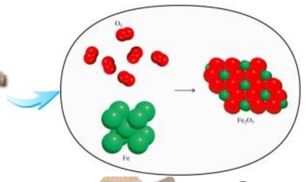
international baccalaureate chemistry year 2: year 1 review

The study of chemistry



why chemistry is awesome:

chemistry is :

a chemical is:

ok...what is matter?

compare mass and weight:

you?

air?

an idea?

energy?

religion?

a perfect vacuum?
a black hole?

chemists

what do chemists do? they all

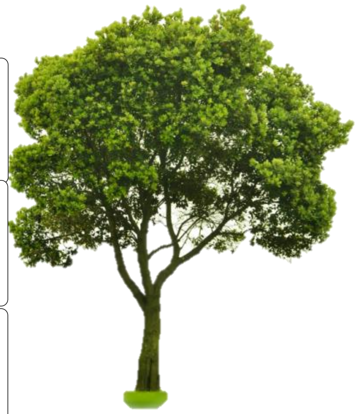
the branches of chemistry

carbon-based:
ex: plastics

not carbon-based
ex: mining

physical change:
ex: reaction rates

Medicines:
ex: viagra



analysis

crime solvers:

chemistry of life:

where does chemistry fit in?

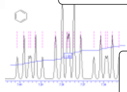
basic — applied

physics math social science chemistry biology

chemistry is the ____ science

what kind of chemist am I?

I make aspirin: I am a ____ chemist.



I analyze: I am an ____ chemist

I study the chemistry of fruit flies, so I am a ____ chemist

I solve crimes using chemistry : I am a ____ chemist.

I make plastics: I am a ____ chemist.

I study physical processes: I am a ____ chemist

I study gold; this is ____ chemistry

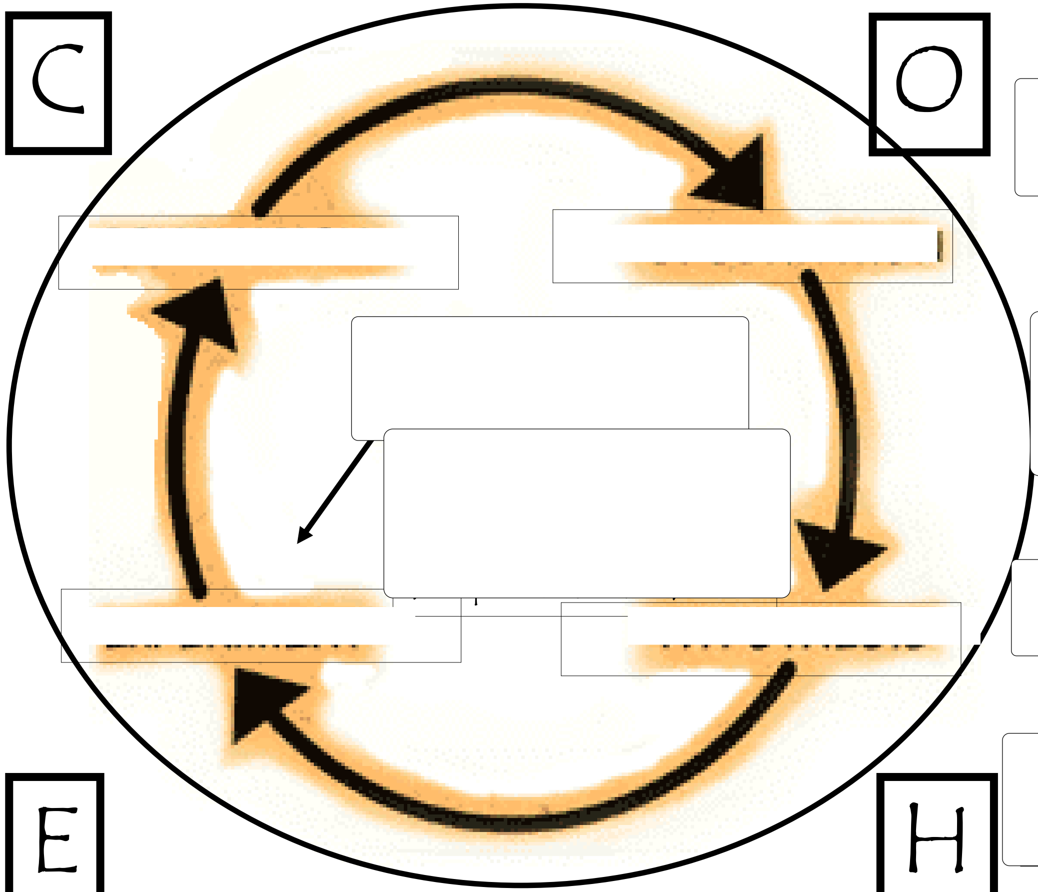
the "ohec" scientific method

oh heck I know that

what might each letter stand for?

