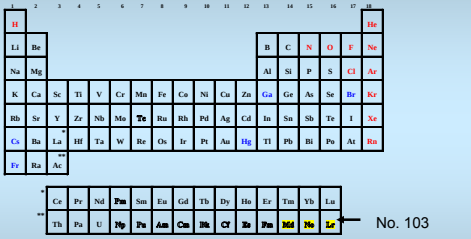
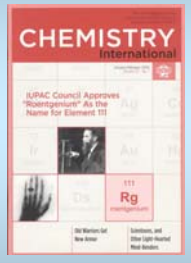
The elements: their names?



Naming trans-uranium elements

Atomic number	Systematic name	Final name 1997
101	unnilunium (Unu)	mendelevium (Md)
102	unnilbium (Unb)	nobelium (No)
103	unniltrium (Unt)	lawrencium (Lr)
104	unnilquadium (Unq)	rutherfordium (Rf)
105	unnilpentium (Unp)	dubnium (Db)
106	unnilhexium (Unh)	seaborgium (Sg)
107	unnilseptium (Uns)	bohrium (Bh)
108	unniloctium (Uno)	hassium (Hs)
109	unnilennium (Une)	meitnerium (Mt)
110	ununnilium (Uun)	darmstadtium (Ds)
111	unununium (Uuu)	roentgenium (Rg) (2005)
112	ununbium (Uub)	copernicium (Cn) (2010)

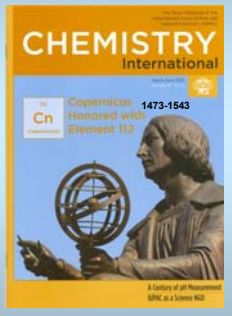


$^{64}Ni + {}^{209}Bi \rightarrow {}^{272}Rg + n$

Copernicium

112: ununbium uub , now Cn

In group12 below Mercury Hg



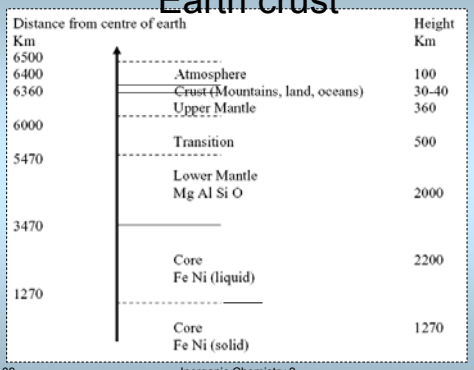
Bronze statue by Bertel Thorvaldsen

The elements 1 - 112

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	* La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	** Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn						

*	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
**	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Earth crust

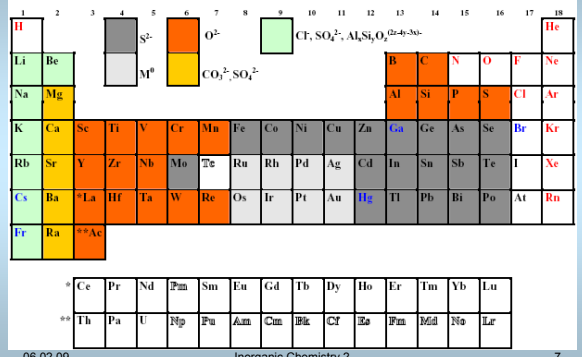


The composition of earth's crust (numbers in ppm)

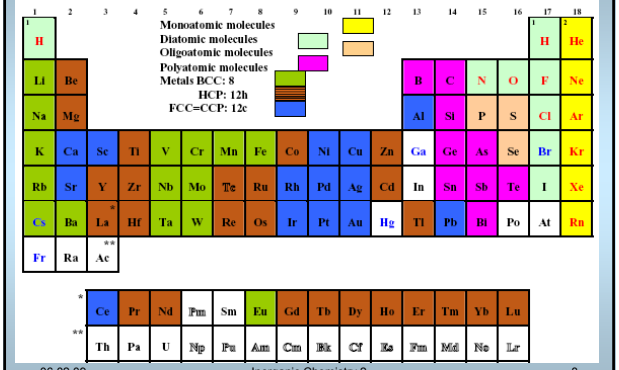
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H 9000																	He $4\cdot10^{-3}$
Li 70	Be 6											B 3	C 300	N 300	O $46.6\cdot10^4$	F 300	Ne $5\cdot10^{-3}$
Na $2.8\cdot10^4$	Mg $2.1\cdot10^4$											Al $8.1\cdot10^4$	Si $27.7\cdot10^4$	P 800	S 500	Cl 500	Ar 4
K $2.6\cdot10^4$	Ca $3.6\cdot10^4$	Sc 5	Ti 4000	V 200	Cr 200	Mn 1000	Fe $5\cdot10^4$	Co 40	Ni 100	Cu 100	Zn 40	Ga 20	Ge 7	As 5	Se 0.09	Br 6	Kr $2\cdot10^{-4}$
Rb 300	Sr 200	Y 30	Zr 200	Nb 20	Mo 20	Tc	Ru $2\cdot10^{-7}$	Rh $1\cdot10^{-3}$	Pd 0.01	Ag 0.1	Cd 0.5	In 0.1	Sn 40	Sb 1	Te $2\cdot10^{-3}$	I 0.3	Xe $2\cdot10^{-3}$
Cs 7	Ba 300	*La 20	Hf 5	Ta 20	W 70	Re $1\cdot10^{-3}$	Os $6\cdot10^{-4}$	Ir $1\cdot10^{-3}$	Pt $5\cdot10^{-3}$	Au $5\cdot10^{-3}$	Hg 0.5	Tl 0.3	Pb 20	Bi 0.2	Po	At	Rn
Fr	Ra	**Ac															

