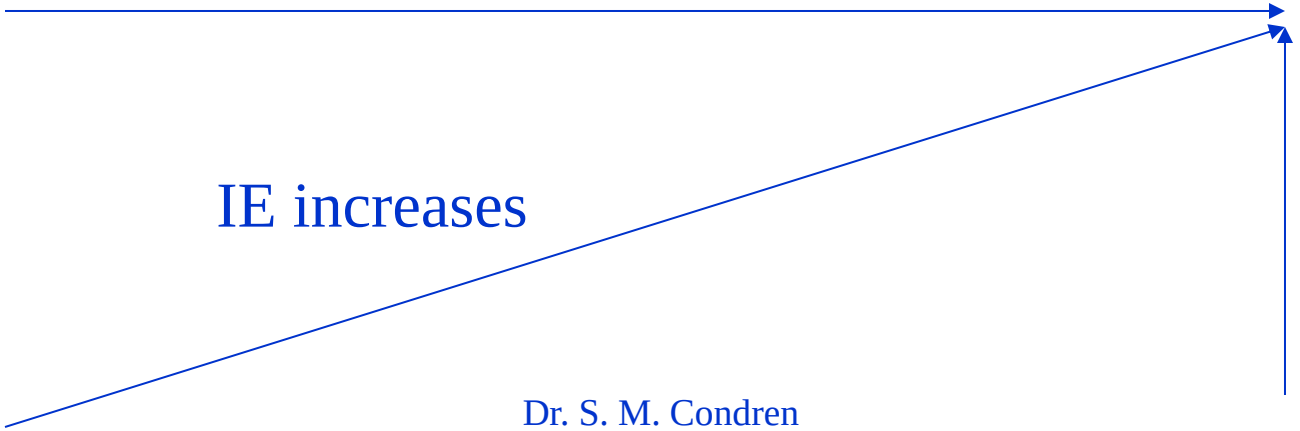
- series of negative ions, noble gas atom, and positive ions with the same electronic configuration (same No. of electron)
- size decreases as “positive charge” of the nucleus increases
- $C^{4-} > N^{3-} > O^{2-} > F^{-} > Ne > Na^{+} > Mg^{2+} > Al^{3+} > Si^{4+}$: 10e

Ionization Energy (IE)

- energy necessary to remove an electron to form a positive ion
- Characteristic properties of metal
- low value for metals, electrons easily removed
- high value for non-metals, electrons difficult to remove
- increases from lower left corner of periodic table to the upper right corner

IE

- $X - 1e \rightarrow X^+$
- Across a period: IE increases from left to right (same No. of shells, Z increases)
- Top down to bottom: No. of shells increase, shielding effect, distance increase → IE decrease



Ionization Energies

first ionization energy

- energy to remove first electron from an atom ($X - 1e \rightarrow X^{+}$)