C

O



E

H

example:
pain medication study

positive control:

negative control:

hypothesis:

theory:

law

supplemental terms: qualitative ,

quantitative

classification of matter

a pure form of matter:

a sample containing more than one substance:

a substance that cannot be separated into simpler substances by ***chemical means***:

a substance composed of atoms of two or more elements chemically united in fixed proportions.

matter

element, compound, or mixture?

gold

ocean

milk

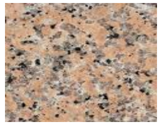
copper

glass

nothing is pure in this world.

classify a drop of blood:

classify granite:



looks pure but isn't
one thing visible

doesn't look pure
multiple things visible

what can we say about mixtures?

suggest a solution:

gas-gas:

solid-liquid:

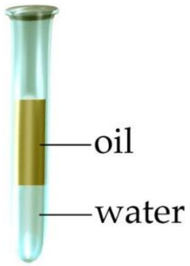
gas-liquid:

liquid-liquid:

solid-solid:

either way it's still a mixture…until it is separated we don't know much about it.

purification: how would you separate these mixtures?

		you have:		
				
oil/water	wet sand	sugar/water	oils	???
		want pure:		
oil	dry sand	sugar	each pure oil	each pure solute

physical vs. chemical

p6

chemical property:

physical property:

suggest the property responsible and if it is physical or chemical:


boiling


rusting


melting


rising

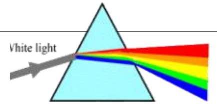

burning


crystallizing


flattening

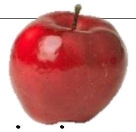

molding


stretching



light bending


observing

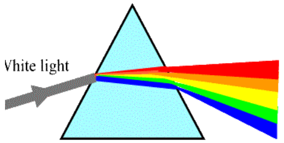

shining

extensive and intensive properties

melting point

mass

density

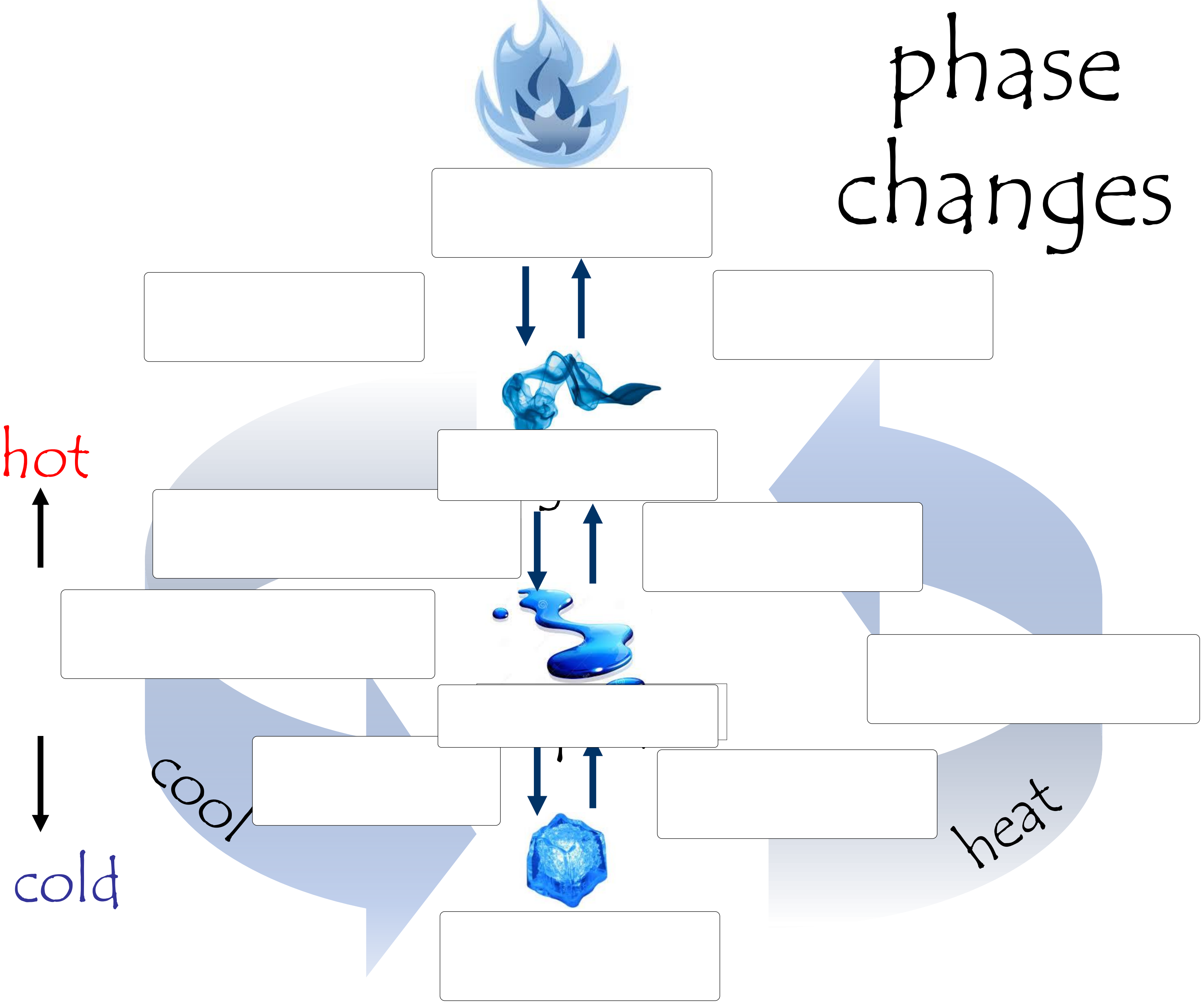


refractive index

toxicity

crystalline or amorphous?

