LECTURE 1
Goals of the Course

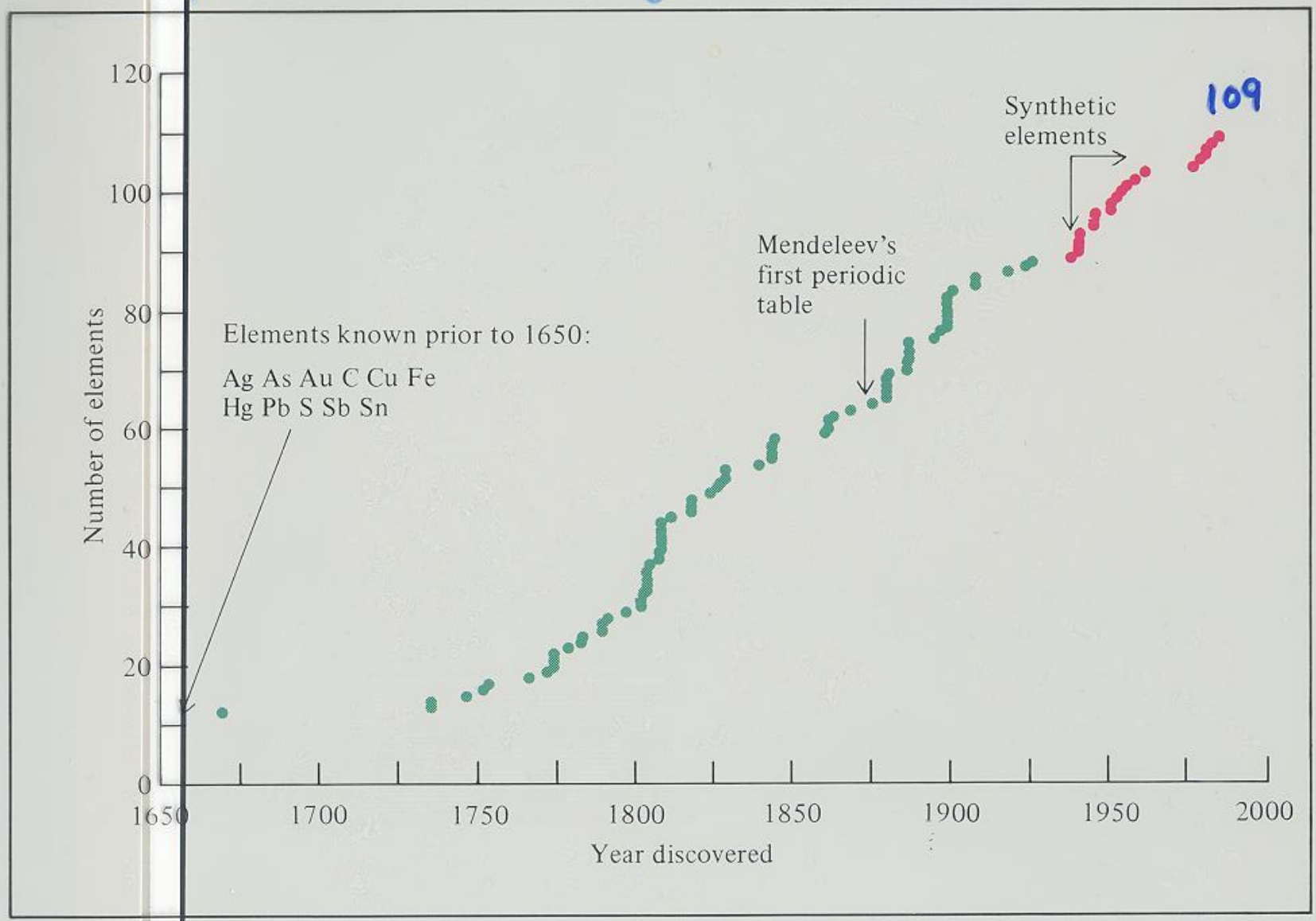
1. **To be familiar with the periodic table and how it is organized according to the relationships among the elements.**

2. **To have a firm grasp of fundamental physical principles regarding energy (thermodynamics) and reaction rates (kinetics) such that you can use this knowledge to make predictions.**

