Periodicity and Nomenclature

“...I have tried to base a system on the magnitudes of the atomic weights of the elements. My first attempt in this respect was the following: I chose the smallest atomic weights and arranged them according to the sizes of their atomic weights. This showed that there existed a periodicity in the properties of these simple substances and that even according to their atomicity [valence] the **elements followed one another in the arithmetical sequence of their atomic weights**.“

Dimitri Ivanovich Mcndeleyev (Mendeleev), 1869

LAB REPORTS

due next week (1 week after lab)

include prelab again

quiz next Friday in discussion

online 8 am labs begin at 9 am

myuic.edu, Excel, LibreOffice

REVIEW FROM WEDNESDAY

Law of Multiple Proportions

When two elements form a series of compounds the masses of one element that combine with a fixed mass of the other element are in the ratio of small integers to each other

EX 3. Chlorine (Cl) and oxygen form four different binary compounds. Analysis gives the following results

a) Show that the law of multiple proportions holds for these compounds.

cmpd	mass O combined with 1.0000 g Cl
A	0.22564 g
B	0.90255
C	1.3539
D	1.5795

B/A = 0.90255/0.22564 = 3.9999... = 4

C/A = 1.3539/0.22564 = 5.9998... = 6

D/A = 1.5795/0.22564 = 7.0000... = 7

b) If the formula of compound A is a multiple of Cl_2O, then determine the formulas of the other compounds.

Note: B/A = $\mathbf{(m_O/m_{Cl})_B \,/\, (m_O/m_{Cl})_A = (m_O \div M_o/m_{Cl} \div M_{Cl})_B \,/\, (m_O \div M_o/m_{Cl} \div M_{Cl})_A = (n_O/n_{Cl})_B \,/\, (n_O/n_{Cl})_A}$

then A = $x(Cl_2O)$ => $(n_O/n_{Cl})_A = ½$

so B/A = 4 => Cl_2O_4 ClO_2 Cl_3O_6

B/A = 6 => Cl_2O_6 ClO_3 Cl_3O_9

B/A = 7 => Cl_2O_7

law of multiple proportions is based on mole ratios

REVIEW FROM WEDNESDAY

Atomic Theory

1803 – Dalton's Atomic Theory

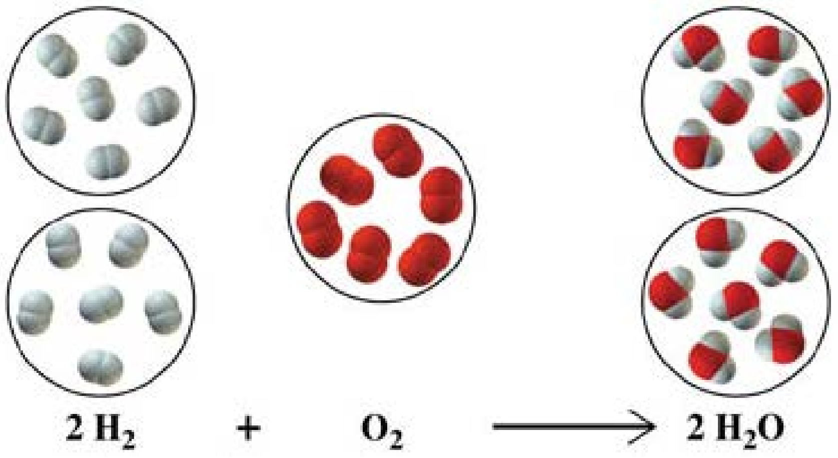
all matter consists of individual atoms
atoms are indestructible
all atoms of the same element are identical
different elements have different kinds of atoms
compounds formed from elements combining in small whole-number ratios

1808 - Guy-Lussac: gases (same *T, P)* combine in simple whole number ratios

1811 - **Avogadro's Hypothesis** - equal *V* (gas; same *T*, *P)* contain equal number of particles

$PV = nRT \Rightarrow \quad n = PV/RT$

Avogadro's law corrected Dalton's flaw and showed that many gases exist as diatomics

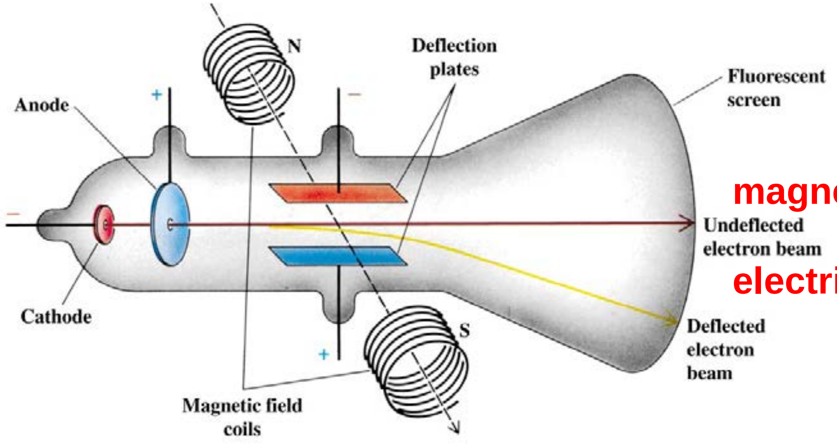


1860 - Cannizzaro: experiments convinced world that Avogadro was correct

REVIEW FROM WEDNESDAY

Building Blocks of Atoms electrons, protons, neutrons (electrons and **quarks**!)