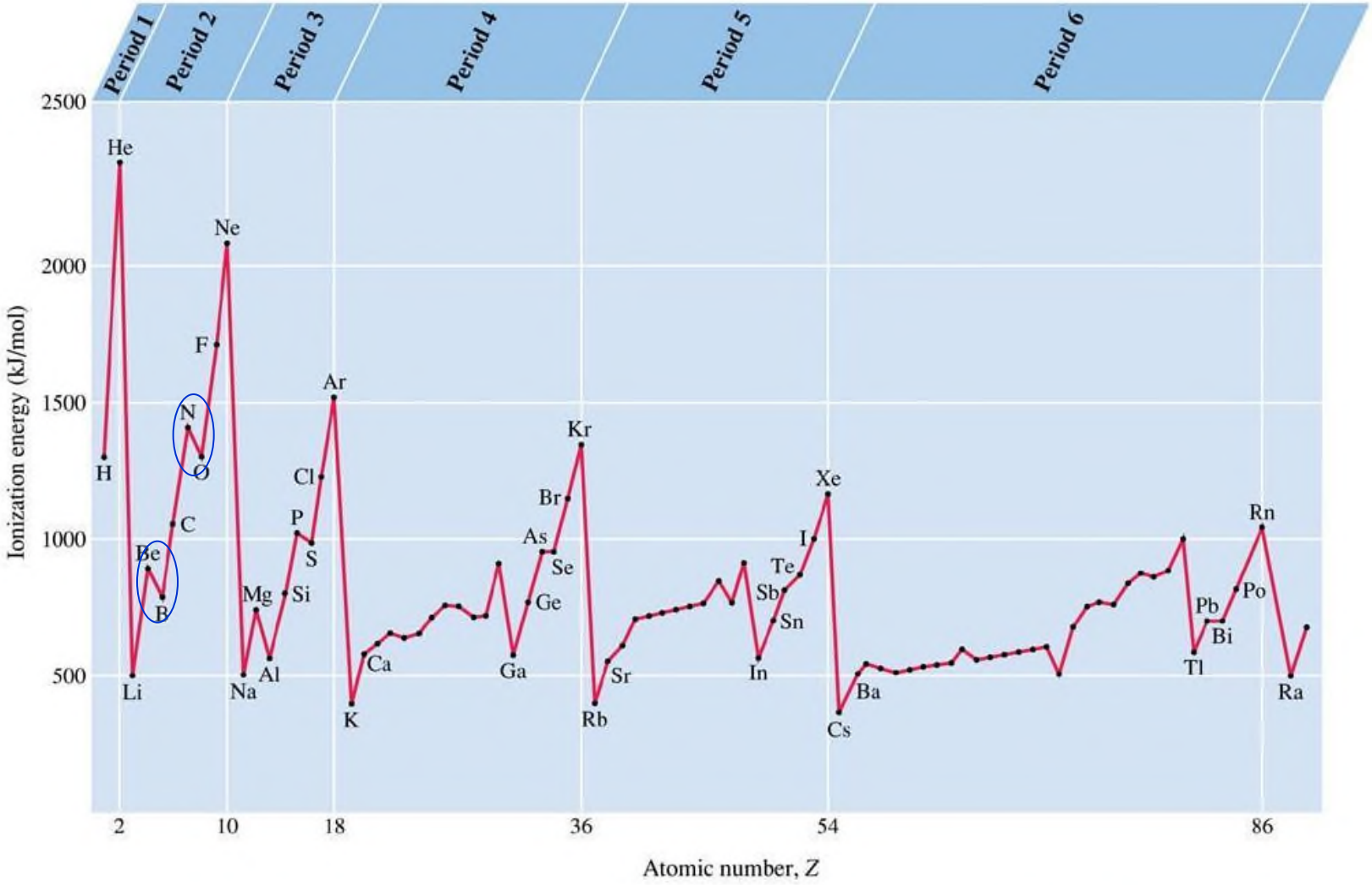
second ionization energy

- energy to remove second electron from a +1 ion ($X^{+} - 1e \rightarrow X^{2+}$) (not $X - 2e \rightarrow X^{2+}$)

etc.