3. **To accumulate a database of descriptive chemistry of the inorganic elements (facts are important!)**

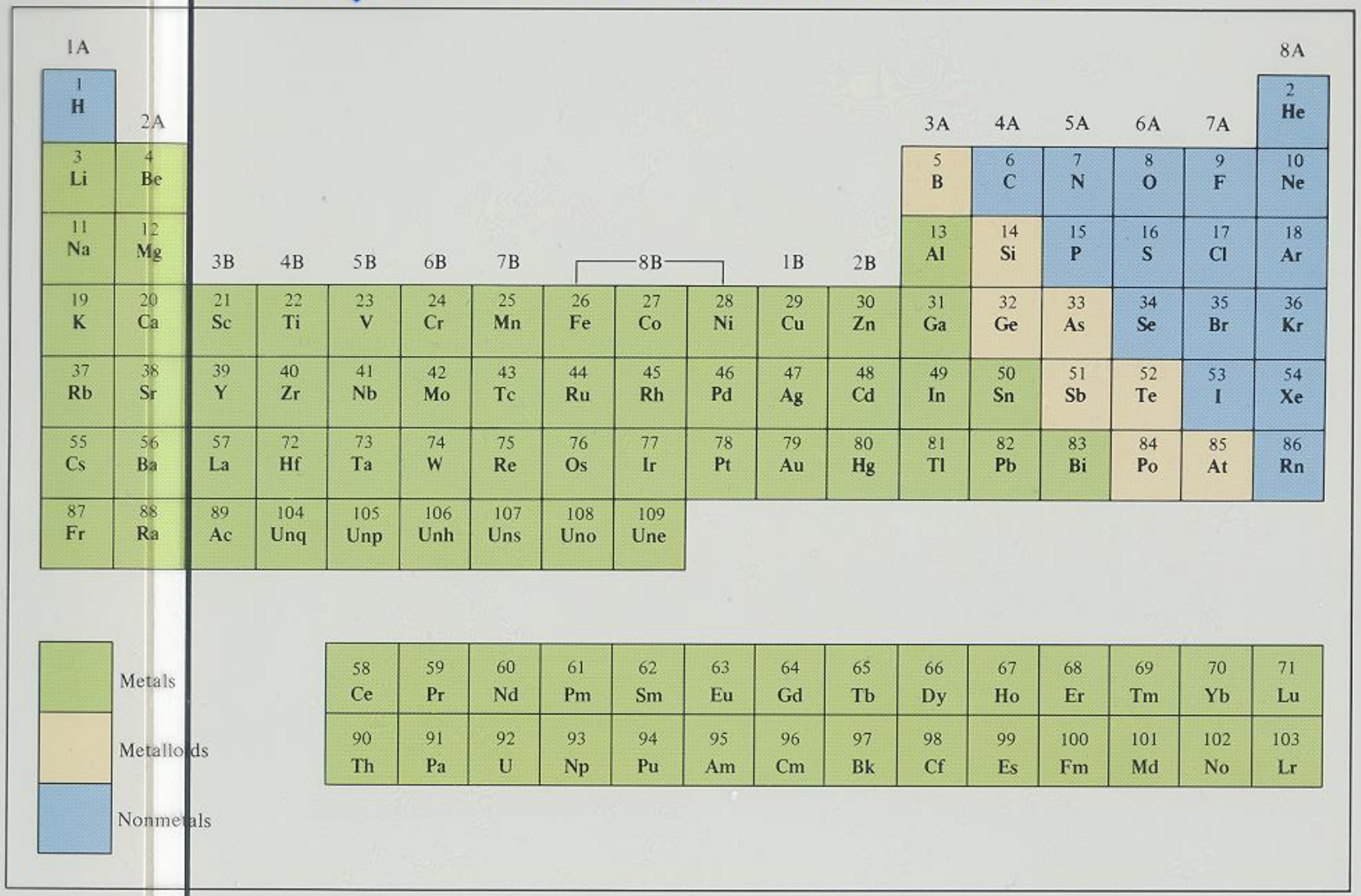
4. **Ultimately to achieve a basic understanding, through the knowledge of facts, of the periodicity of structure, bonding and reactivity patterns.**