*	Ce 50	Pr 6	Nd 20	Pm	Sm 6	Eu 1	Gd 6	Tb 0.9	Dy 4	Ho 1	Er 2	Tm 0.3	Yb 3	Lu
**	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Appearance of the Elements in nature



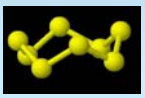
The elements in standard state



Small Molecules

X_2

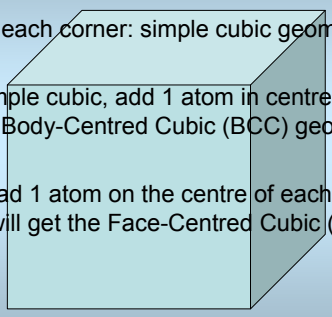
P_4



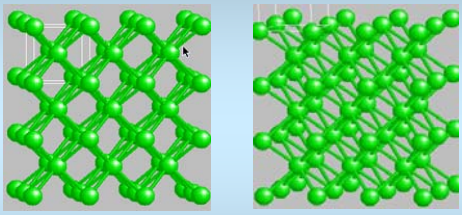
S_8

Cubic arrangements

- 1 atom in each corner: simple cubic geometry
- To the simple cubic, add 1 atom in centre; then you get a Body-Centred Cubic (BCC) geometry
- Add instead 1 atom on the centre of each face, and you will get the Face-Centred Cubic (FCC) geometry



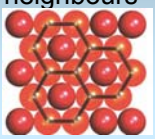
Iron

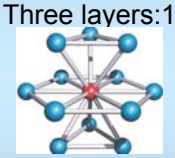


Body-Centred Cubic: BCC
8 – 8 coordination

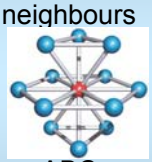
Packing of spheres

- Close-packing in one layer: 6 neighbours
- Three layers:12 neighbours





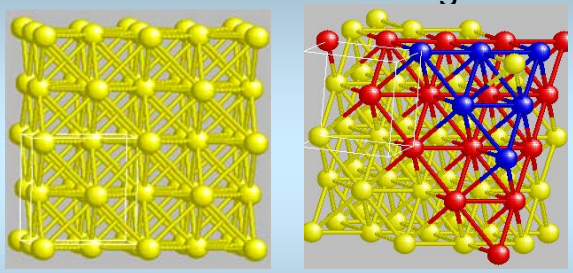
ABA
Hexagonal
HCP



ABC
Cubic
CCP

close-packing

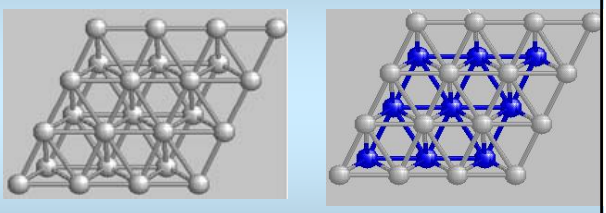
Cubic Close-Packing



Gold CCP Also called Face-Centred Cubic: FCC

12 – 12 coordination

Hexagonal Close-Packing



Zink HCP

12 – 12 coordination

The elements in standard state

Monoatomic molecules
Diatomic molecules
Oligoatomic molecules
Polyatomic molecules
Metals BCC: 8
HCP: 12h
FCC=CCP: 12c

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																H	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	* La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	** Ac															

*	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
**	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

VSEPR model

Valence Shell Electron Pair Repulsion model for covalent molecules (and ions)

Identify central atom

Count the number of electrons around that atom

Pairs of electrons in lone pairs and in bonds repel each other and occupy a bit space