Discuss 2nd IE → look at e. config of X^{+}, not X

Ionization Energy vs. Atomic Number



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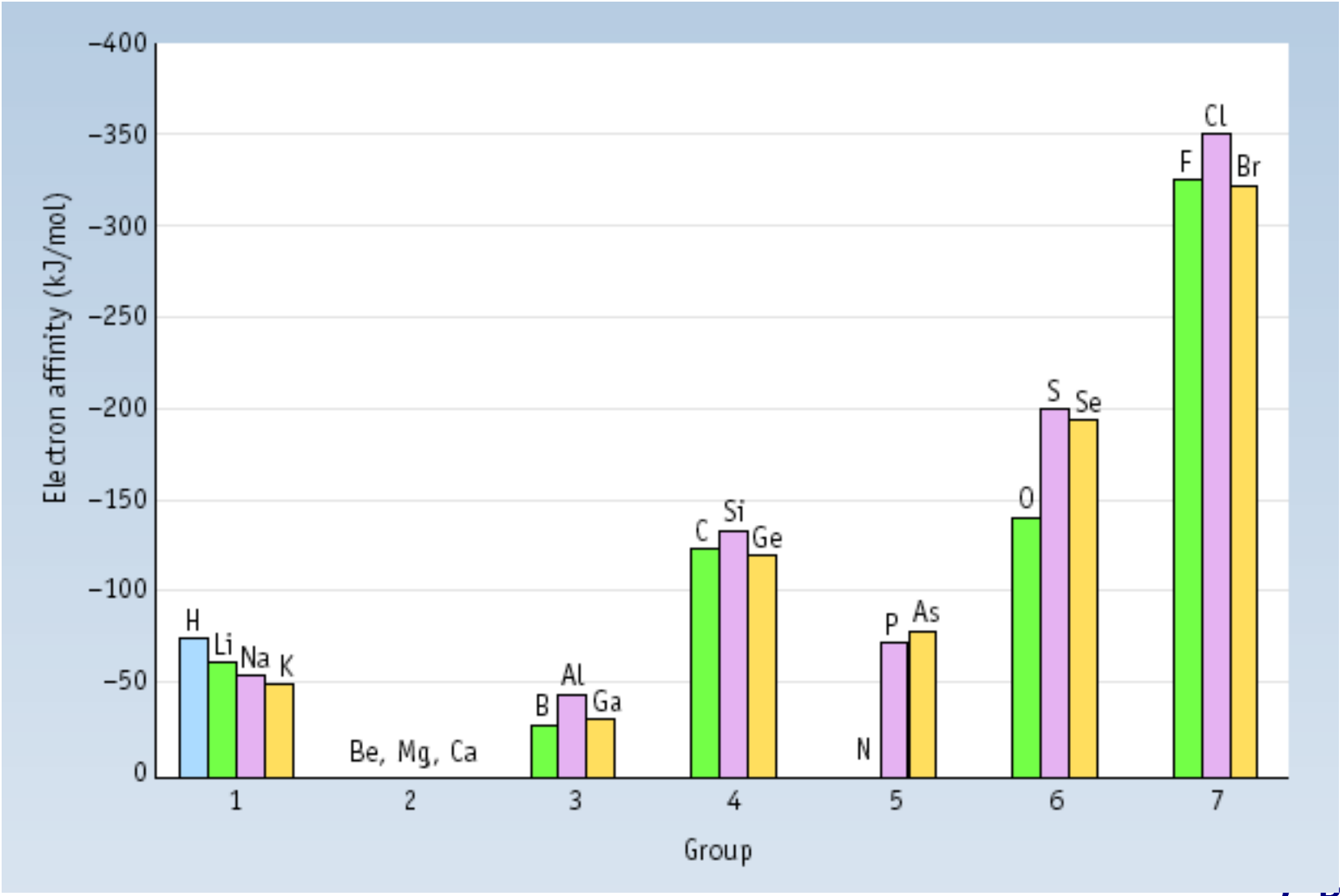
Electron Affinity (EA)