Timeline for Discover of the Elements



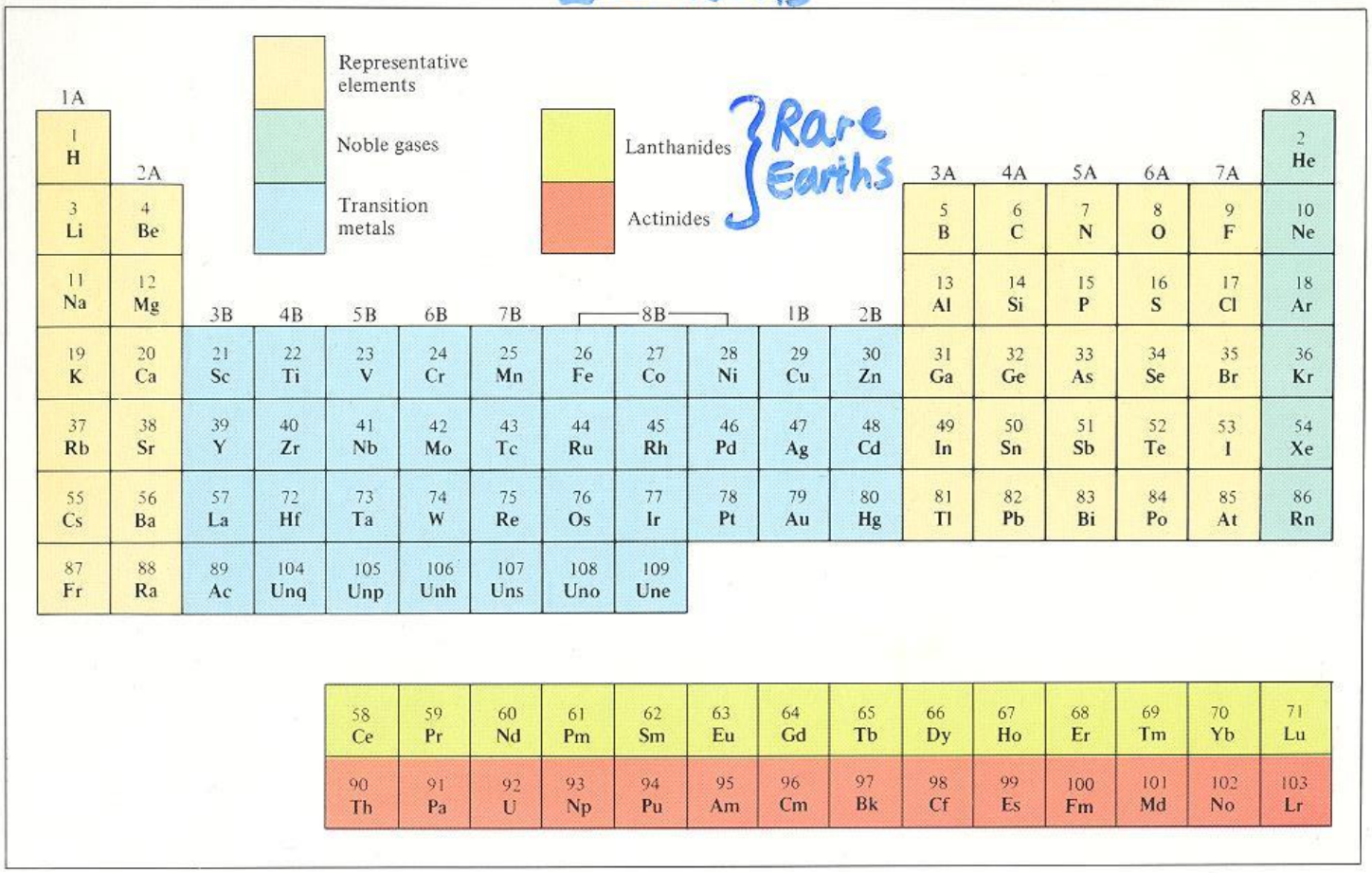
Metals, Non-Metals and Metalloids