FIG I. 1897 – Thomson: charge/mass of e^-
(Plum Pudding Model, e^- + cloud of charge)



deflects up
magnetic field (N → S) ↑
electric field (– → +) ↓
deflects down

FIG II. 1909 – Mulikan: charge (oil drop exp)

gas in chamber ionized, e^-'s produced adhere to droplets

- gravity ↓
- electric field (– → +) ↑

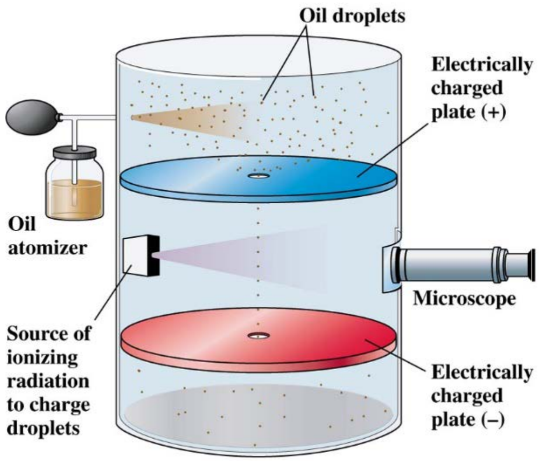
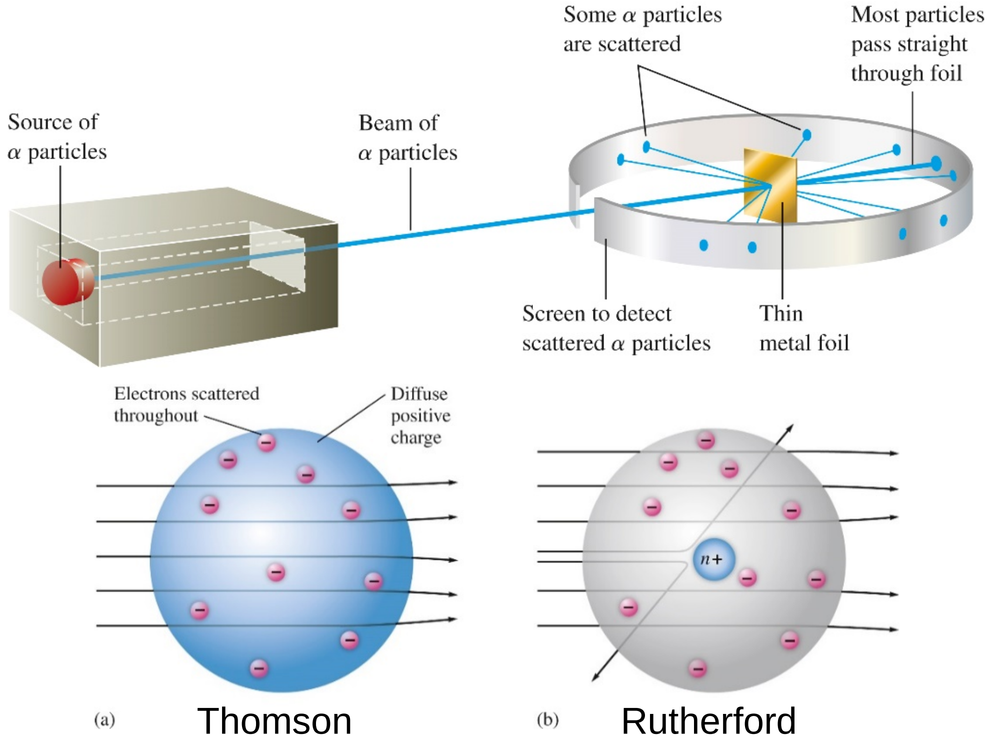
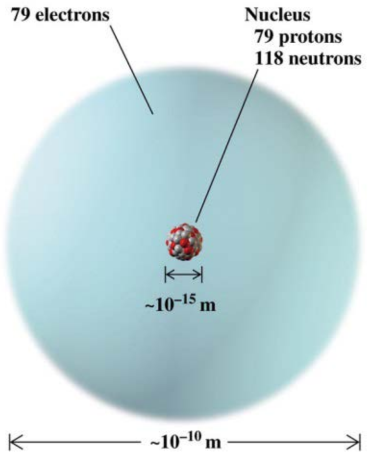


FIG III. 1909 – Geiger/Marsden (α off Au) $^4_2He^{2+}$
(**nuclear model** – V, e^-; m small + nucleus)
1898 – Rutherford discovered α, β (1908 Nobel)
1911 – explanation, nucleus (mass, + charge)
1919 – discovers proton
1932 – Chadwick discovers neutron



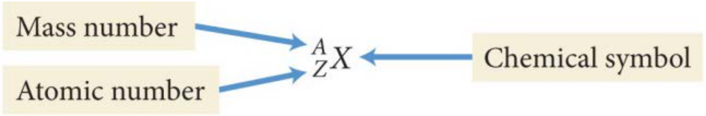
Basics of the Atom

small, dense world – example of an atom of gold
diameter of a nucleus, 10^{-15} m
diameter of an atom, 10^{-10} m
density of 2.3×10^{14} g cm^{-3}