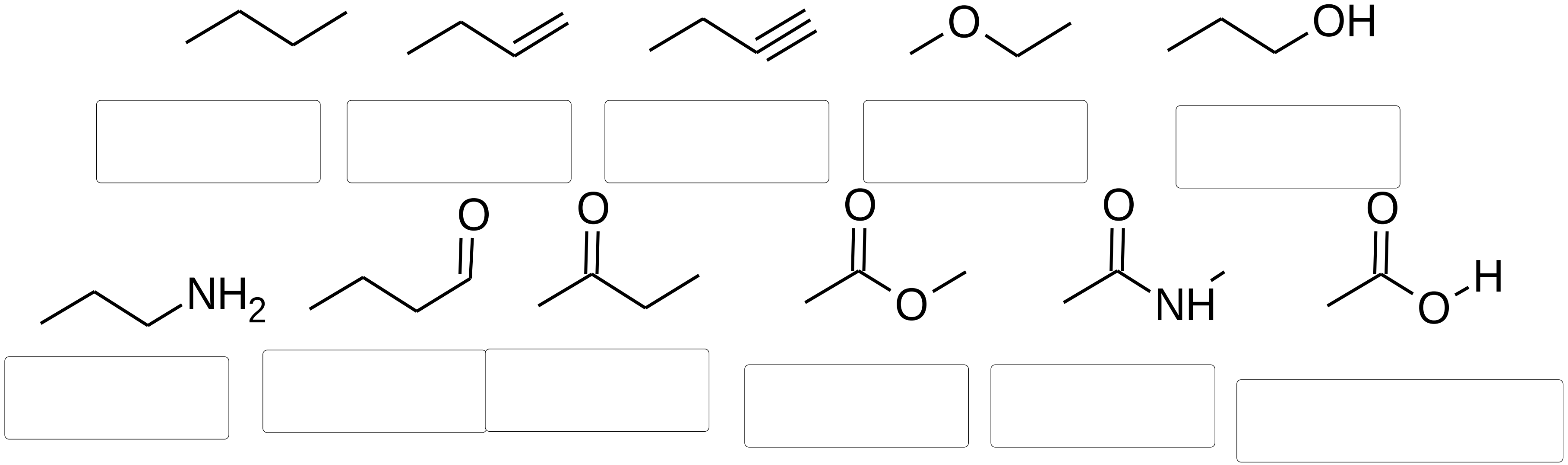
phase changes



organic functional groups

Here are the skeletal formulas of some common types of organic compounds, known as functional groups.

what types of organic molecules are there?

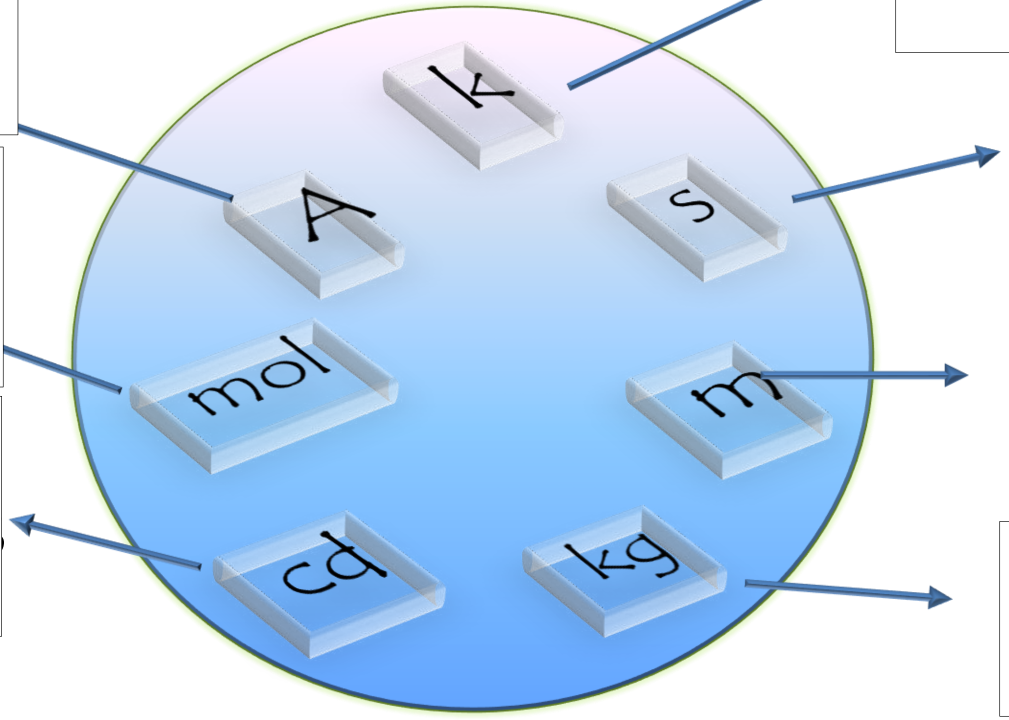


The groups shown above generally contain **more hydrogen** and **less oxygen** as one reads across from alkanes to carboxylic acids: they become **more oxidized**.