Figure 1.5



Detailed Classifications of the Elements

Figure 8.4



Natural Abundances in % by mass

Figure 8.26

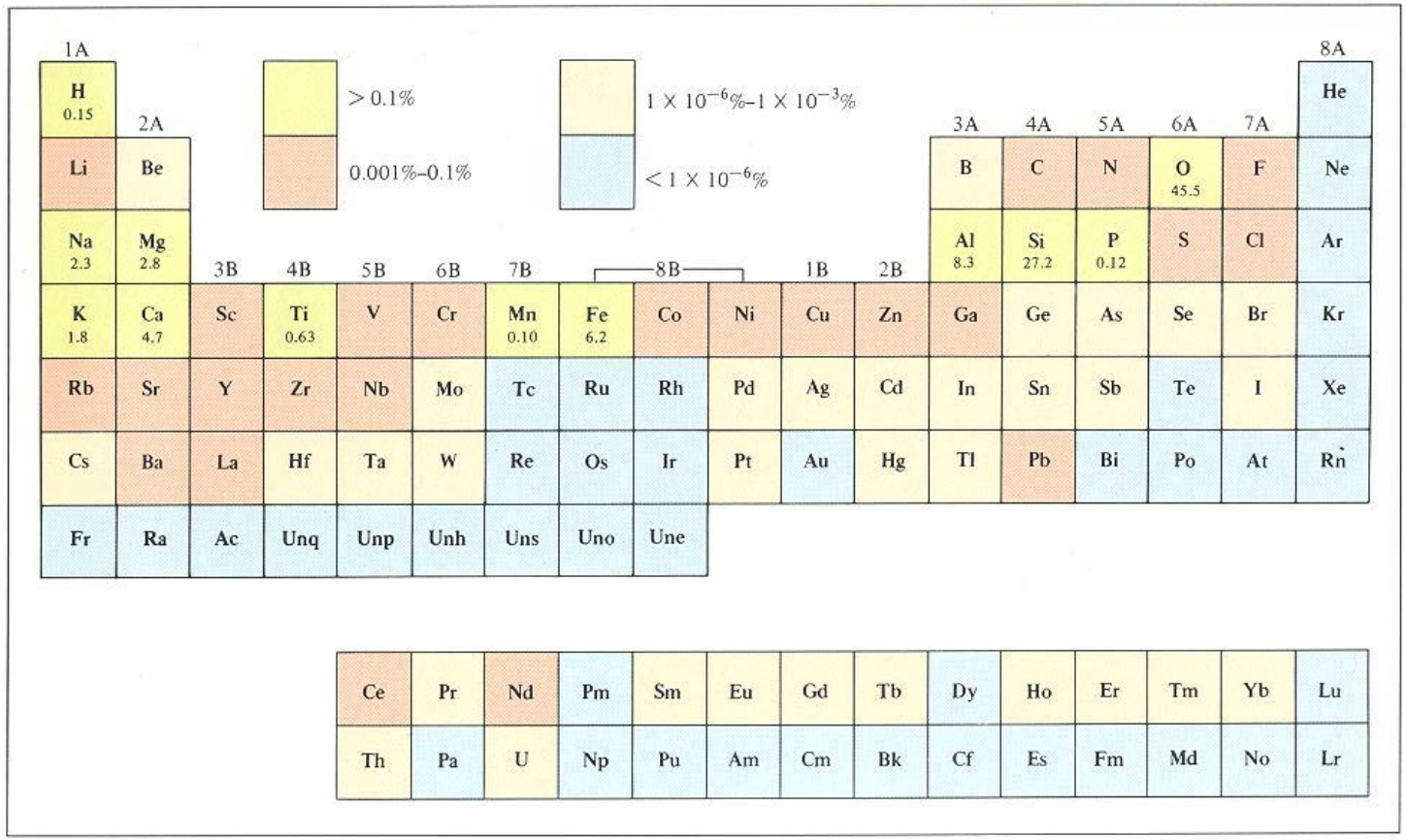
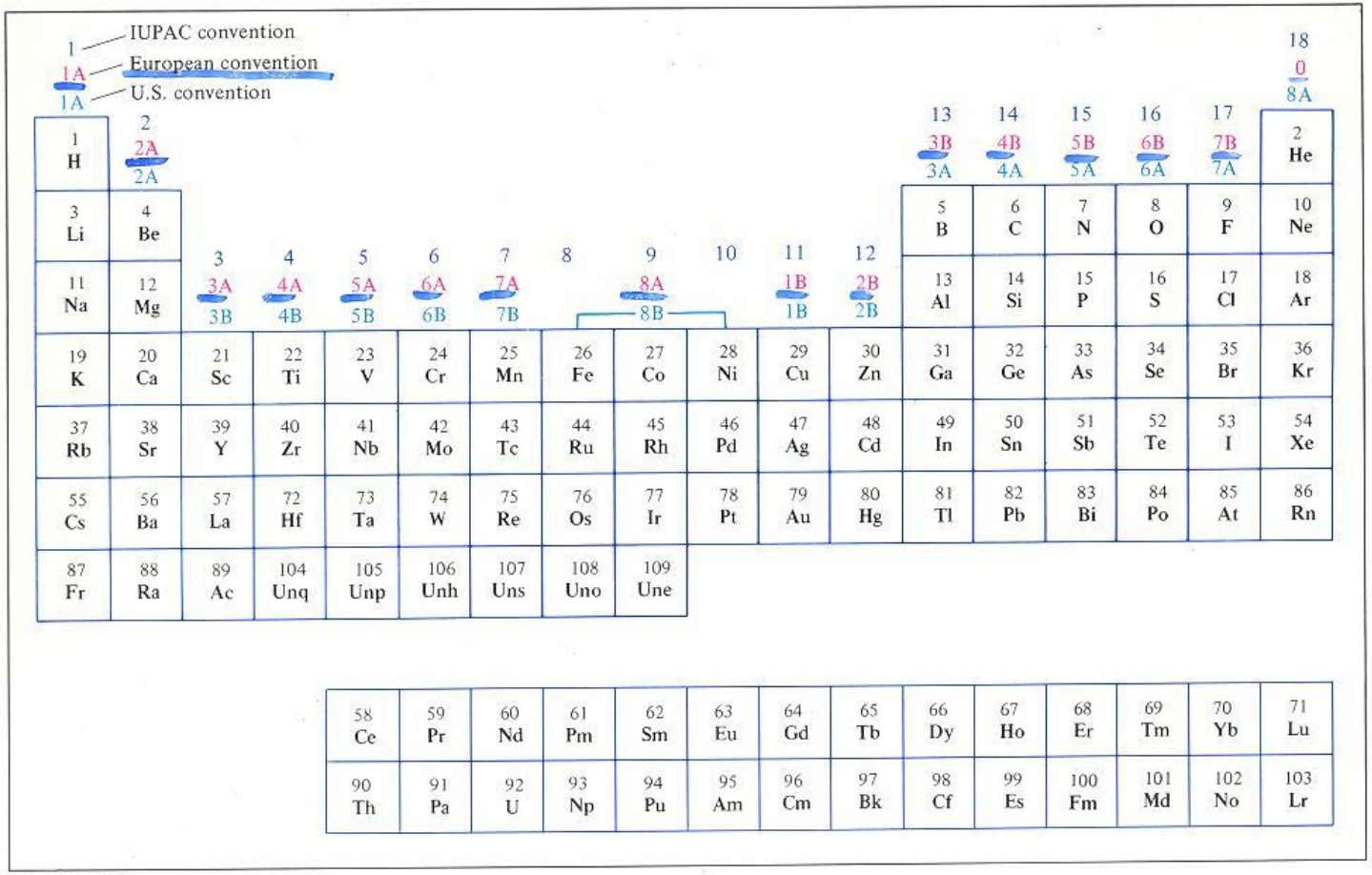