- energy released when an electron is added to an atom

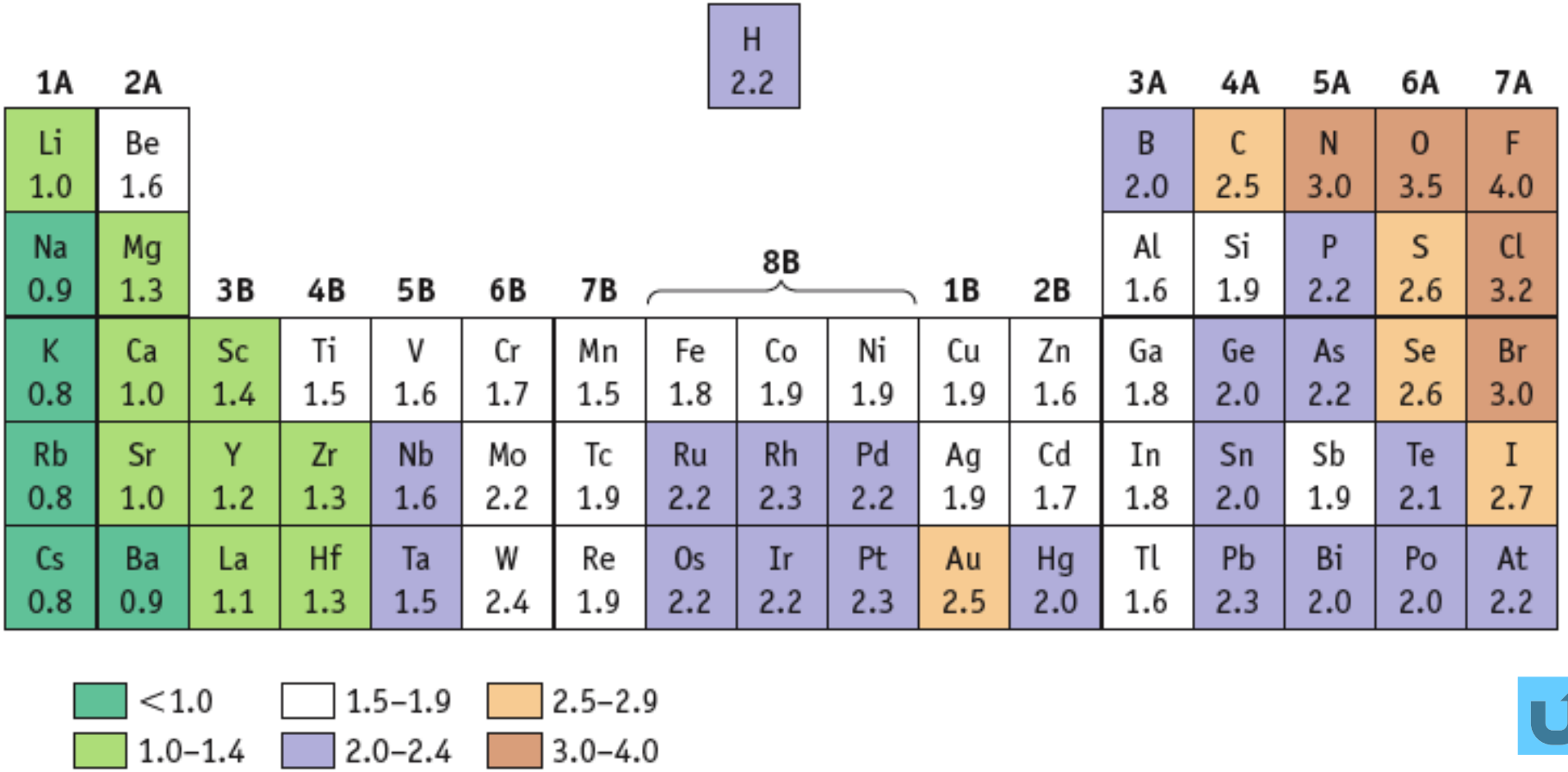
  $X + 1e \rightarrow X^-$ (EA=ΔH) negative number
- metals have low "EA"
- **nonmetals** have high "EA"
- Characteristic of non-metal: ability to receive an electron