VSEPR

Repulsion determine geometry around central atom. Predictons:

2 pairs: linear

3 pairs: trigonal planar

4 pairs: tetrahedral

5 pairs: trigonal bipyramidal

6 pairs: octahedron

7 pairs: pentagonal bipyramidal

A lone pair is a little more repulsive than an electron pair bond

VSEPR

H_2S	SbF_5
I_3^-	BH_4^-
H_2O	H_3O^+
I_3^+	NF_3
IF_7	ClO_2^-
SO_3	XeF_4

Atomic property

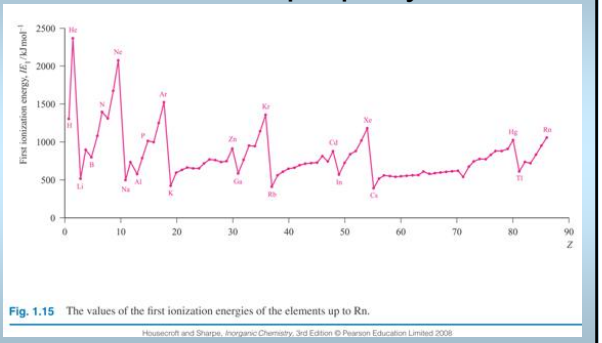


Fig. 1.15 The values of the first ionization energies of the elements up to Rn.

Housecroft and Sharpe, *Inorganic Chemistry*, 3rd Edition © Pearson Education Limited 2008

Electronegativity

- To understand **Polar bonds** in molecules

Usefull concept : Electronegativity
without a firm theoretical background

Pauling: $\Delta H^{o}_{atom\ A}$ in A-A

$$(\chi_A - \chi_B)^2 \sim D(A\text{-}B) - \tfrac{1}{2}[D(A\text{-}A) - D(B\text{-}B)]$$

Electronegativity

Pauling

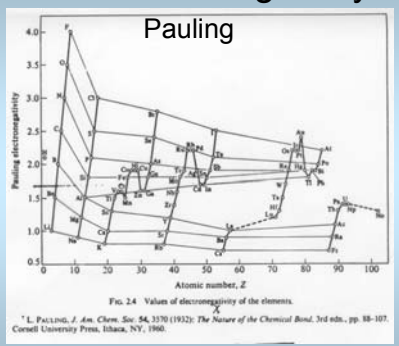


FIG. 2.4 Values of electronegativity of the elements.

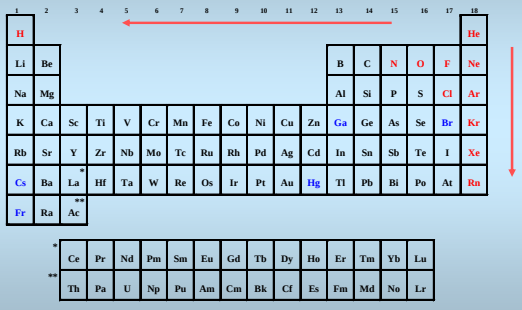
† L. PAULING, *J. Am. Chem. Soc.* **54**, 3570 (1932); *The Nature of the Chemical Bond*, 3rd edn., pp. 88–107. Cornell University Press, Ithaca, NY, 1960.

Electronegativity

- Pauling: $(\chi_A - \chi_B)^2 \sim D(A\text{-}B) - \frac{1}{2}[D(A\text{-}A) - D(B\text{-}B)]$
- Mulliken: $\chi_A = k \cdot (\Delta H_{ion} - \Delta H_{EA})$
- Allred-Rochow: $\chi_A = .359 \cdot (Z_{eff}/r^2) + .744$

Σ: Values are much alike

Less electronegative



Chemistry:

- Micro-level

Breaking and forming bonds between atoms

Shifting and removing electrons

- Macro-level

Chemical reactions to make new compounds

Physical properties of compounds

Bond types X-A

- $\chi_A - \chi_X$ zero (A=X): covalent bonds.
  Non-polar molecules (small to mega-large)
- $\chi_A - \chi_X$ large: electrostatic bonds: Salts (solids) in extended structures
- $\chi_A - \chi_X$ moderate: polar covalent bonds.
  Polar molecules

Polarity of bonds

Structure and polar molecules

H_2S CO_2 BF_3

HCN PF_5 SO_2

Dipole moment?

Structure and polar molecules

Why is IF_5 polar?

Which ionisation potential is larger. That of potassium or that of lithium?

Why is BI_3 trigonal planar, while PI_3 is trigonal pyramidal?

Polarity of bonds

- Solubility in polar and non-polar solvents (molecules)
- Reactivity towards polar molecules or ions - consider partial charge
- Lewis acidity and basicity

Acids and bases

- Continued