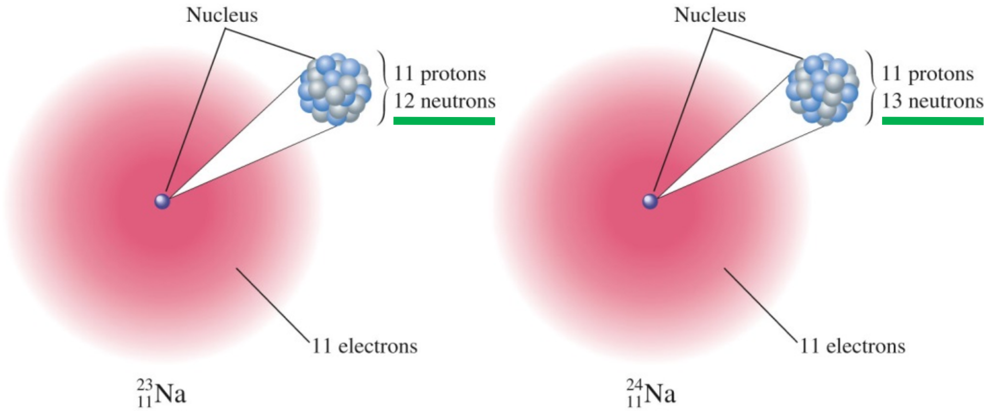


particle	charge	atomic mass units (amu)
electron	-1	0.000548579911
proton	+1	1.0072764669
neutron	0	1.0086649158

designation



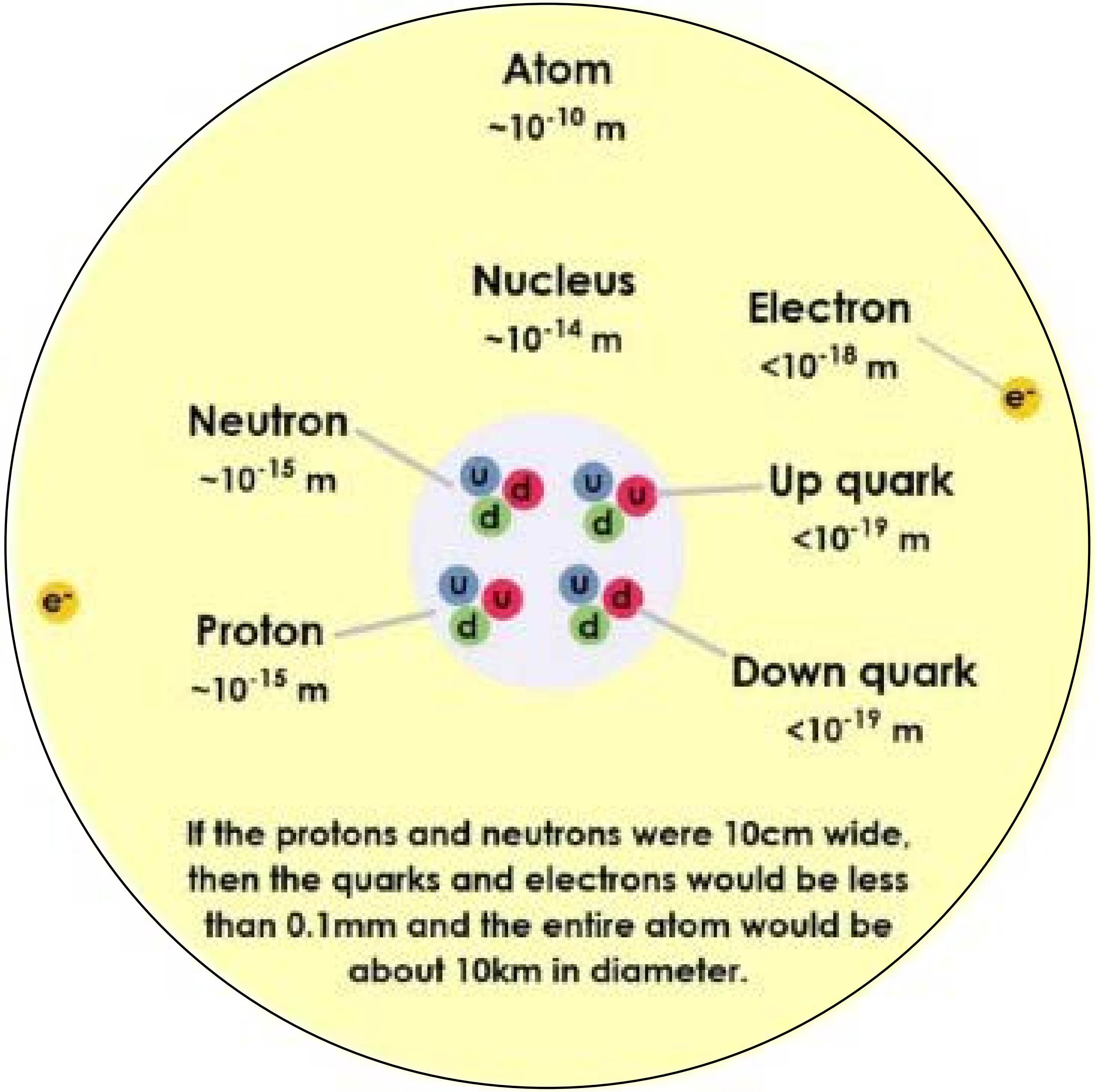
Z = atomic number (number of protons)
A = mass number (sum of the numbers of protons and neutrons) – there can be isotopes



Two Isotopes of Sodium
differ in number of neutrons

leptons (*e.g.*, electrons) and quarks are the true elementary particles of matter
proton – 2u (+2/3) + 1d (-1/3)
neutron – 2d (-1/3) + 1u/(+2/3)

Structure of Helium Nucleus (^4_2He)



The Periodic Table

Its Organization, and Chemistry (a beginning ...)