Figure 8.5



Aufbau
valence orbital fillings

Figure 8.3

	1A												3A	4A	5A	6A	7A	8A
1	1 H $1s^1$	2A																2 He $1s^2$
2	3 Li $2s^1$	4 Be $2s^2$											5 B $2s^2 2p^1$	6 C $2s^2 2p^2$	7 N $2s^2 2p^3$	8 O $2s^2 2p^4$	9 F $2s^2 2p^5$	10 Ne $2s^2 2p^6$
3	11 Na $3s^1$	12 Mg $3s^2$	3B	4B	5B	6B	7B	8B			1B	2B	13 Al $3s^2 3p^1$	14 Si $3s^2 3p^2$	15 P $3s^2 3p^3$	16 S $3s^2 3p^4$	17 Cl $3s^2 3p^5$	18 Ar $3s^2 3p^6$
4	19 K $4s^1$	20 Ca $4s^2$	21 Sc $4s^2 3d^1$	22 Ti $4s^2 3d^2$	23 V $4s^2 3d^3$	24 Cr $4s^1 3d^5$	25 Mn $4s^2 3d^5$	26 Fe $4s^2 3d^6$	27 Co $4s^2 3d^7$	28 Ni $4s^2 3d^8$	29 Cu $4s^1 3d^{10}$	30 Zn $4s^2 3d^{10}$	31 Ga $4s^2 4p^1$	32 Ge $4s^2 4p^2$	33 As $4s^2 4p^3$	34 Se $4s^2 4p^4$	35 Br $4s^2 4p^5$	36 Kr $4s^2 4p^6$
5	37 Rb $5s^1$	38 Sr $5s^2$	39 Y $5s^2 4d^1$	40 Zr $5s^2 4d^2$	41 Nb $5s^1 4d^4$	42 Mo $5s^1 4d^5$	43 Tc $5s^2 4d^5$	44 Ru $5s^1 4d^7$	45 Rh $5s^1 4d^8$	46 Pd $4d^{10}$	47 Ag $5s^1 4d^{10}$	48 Cd $5s^2 4d^{10}$	49 In $5s^2 5p^1$	50 Sn $5s^2 5p^2$	51 Sb $5s^2 5p^3$	52 Te $5s^2 5p^4$	53 I $5s^2 5p^5$	54 Xe $5s^2 5p^6$
6	55 Cs $6s^1$	56 Ba $6s^2$	57 La $6s^2 5d^1$	72 Hf $6s^2 5d^2$	73 Ta $6s^2 5d^3$	74 W $6s^2 5d^4$	75 Re $6s^2 5d^5$	76 Os $6s^2 5d^6$	77 Ir $6s^2 5d^7$	78 Pt $6s^1 5d^9$	79 Au $6s^1 5d^{10}$	80 Hg $6s^2 5d^{10}$	81 Tl $6s^2 6p^1$	82 Pb $6s^2 6p^2$	83 Bi $6s^2 6p^3$	84 Po $6s^2 6p^4$	85 At $6s^2 6p^5$	86 Rn $6s^2 6p^6$
7	87 Fr $7s^1$	88 Ra $7s^2$	89 Ac $7s^2 6d^1$	104 Unq $7s^2 6d^2$	105 Unp $7s^2 6d^3$	106 Unh $7s^2 6d^4$	107 Uns $7s^2 6d^5$	108 Uno $7s^2 6d^6$	109 Une $7s^2 6d^7$									

58 Ce $6s^2 4f^1 5d^1$	59 Pr $6s^2 4f^3$	60 Nd $6s^2 4f^4$	61 Pm $6s^2 4f^5$	62 Sm $6s^2 4f^6$	63 Eu $6s^2 4f^7$	64 Gd $6s^2 4f^7 5d^1$	65 Tb $6s^2 4f^9$	66 Dy $6s^2 4f^{10}$	67 Ho $6s^2 4f^{11}$	68 Er $6s^2 4f^{12}$	69 Tm $6s^2 4f^{13}$	70 Yb $6s^2 4f^{14}$	71 Lu $6s^2 4f^{14} 5d^1$
90 Th $7s^2 6d^2$	91 Pa $7s^2 5f^2 6d^1$	92 U $7s^2 5f^3 6d^1$	93 Np $7s^2 5f^4 6d^1$	94 Pu $7s^2 5f^6$	95 Am $7s^2 5f^7$	96 Cm $7s^2 5f^7 6d^1$	97 Bk $7s^2 5f^9$	98 Cf $7s^2 5f^{10}$	99 Es $7s^2 5f^{11}$	100 Fm $7s^2 5f^{12}$	101 Md $7s^2 5f^{13}$	102 No $7s^2 5f^{14}$	103 Lr $7s^2 5f^{14} 6d^1$