Each student should be able to recognize and draw these functional groups.

s.i. units

s.i. units: le systeme internationale



combined Units:

speed acceleration volume density density formula:

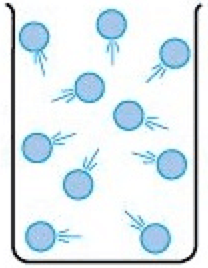
density

= mass/volume

g/mL

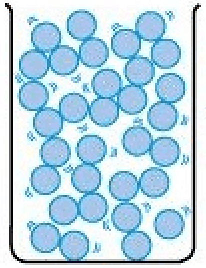
Gas

Hydrogen: 0.089 kg/m^3
Oxygen: 1.43 kg/m^3
Carbon Dioxide: 1.96 kg/m^3



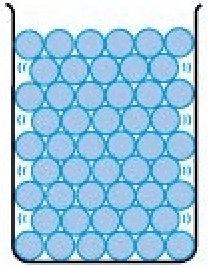
Liquid

Alcohol: 789 kg/m^3
Water: 1000 kg/m^3
Mercury: 13534 kg/m^3



Solid

Aluminium: 2700 kg/m^3
Steel: 7500 kg/m^3
Uranium: 18800 kg/m^3



13.5 g of aluminum has a volume of 5.0 mL. Density?

what is the mass of 2 mL of aluminum?

unit prefixes

billion (10^9)

million (10^6)

thousand (10^3)

hundred (10^2)

ten (10)

1

tenth (10^{-1})

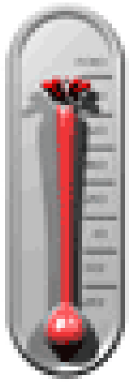
hundredth 10^{-2}

thousandth (10^{-3})

millionth (10^{-6})

billionth (10^{-9})

temperature



S.I. unit: Kelvin….why?

K to ^oC: $K = {}^oC + 273.15$

25^oC = ?K

^oF to ^oC:

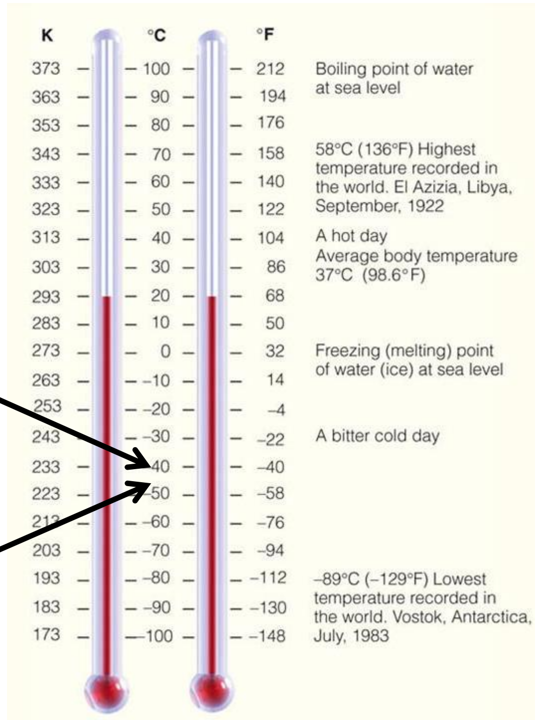
$^\circ C = (^\circ F - 32) \times 5/9$

$^\circ F = {}^\circ C \times 9/5 + 32$

°F to °C	Deduct 32, then multiply by 5, then divide by 9
°C to °F	Multiply by 9, then divide by 5, then add 32

-40^oC = ?^oF

-40^oF = ?^oC



scientific notation

for big and small numbers

10,000

draw a line to make it between 1 and 10; count to decimal point.

always 1-10

always 10^x

212

.0097

602,000,000,000,000,000,000,000

= -2.86×10^3

= 9.742×10^{-4}

entering scientific data on your calculators:
use the E button: 3×10^8 = 3E8

may be E, e, ee, exp; often requires 2nd button (yuck)

how do you enter 6.02×10^{23}?