1A	2A	3B	4B	5B	6B	7B	--------	8B	--------	1B	2B	3A	4A	5A	6A	7A	8A
1 H 1.008																	2 He 4.0026
3 Li 6.94	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.085	15 P 30.974	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.85	27 Co 58.933	28 Ni 58.693	29 Cu 63.55	30 Zn 65.4	31 Ga 69.723	32 Ge 72.63	33 As 74.922	34 Se 78.97	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.906	42 Mo 495.95	43 Tc (97/8)	44 Ru 101.1	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.6	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.5	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.2	77 Ir 102.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 201.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (271)	108 Hs (277)	109 Mt (276/7)	110 Ds (281)	111 Rg (282)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (290)	116 Lv (293)	117 Ts (294)	118 Og (294)

Lanthanides	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.3	65 Tb 158.93	66 Dy 162.50	67 Ho 164.94	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
Actinides	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (253)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

Major Classification

metals
nonmetals
metalloids (semimetals)

Periods/Groups

main group
transition
lanthanides
actinides

Main Group Elements

alkali metals
alkaline earth metals
chalcogens
halogens
noble gases

Electronegativity

Acidic/Basic

basic oxides (Na_2O)
acidic oxides (SO_3)
amphoteric (Al_2O_3)

ACTINIUM	Ac	GOLD	Au	polonium	Po
ALUMINUM	Al	hafnium	Hf	POTASSIUM	K
americium	Am	hassium	Hs	praseodymium	Pr
ANTIMONY	Sb	HELIUM	He	promethium	Pm
ARGON	Ar	holmium	Ho	protactinium	Pa
ARSENIC	As	HYDROGEN	H	RADIUM	Ra
astatine	At	indium	In	RADON	Rn
BARIUM	Ba	IODINE	I	rhenium	Re
berkelium	Bk	iridium	Ir	rhodium	Rh
BERYLLIUM	Be	IRON	Fe	roentgenium	Rg
BISMUTH	Bi	KRYPTON	Kr	RUBIDIUM	Rb
bohrium	Bh	LANTHANUM	La	ruthenium	Ru
BORON	B	lawrencium	Lr	rutherfordium	Rf
BROMINE	Br	LEAD	Pb	samarium	Sa
CADMIUM	Cd	LITHIUM	Li	scandium	Sc
CALCIUM	Ca	livermorium	Lv	seaborgium	Sg
californium	Cf	lutetium	Lu	SELENIUM	Se
CARBON	C	MAGNESIUM	Mg	SILICON	Si
cerium	Ce	MANGANESE	Mn	SILVER	Ag
CESIUM	Cs	meitnerium	Mt	SODIUM	Na
CHLORINE	Cl	mendelevium	Md	STRONTIUM	Sr
CHROMIUM	Cr	MERCURY	Hg	SULFUR	S
COBALT	Co	molybdenum	Mo	tantalum	Ta
copernecium	Cn	moscovium	Mc	technetium	Tc
COPPER	Cu	neodymium	Nd	TELLURIUM	Te
curium	Cm	NEON	Ne	tennessine	Ts
darmstadtium	Ds	neptunium	Np	terbium	Tb
dubnium	Db	NICKEL	Ni	thallium	Tl
dysprosium	Dy	nihonium	Nh	thorium	Th
einsteinium	Es	niobium	Nb	thulium	Tm
erbium	Er	NITROGEN	N	TIN	Sn
europium	Eu	nobelium	No	titanium	Ti
fermium	Fm	oganesson	Og	TUNGSTEN	W
flevorium	Fl	osmium	Os	URANIUM	U
FLUORINE	F	OXYGEN	O	vanadium	V
francium	Fr	palladium	Pd	XENON	Xe
gadolinium	Gd	PHOSPHORUS	P	ytterbium	Yb
gallium	Ga	PLATINUM	Pt	yttrium	Yr
germanium	Ge	PLUTONIUM	Pu	ZINC	Zn
				zirconium	Zr

Elements to Know (in capital letters)

Seven oldest known metals

Not modern

Spelling

Most common ending: __ium

Few have ending: __um

Halogens ending: __ine

Non-halogen diatomic gases (H_2, N_2, O_2): __gen

Noble gases (not He), B, C, Si: __on

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	Nh	Fl	Mc	Lv	Ts	Og
				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

When you want to have some fun!

astrology
astronomy
religion
language
chemistry

all come together

The Chemical Elements: Their Names, Symbols, and History

The Seven Metals Known to the Ancients (A cosmic allegory)

> "If gold ruste, what shall iren do?"
> Geoffrey Chaucer (1340?-1400)
> Canterbury tales, prologue, line 500

About 1700 B.C., the Chaldeans invented a cosmology in which the seven days of the week and the seven known heavenly bodies were identified with the seven most famous gods. Part of their argument may have been: gods don't follow rules, planets ("wanderers") don't follow rules, thus planets are gods. This system pleased them so much that they also named the seven known metals after those seven gods. As time went on, other people added further allegorical correlations to the pattern. Their system and its remnants in modern languages is outlined below.

Days of the Week	English name	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
	from Anglo-Saxon	Sun's day	Moon's day	Tiw's day	Woden's day	Thor's day	Freya's day	Saturn's day
	French name	(Dimanche)	Lundi	Mardi	Mercredi	Jeudi	Vendredi	Samedi
	German name	Sonntag	Montag	Dienstag	(Mittwoch)	Donnerstag	Freitag	Samstag
Deities		Sun god	Moon goddess	God of war	God of storms	God of thunder	Goddess of love	God of time (Father time)
	Roman name	Apollo	Luna	Mars	Mercury	Jupiter	Venus	Saturn
	Greek name	Helios	Selene	Ares	Hermes	Zeus	Aphrodite	Kronos
Moods (astrological)	English adjective	sunny	loony (lunatic)	martial	mercurial	jovial	venereal	saturnine
Planets	Heavenly bodies	Sun	Moon	Mars (the red planet)	Mercury ("fast-moving", always near sun)	Jupiter (a bright, shimmering planet)	Venus	Saturn (a "slow-moving", dull appearance planet)
Symbols	Used by alchemists	☉	☽ crescent moon	♂ spear of mars	☿ caduceus of Mercury	♃ thunderbolt of Jove (or 4th planet)	♀ looking glass of Venus	♄ scythe of Saturn
Metals	English name	**gold**	**silver**	**iron**	quicksilver	**tin**	**copper**	**lead**
	Latin name	Aurum	Argentum	Ferrum	Hydrargentum	Stannum	Cuprum	Plumbum
	Modern chemical symbol	**Au**	**Ag**	**Fe**	**Hg**	**Sn**	**Cu**	**Pb**

So, the names of the days of the week are related to seven of the elements having symbols that do not come directly from the English name. Each of these seven (the oldest known metals) do not use letters from the modern name, but rather use letters that come from the ancient name.