Trends in Electron Affinity

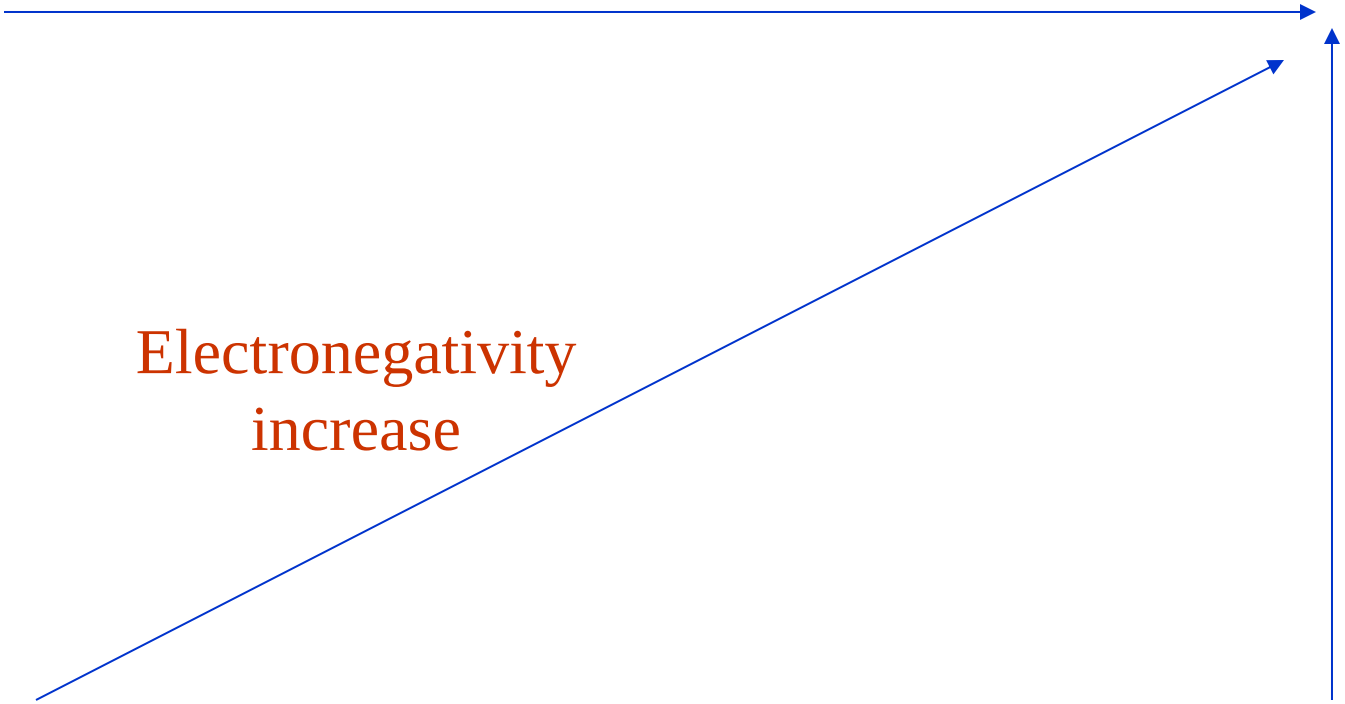


Electronegativity

Tendency of an atom to attract the sharing electron in bonding



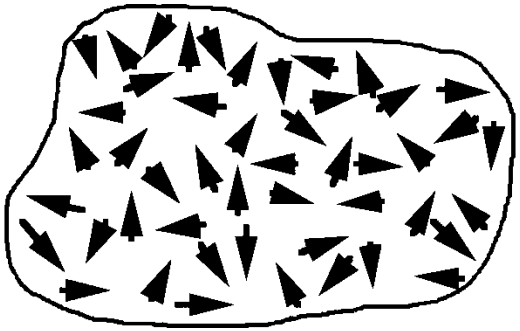
Electronegativity



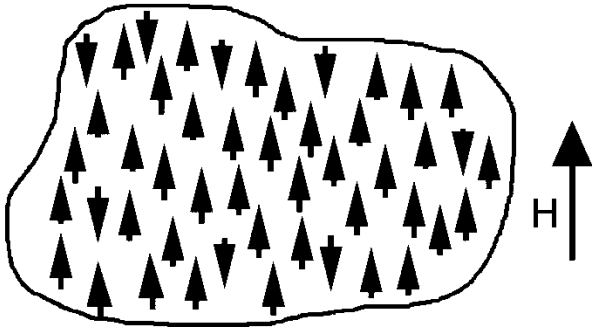
Magnetism

- Result of the spin of electrons
- diamagnetism - no unpaired electrons
- paramagnetism - one or more unpaired electrons (at least one unpaired e)
- ferromagentism - case of paramagnetism where the substance retains its magnetism

Magnetism

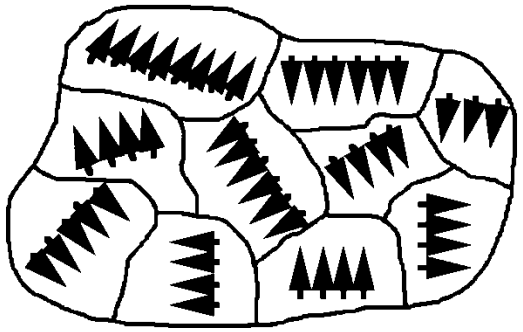


Without applied field



With applied field

Paramagnetism



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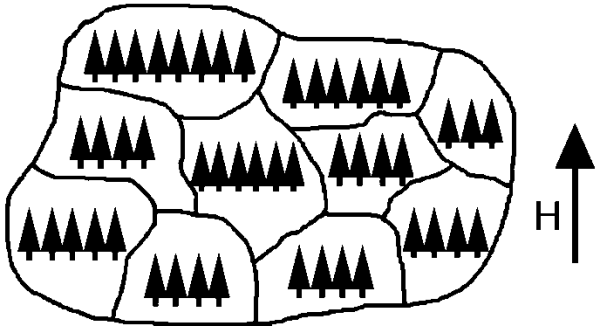

With applied field

Ferromagnetism