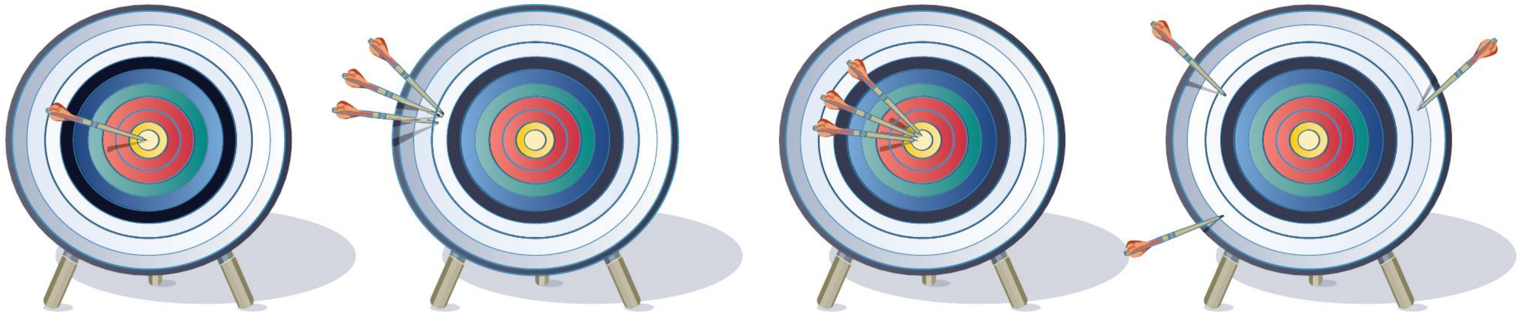
find change sign button (+/-)

$(3 \times 10^{-2}) \times (-4.2 \times 10^{-4}) = ?$

translate: 3E-0.42

$(2 \times 10^1)(1 \times 10^1) = ?$

accurate, precise, or both?



ok…but why are they used interchangeably so often??

accuracy: The quality, of being correct o precise.

precision: The quality, condition, or fact of being exact and accurate.

:

qualitative or quantitative?

several arrows 3 arrows

unit conversions

1. start with what you are given

2. estimate steps and write the final units

3. multiply using conversion factors

4. cancel your units.

a. 7.25 dollars = _____ quarters

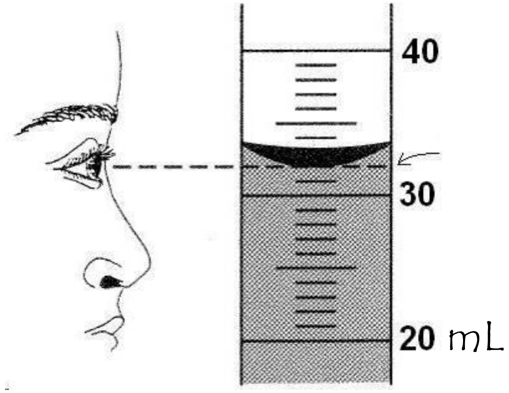
b. 1,285 quarters = _____ dollars

c. 65 miles/hour = ______meters/second (1609 meters = 1 mile; 3600 seconds = 1 hour)

d. Most gases occupy 24 liters per mole at room temperature. Given that carbon dioxide has a molar mass of 44 grams per mole, what is the density of carbon dioxide at room temperature in grams per liter?

significant figures

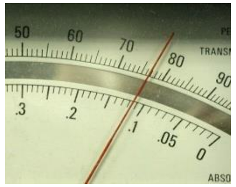
volume?



when measuring:

why is it important to line up level to the meniscus?

how does this device minimize parallax??



number	# sig. figs (sf).	why
32		
0.0323		
3.004		
300		
300.		
300.20		

how many significant figures??

.030690

rounding: ex: 2.25 to 2 sf:

+,– ex: 4.16+ 3.3 =

x, / ex: 666 /333 =

infinite sig. figs.

round as you go?

how many extra digits should I carry along?

combinations?

ex: (3.111 + 5.03) x 33 =

percent accuracy and percent error

you measure your mass to be 120 lbs,
but in reality it is 150 lbs. What is your percent error?

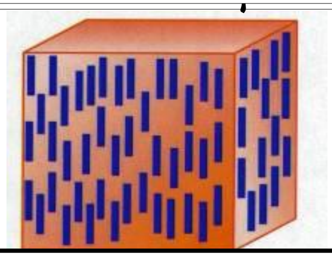
5 states of matter

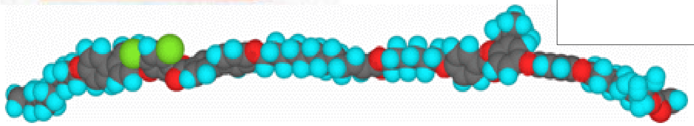
state?	fill bottom of container perfectly?	fills all of container?	compressible?