Other elements having symbols not derived from the modern name:

Modern name	Symbol	Former name
Antimony	Sb	Stibium (Latin)
Potassium	K	Kalium (Latin)
Sodium	Na	Natrium (Latin)
Tungsten	W	Wolfram (German)

An old (tenth century) manuscript at St. Mark's, Venice, gives the following early list:

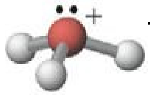
Metal		*Planet*		*Symbol*
χρυσος	gold	Ηλιος	Sun	☉
αργυρος	silver	Σεληνη	Moon	☾
μολιβος	lead	Κρονος	Saturn	♄
ηλεκτρος	electrum	Ζευς	Jupiter	♃
σιδηρος	iron	Αρης	Mars	♂
χαλκος	copper	Αφροδιτη	Venus	♀
κασσιτηρος	tin	Ερμης	Mercury	☿

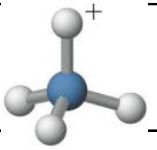
METAL	DATE OF INTRODUCTION	PLACE OF INTRODUCTION
gold	before 5000 B.C.	Armenia-Anatolia
electrum (= Ag/Au alloy)	3800	—
native copper	before 5000	Asia
smelted copper	4300	Armenia-Anatolia
bronze	4300	Armenia-Anatolia
lead	3500	—
silver (gold free)	2500	Asia Minor?
tin	1800–1600	NW Persia
iron	1400	Anatolia

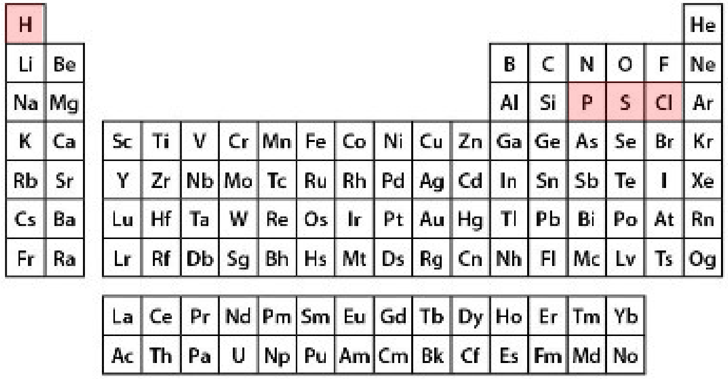
Gold is for the mistress—silver for the maid—
Copper for the craftsman, cunning at his trade.
—*Kipling.*

Nomenclature of Some **Monatomic** and Polyatomic Ions (Know)

hydride	**H^-**	oxide	O^{2-}
fluoride	F^-	**sulfide**	**S^{2-}**
chloride	**Cl^-**	nitride	N^{3-}
bromide	Br^-	**phosphide**	**P^{3-}**
iodide	I^-		
hydroxide	OH^-	sulfite	SO_3^{2-}
peroxide	O_2^{2-}	hydrogen sulfite	HSO_3^{2-}
cyanide	CN^-	sulfate	SO_4^{2-}
nitrite	NO_2^-	hydrogen sulfate	HSO_4^{2-}
nitrate	NO_3^-	chromate	CrO_4^{2-}
carbonate	CO_3^{2-}	dichromate	$Cr_2O_7^{2-}$
hydrogen carbonate	HCO_3^-	permanganate	MnO_4^-
phosphate	PO_4^{3-}	hypochlorite	ClO^-
hydrogen phosphate	HPO_4^{2-}	chlorite	ClO_2^-
dihydrogen phosphate	$H_2PO_4^-$	chlorate	ClO_3^-
arsenate	AsO_4^{3-}	perchlorate	ClO_4^-
hydronium	H_3O+	mercury(I)	Hg_2^{2+}
ammonium	NH_4^+		





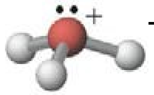


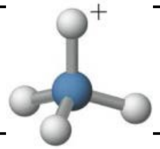
monatomic anions end with __**ide**

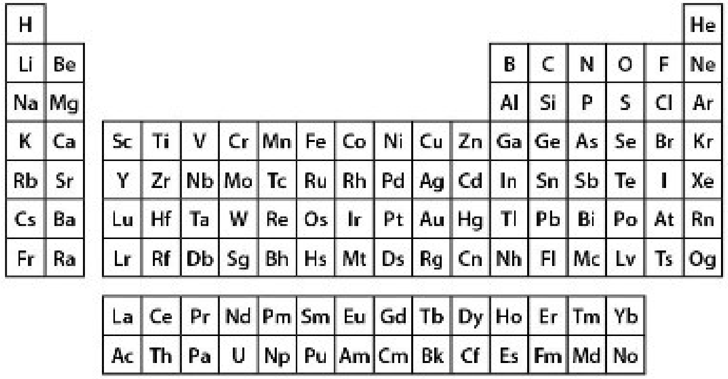
ions obtain **noble gas** electron **configuration**