Figure 3.9

Oxidation Numbers of Elements in Their Compounds

1A												3A	4A	5A	6A	7A	8A
1 H +1 −1	2A																2 He
3 Li +1	4 Be +2											5 B +3	6 C +4 +2 −4	7 N +5 +4 +3 +2 +1 −3	8 O +2 $-\frac{1}{2}$ −1 −2	9 F −1	10 Ne
11 Na +1	12 Mg +2	3B	4B	5B	6B	7B	8B			1B	2B	13 Al +3	14 Si +4 −4	15 P +5 +3 −3	16 S +6 +4 +2 −2	17 Cl +7 +6 +5 +4 +3 +1 −1	18 Ar
19 K +1	20 Ca +2	21 Sc +3	22 Ti +4 +3 +2	23 V +5 +4 +3 +2	24 Cr +6 +5 +4 +3 +2	25 Mn +7 +6 +4 +3 +2	26 Fe +3 +2	27 Co +3 +2	28 Ni +2	29 Cu +2 +1	30 Zn +2	31 Ga +3	32 Ge +4 −4	33 As +5 +3 −3	34 Se +6 +4 −2	35 Br +5 +3 +1 −1	36 Kr +4 +2
37 Rb +1	38 Sr +2	39 Y +3	40 Zr +4	41 Nb +5 +4	42 Mo +6 +4 +3	43 Tc +7 +6 +4	44 Ru +8 +6 +4 +3	45 Rh +4 +3 +2	46 Pd +4 +2	47 Ag +1	48 Cd +2	49 In +3	50 Sn +4 +2	51 Sb +5 +3 −3	52 Te +6 +4 −2	53 I +7 +5 +1 −1	54 Xe +6 +4 +2
55 Cs +1	56 Ba +2	57 La +3	72 Hf +4	73 Ta +5	74 W +6 +4	75 Re +7 +6 +4	76 Os +8 +4	77 Ir +4 +3	78 Pt +4 +2	79 Au +3 +1	80 Hg +2 +1	81 Tl +3 +1	82 Pb +4 +2	83 Bi +5 +3	84 Po +2	85 At −1	86 Rn

Week 1

Review of Basic Concepts

- **Periodic Table**

- **Thermodynamics & Kinetics**

- **Electronic Structure**

WHAT IS INORGANIC CHEMISTRY?

Inorganic Chemistry is the chemistry of the elements other than that of C combined with H, O, N, S, halogens, and the physical properties that these elements and their compounds exhibit. *Inorganic Chemistry* covers a vast area of aqueous as well as non-aqueous chemistry. Types of inorganic compounds range from ionic solids to gases and molecular compounds.
Inorganic Chemistry is the chemistry of life as much as it is the chemistry of metallurgy.

To Name but a few Important Applications:
Main group elements (s, p block) are important in semiconductor technology (*e.g.*, Ga, As).

Transition elements (d block) are found in trace quantities as the active center of enzymes that catalyze all the reactions in our body, and, indeed, are the catalysts that allow us to produce vast quantities of fine chemicals and polymers from petroleum (Rh is one of the most common and is in our catalytic converters in our exhaust systems in our cars).

The rare earth elements (f block – lanthanides and actinides), many of which are radioactive, are important in magnetic materials.

Classes of Inorganic Substances

In the broadest sense, the materials that we shall discuss can be grouped into four classifications: elements, ionic compounds, molecular compounds, and polymers or network solids. The following brief list is presented to show the complicated variety of substances that are encountered in a discussion of inorganic chemistry. Greater detail is presented in the appropriate chapters to follow.

1. The elements. The elements have an impressive variety of structures and properties. Thus they can be

(a) Either atomic (Ar, Kr) or molecular (H_2, O_2) gases.
(b) Molecular solids (P_4, S_8, C_{60}).
(c) Extended molecules or network solids (diamond, graphite).
(d) Solid (W, Co) or liquid (Hg, Ga) metals.