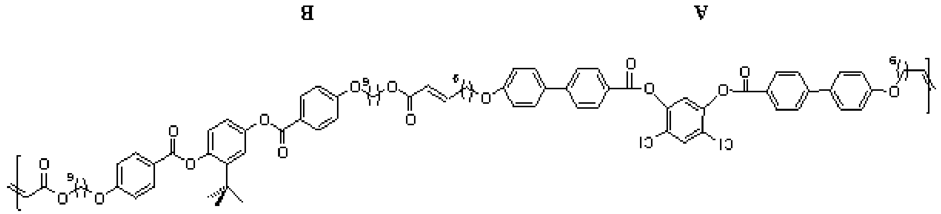
hot

cold

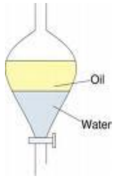
liquid crystals and plasmas



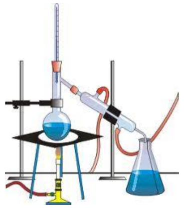


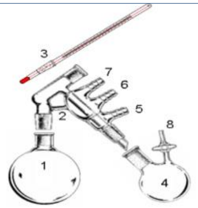


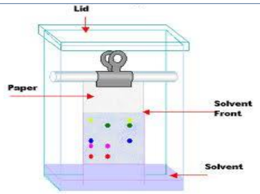
purification methods

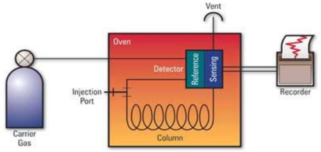


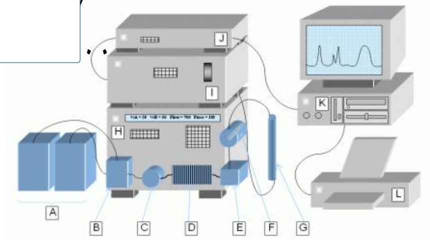
still in use



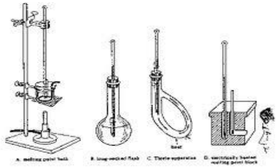


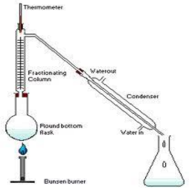






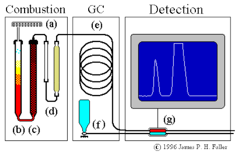
classical identification methods

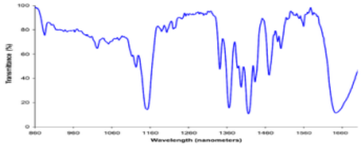


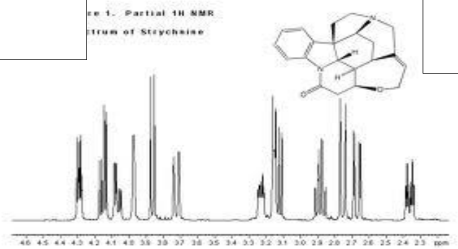


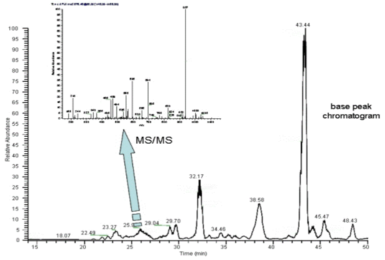
still in use

modern identification methods (L1, honors only)









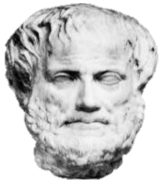
10

a brief history of the atom

early ideas

symbol | inventor | idea, source

400 BC

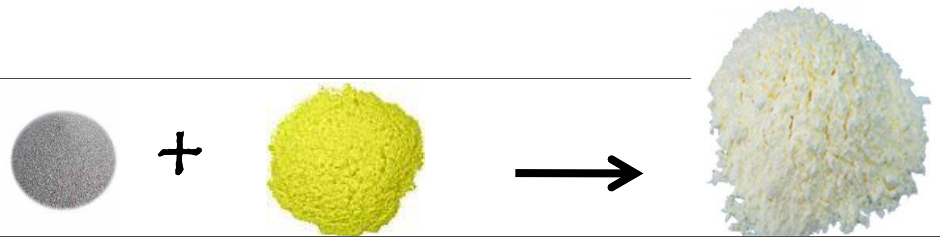


400 BC

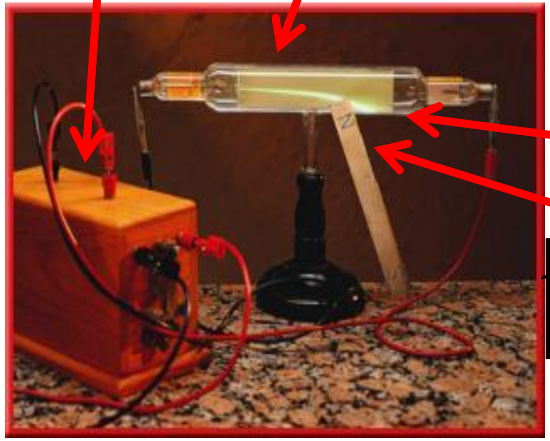
1000 AD

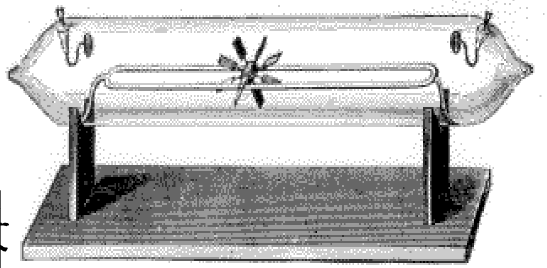
their evidence:

early evidence for the atom



thomson's 1897 cathode ray tube experiment:



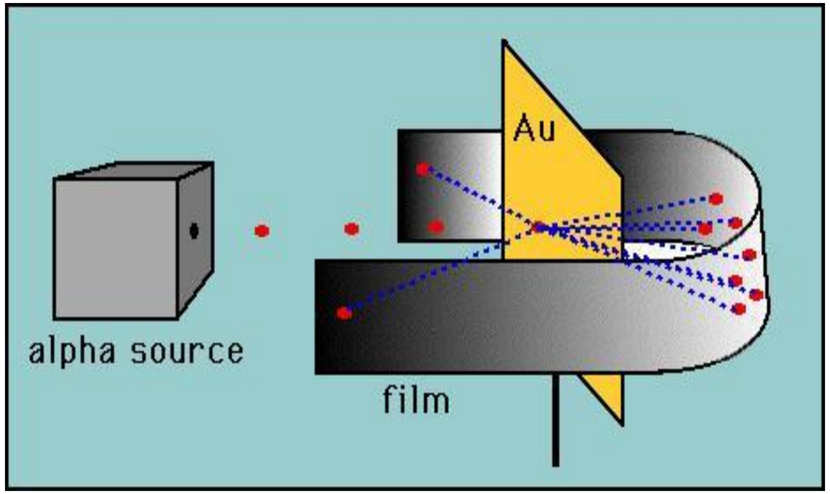


proposes:

thomson

where are the electrons?

Rutherford's 1907 gold foil experiment

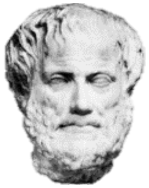


conclusion:

Rutherford

history of the atom

5

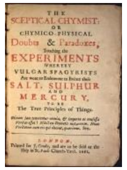








cosmology
400 BC

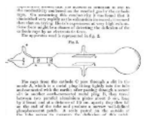
metaphysics
350 BC



the skeptical chymist annotated
1661

physical and chemical essays 1776

a new system of chemical philosophy
1808

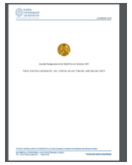


on the structure of the atom
1913

the structure of the atom
1914

Imaging the atomic orbitals of carbon with field-emission electron microscopy
2009

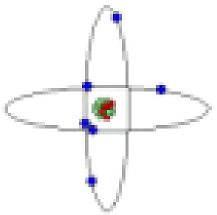
images of a molecule
2013

cryo-electron microscopy
2017

what is everything made out of?

a history of our understanding of the atom



atomic bookkeeping: p^+, n^o, and e^-

term		
atomic #		
mass #		
isotope		
ion		
cation		
anion		
average atomic mass		
band of stability		

F^- and Neon both have ___ electrons: They are _______________.

determination of average atomic mass

solve this problem

element X has 2 isotopes:

isotope a

10 protons,

10 neutrons

abundance: 40%

isotope b

10 protons

11 neutrons

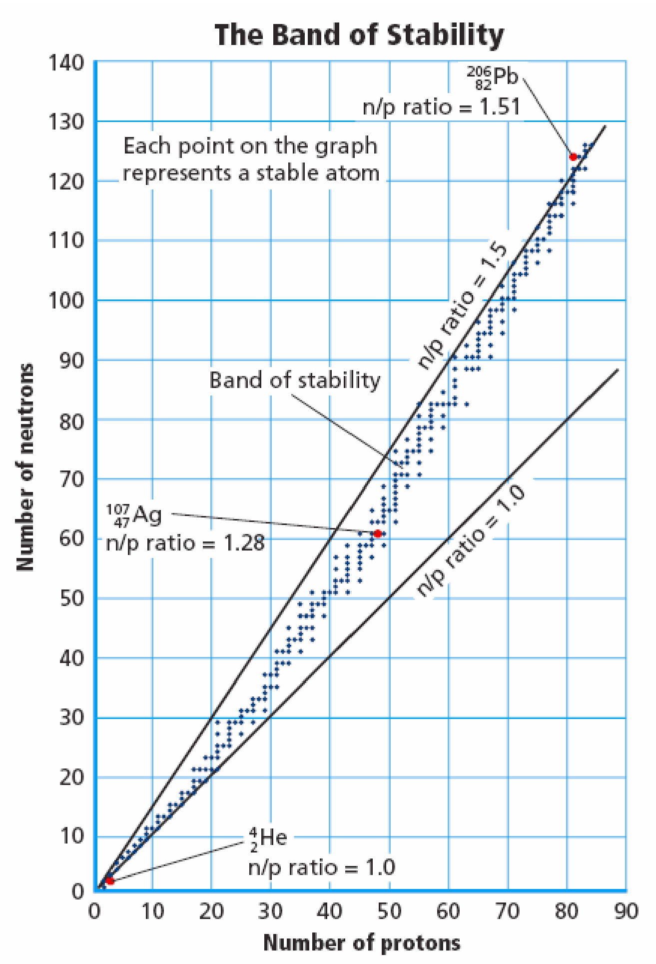
abundance: 60%

what is the average atomic mass of element X?

average atomic mass calculation consider the hypothetical element binkowskium (Bn)

P	N	abundance
15	15	66%
15	17	34%

average atomic mass?