Nomenclature of Some Monatomic and Polyatomic Ions (Know)

hydride	H^-	oxide	O^{2-}
fluoride	F^-	sulfide	S^{2-}
chloride	Cl^-	nitride	N^{3-}
bromide	Br^-	phosphide	P^{3-}
iodide	I^-		
hydrox**ide**	OH^-	sulfite	SO_3^{2-}
perox**ide**	O_2^{2-}	hydrogen sulfite	HSO_3^{2-}
cyan**ide**	CN^-	sulfate	SO_4^{2-}
nitrite	NO_2^-	hydrogen sulfate	HSO_4^{2-}
nitrate	NO_3^-	chromate	CrO_4^{2-}
carbonate	CO_3^{2-}	dichromate	$Cr_2O_7^{2-}$
hydrogen carbonate	HCO_3^-	permanganate	MnO_4^-
phosphate	PO_4^{3-}	hypochlorite	ClO^-
hydrogen phosphate	HPO_4^{2-}	chlorite	ClO_2^-
dihydrogen phosphate	$H_2PO_4^-$	chlorate	ClO_3^-
arsenate	AsO_4^{3-}	perchlorate	ClO_4^-
hydronium	H_3O+	mercury(I)	Hg_2^{2+}
ammonium	NH_4^+		


H_3O^+


NH_4^+

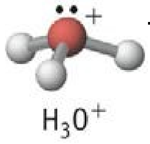


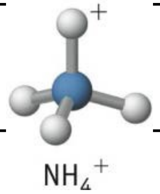
polyatomic anions also end with __**ide**

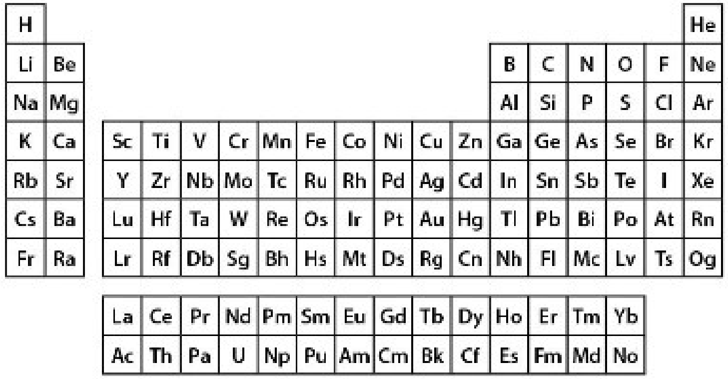
Nomenclature Depending Upon Amount of Oxygen

hydride	H^-	oxide	O^{2-}
fluoride	F^-	sulfide	S^{2-}
chloride	Cl^-	nitride	N^{3-}
bromide	Br^-	phosphide	P^{3-}
iodide	I^-		
hydroxide	OH^-	sulf**ite**	SO_3^{2-}
peroxide	O_2^{2-}	hydrogen sulfite	HSO_3^{2-}
cyanide	CN^-	sulf**ate**	SO_4^{2-}
nitr**ite**	NO_2^-	hydrogen sulfate	HSO_4^{2-}
nitr**ate**	NO_3^-	chromate	CrO_4^{2-}
carbonate	CO_3^{2-}	dichromate	$Cr_2O_7^{2-}$
hydrogen carbonate	HCO_3^-	permanganate	MnO_4^-
phosphate	PO_4^{3-}	**hypo**chlor**ite**	ClO^-
hydrogen phosphate	HPO_4^{2-}	chlor**ite**	ClO_2^-
dihydrogen phosphate	$H_2PO_4^-$	chlor**ate**	ClO_3^-
arsenate	AsO_4^{3-}	**per**chlor**ate**	ClO_4^-
hydronium	H_3O+	mercury(I)	Hg_2^{2+}
ammonium	NH_4^+		

least
less
more
most







Nomenclature Depending Upon Amount of Oxygen

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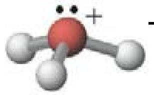
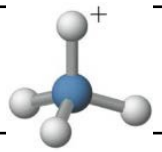
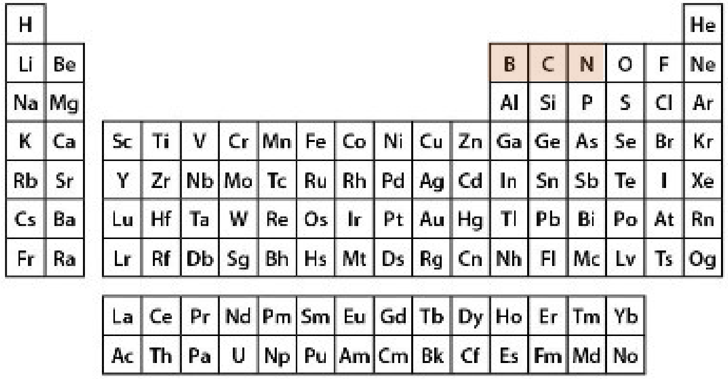
iodide	I^-		
hydroxide	OH^-	sulfite	SO_3^{2-}
peroxide	O_2^{2-}	hydrogen sulfite	HSO_3^{2-}
cyanide	CN^-	**sulfate**	$\mathbf{SO_4^{2-}}$
nitrite	NO_2^-	hydrogen sulfate	HSO_4^{2-}
nitrate	$\mathbf{NO_3^-}$	**chromate**	$\mathbf{CrO_4^{2-}}$
carbonate	CO_3^{2-}	dichromate	$Cr_2O_7^{2-}$
hydrogen carbonate	HCO_3^-	**permanganate**	$\mathbf{MnO_4^-}$
phosphate	$\mathbf{PO_4^{3-}}$	hypochlorite	ClO^-
hydrogen phosphate	HPO_4^{2-}	chlorite	ClO_2^-
dihydrogen phosphate	$H_2PO_4^-$	chlorate	ClO_3^-
arsenate	$\mathbf{AsO_4^{3-}}$	**perchlorate**	$\mathbf{ClO_4^-}$
hydronium	H_3O+	mercury(I)	Hg_2^{2+}
ammonium	NH_4^+		