2. Ionic Compounds. These compounds are always solids at the standard temperature and pressure. They include

(a) Simple ionic compounds, such as NaCl, which are soluble in water or other polar solvents.

(b) Ionic oxides that are insoluble in water (e.g., ZrO_2) and mixed oxides such as spinet ($MgAl_2O_4$), the various silicates [e.g., $CaMg(Sio_3)_2$], and so on.
(c) Other binary halides, carbides, sulfides, and similar materials. A few examples are AgCl, SiC, GaAs, and BN, some of which should be better considered to be network solids.
(d) Compounds containing polyatomic (so-called complex) ions, such as $[SiF_6]^{2-}$, $[Co(NH_3)_6]^{3+}$, $[Fe(CN)_6]^{4-}$, and $[Ni(H_2O)_6]^{2+}$.

3. Molecular compounds. These compounds may be solids, liquids, or gases, and include, for example,
(a) Simple, binary compounds, such as PF_3, SO_2, OsO_4, and UF_6.
(b) Complex metal-containing compounds, such as $PtCl_2(PMe_3)_2$ and $RuH(CO_2Me)(PPh_3)_3$.
(c) Organometallic compounds that characteristically have metal-to-carbon bonds. Some examples are $Ni(CO)_4$, $Zr(CH_2C_6H_5)_4$, and $U(C_8H_8)_2$.

4. Network solids or polymers. Examples of these substances (discussed in Chapter 32), include the numerous and varied inorganic polymers and superconductors. One example of the latter has the formula $YBa_2Cu_3O_7$.

Classes of Inorganic Structures

Organic is mostly based on the tetrahedral geometry.

Why?

Carbon requires 4 electrons to complete its valence and a tetrahedron is the best way to arrange four groups around a central atom (w/o lone pairs) with s and p orbitals.

Inorganic chemistry is much more complicated.

tetrahedron
cube
octahedron
dodecahedron
Icosahedron

} For example,
The five “Platonic solids”
form the basis for many inorganic structures

Less regular polyhedra:

Trigonal bipyramid
Trigonal prism
Square prism

And

Other planar structures:

Chains
Square planes
Triangles

Are also known for inorganic structures.

⇨ Quite diverse

Classes of Inorganic Reactions
Cotton book cites 12 different ones:

1. Acid – base. According to the definition of Bronsted-Lowry, the neutralization of a proton donor by a proton acceptor. According to the definition of Lewis, the formation of an adduct between an electron-pair donor and an electron-pair acceptor. A lesser known definition is that of Lux-Flood, namely the reaction of an oxide ion acceptor with an oxide.

2. Addition. A reaction in which a group, molecule, or ion combines with another. Common examples are additions across a multiple bond and addition to an atom that is able to undergo coordination sphere expansion (an increase in occupancy). This reaction is the converse of elimination.

3. Elimination. A reaction in which a group, molecule, or ion is separated from another. Examples are dehydrohalogenations, and eliminations from metal centers that are able to undergo coordination number reduction (a decrease in occupancy). This is the converse of an addition reaction.

4. Redox (a reaction in which an atom, ion or molecule gains (reduction) or loses (oxidation) an electron or electrons.

5. Insertion. The interposition of a new molecule, group, or ion between atoms in a structure such that the added molecule, group, or ion separates the two parts of the structure that were formerly bound together.

6. Substitution (Displacement). The exchange of one atom, molecule or ion for another in a compound.

7. Rearrangement (Isomerization). A conversion of one isomer into another (cis-trans for example).

8. Metathesis (Exchange). An exchange of comparable groups, such that two compounds form two new ones:

   AX + BY **à** AY + BX

9. Solvolysis. A reaction with solvent; when the solvent is water it is called hydrolysis.

10. Chelation. A reaction in which a group (typically called a ligand) is able to bond to a central metal ion simultaneously through more than one donor atom.

11. Cyclization. A reaction that leads to the formation of a ring.

12. Nuclear reaction. A reaction that changes the atomic number or mass number of an atom.