H_3O^+

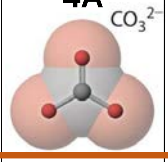
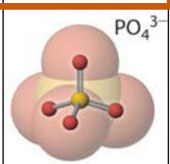
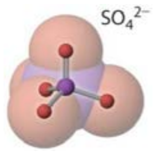


NH_4^+



charge increases →

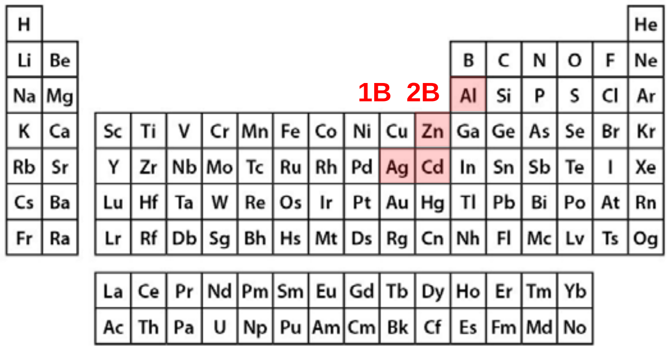
size increases ↓

3A	4A	5A	6A	7A
borate BO_3^{3-}		nitrate NO_3^-		
aluminate AlO_4^{5-}	silicate SiO_4^{4-}			perchlorate ClO_4^-
		arsenate AsO_4^{3-}		
		5B vanadate VO_4^{3-}	**6B** chromate CrO_4^{2-}	**7B** permanganate MnO_4^-
		XO_4^{3-}	XO_4^{2-}	XO_4^-

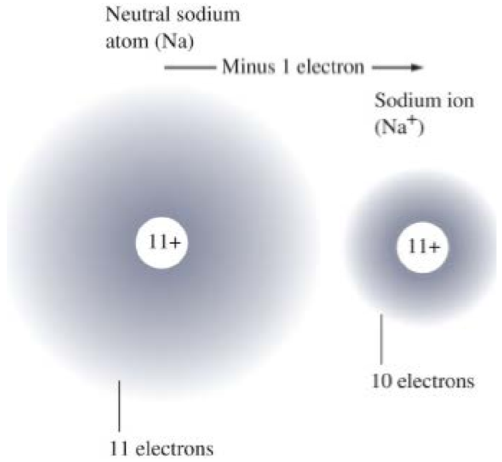
second period different

Positive Ions (Cations)

Monatomic		Polyatomic
Only One Ion Possible	More Than One Ion Possible	
Rule: Name of element + "ion". **Examples:** Na^+ sodium ion Mg^{2+} magnesium ion H^+ hydrogen ion **Al^{3+} aluminum ion** **Ag^+ silver ion** **Zn^{2+} zinc ion** **Cd^{2+} cadmium ion** **Comment:** The number of positive charges is not indicated in the name because it is not necessary, e.g., Group I elements (1+) and Group II elements (2+).	**Rule:** a) Newer rule: positive charges indicated by a roman numeral. **Examples:** Fe^{2+} iron(II) ion Fe^{3+} iron(III) ion Cu^+ copper(I) ion Cu^{2+} copper(II) ion b) Older rule (but still used): Latin stem for the element + "ous" for the lesser charge and + "ic" for the greater charge. (We will use newer rule except coordination compounds) **Examples:** Fe^{2+} ferrous ion Fe^{3+} ferric ion	**Rule:** **Special cases.** **Examples:** NH_4^+ ammonium ion H_3O^+ hydronium ion Hg_2^{2+} mercury(I) ion **Comment:** Hg_2^{2+} is $Hg^+ – Hg^+$ but Hg^+ does not exist, therefore mercury(I) ion is Hg^+. (Hg^{2+} is mercury(II) ion, but that is a monatomic ion.)

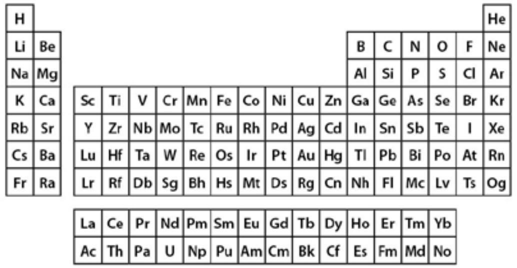


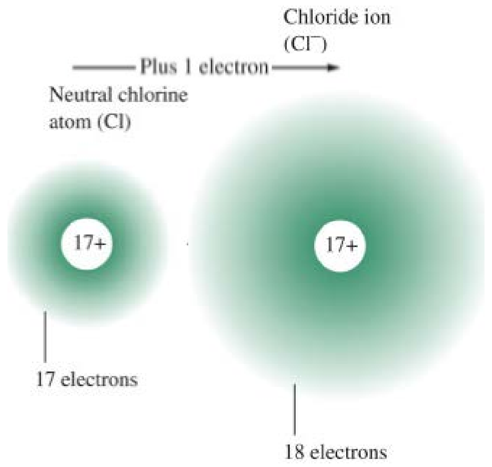
know these oxidation states



Negative Ions (Anions)

Monatomic	Oxyanions (Containing Oxygen)		Others and Exceptions
	(Without Hydrogen)	Containing Hydrogen	
Rule: Stem of the element name + "ide". **Examples:** H^- hydride ion F^- fluoride ion O^{2-} oxide ion N^{3-} nitride ion	**Rule:** least oxygen: hypo_ite ion less oxygen: _ite ion more oxygen: _ate ion most oxygen: per_ate ion **Examples:** ClO^- hypochlorite ion ClO_2^- chlorite ion ClO_3^- chlorate ion **ClO_4^- perchlorate ion** SO_3^{2-} sulfite ion **SO_4^{2-} sulfate ion** **Comment:** Halogens (except F) form all four ions. When only two of the four ions exist, they are the -ite and the -ate ions. **Cl Group 7A** **S Group 6A**	**Rule:** H - oxyanion: "hydrogen" + name of oxyanion or "bi" + oxyanion H_2 - oxyanion: "dihydrogen" + name of oxyanion **Examples:** HCO_3^- hydrogen carbonate (or bicarbonate) ion HSO_4^- hydrogen sulfate (or bisulfate) ion HPO_4^{2-} hydrogen phosphate $H_2PO_4^-$ dihydrogen phos-phate ion **Comment:** H_2CO_3 is not named according to this rule because it is a com pound and not an ion.	**Rule:** These items do not follow any rules: they must be memorized. **Examples:** OH^- hydroxide ion O_2^{2-} peroxide ion CN^- cyanide ion **AsO_4^{3-} arsenate ion** **MnO_4^- permanganate ion** **CrO_4^{2-} chromate ion** $Cr_2O_7^{2-}$ dichromate ion **Comment:** Note that arsenate is a Group V element and forms a polyatomic ion with oxy-gen identical to phosphor-us. **Mn Group 7B** **Cr Group 6B** **As Group 5A, like PO_4^{3-}**





Compounds (Metalloid Can Be Substituted for Nonmetal)

<table>
<tr><th rowspan="3">Ionic
(Cation-Anion)</th><th colspan="3">Covalent (Nonmetals)</th></tr>
<tr><th rowspan="2">Nonmetal-Nonmetal</th><th colspan="2">Compounds Containing Hydrogen</th></tr>
<tr><th>H-Nonmetal</th><th>H-Oxyanion</th></tr>
<tr>
<td rowspan="2">Rule:
Name of cation + name of anion (word "ion" dropped).

Examples:
$ZnSO_4$ zinc sulfate
$NaNO_2$ sodium nitrite
$CaCl_2$ calcium chloride
Fe_3N_2 iron(II) nitride
Li_2CO_3 lithium carbonate
NH_4I ammonium iodide
$Cu(IO_3)_2$ copper(II) iodate
BaH_2 barium hydride

Comment:
The name does not indicate the numbers of cations and anions because there is only one possibility for the ions to combine to form a compound.</td>
<td rowspan="2">Rule:
a) Less electronegative element generally first (exception: when one of the elements is hydrogen)
b) Greek prefixes give number of atoms of each kind
c) Initial prefix mono dropped

Prefixes:
1 = mono 6 = hexa
2 = di 7 = hepta
3 = tri 8 = octa
4 = tetra 9 = nona
5 = penta 10 = deca

Examples:
SCl_6 sulfur hexachloride
N_2O_4 dinitrogen tetroxide
CO carbon monoxide
CO_2 carbon dioxide
NO_2 nitrogen dioxide
N_2O dinitrogen monoxide

Comment:
Tetraoxide becomes tetroxide, monooxide becomes monoxide, etc., so name sounds better</td>
<td>Rule 1:
(without the presence of H_2O)
hydrogen _ide

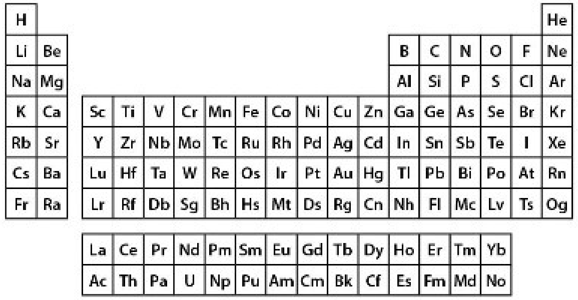
Examples:
HCl hydrogen chloride
HF hydrogen fluoride
H_2S hydrogen sulfide
H_2Se hydrogen selenide</td>
<td>Rule 1:
(without the presence of H_2O) like ionic compounds:
cation + anion
hydrogen hypo_ite
hydrogen _ite
hydrogen _ate
hydrogen per_ate</td>
</tr>
<tr>
<td>Rule 2: H acids
(when dissolved in H_2O)
hydro_ic acid

Examples:
HCl hydrochloric acid
HF hydrofluoric acid
H_2S hydrosulfuric acid
H_2Se hydroselenic acid

Comment:
(a) These H-containing compounds are named as if they were ionic. (b) Often the (aq) in the formulas of the acids is omitted when it is obvious from the context that they are acids.</td>
<td>Rule 2: HO acids
(when dissolved in H_2O)
hypo_ous acid
_ous acid
_ic acid
per_ic acid

Examples:
HClO hypochlorous acid
$HClO_2$ chlorous acid
$HClO_3$ chloric acid
$HClO_4$ perchloric acid
HNO_2 nitrous acid
HNO_3 nitric acid
H_2SO_3 sulfurous acid
H_2SO_4 sulfuric acid
H_3PO_4 phosphoric acid

Comment:
The (aq) is usually omitted.</td>
</tr>
</table>



ordering of elements in formula of binary molecular compounds: order according to Group number, bottom to top; for any pair, element furthest right behaves as the “anion” (H, O need to be memorized):

FOR LATER