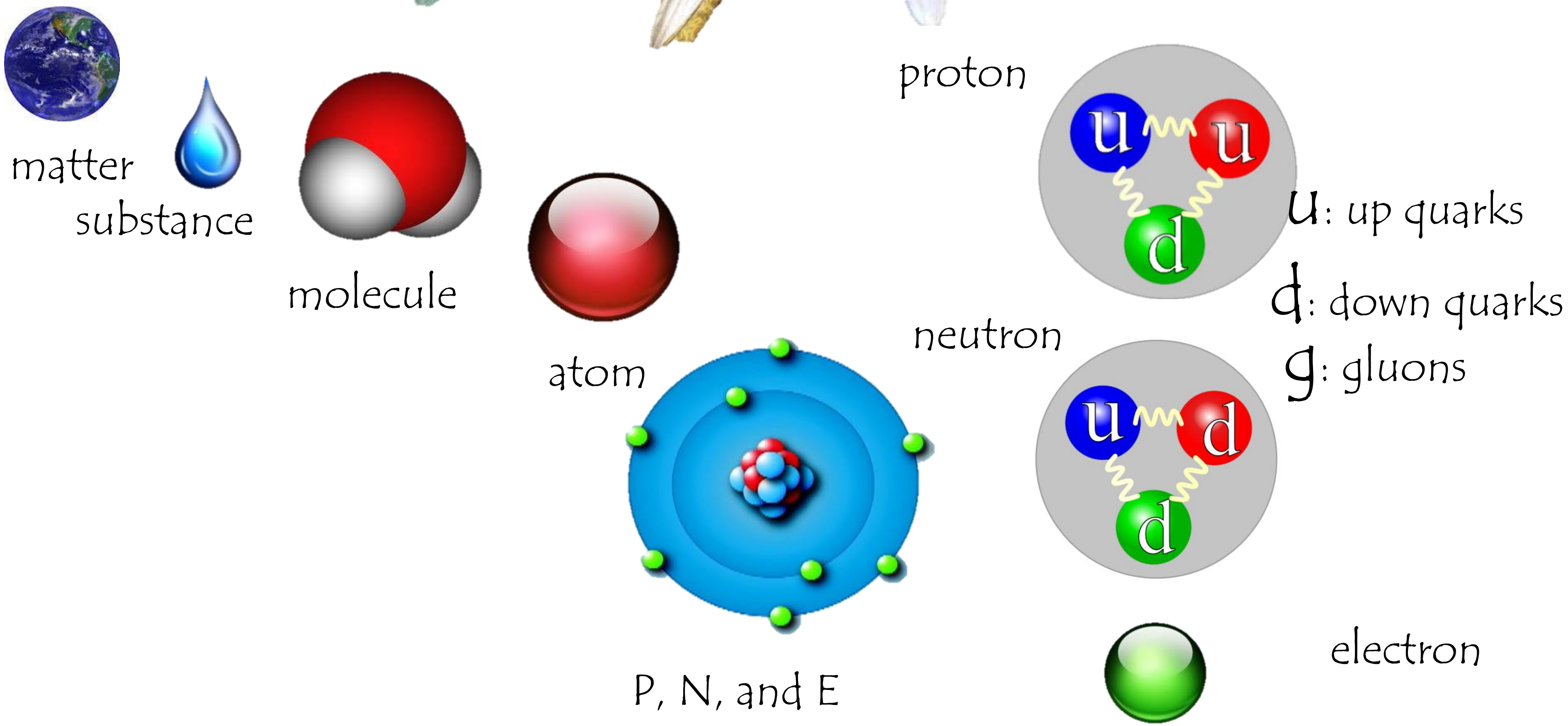


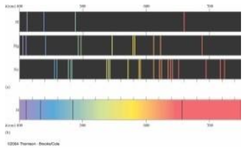
how many neutrons is too many?:

how to predict the scary elements

the "band of stability"

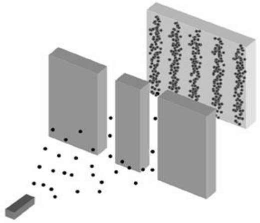
what is everything made out of?





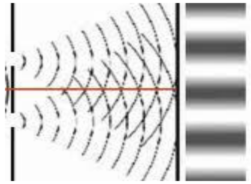
introduction to the electron

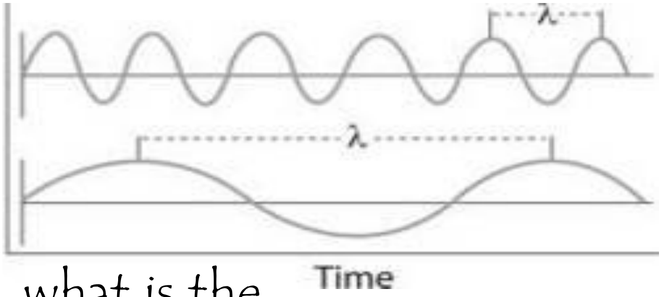
what do you know about light?



observation: light passing through 2 slits can create multiple lines.: this is **superposition**

how can this be?



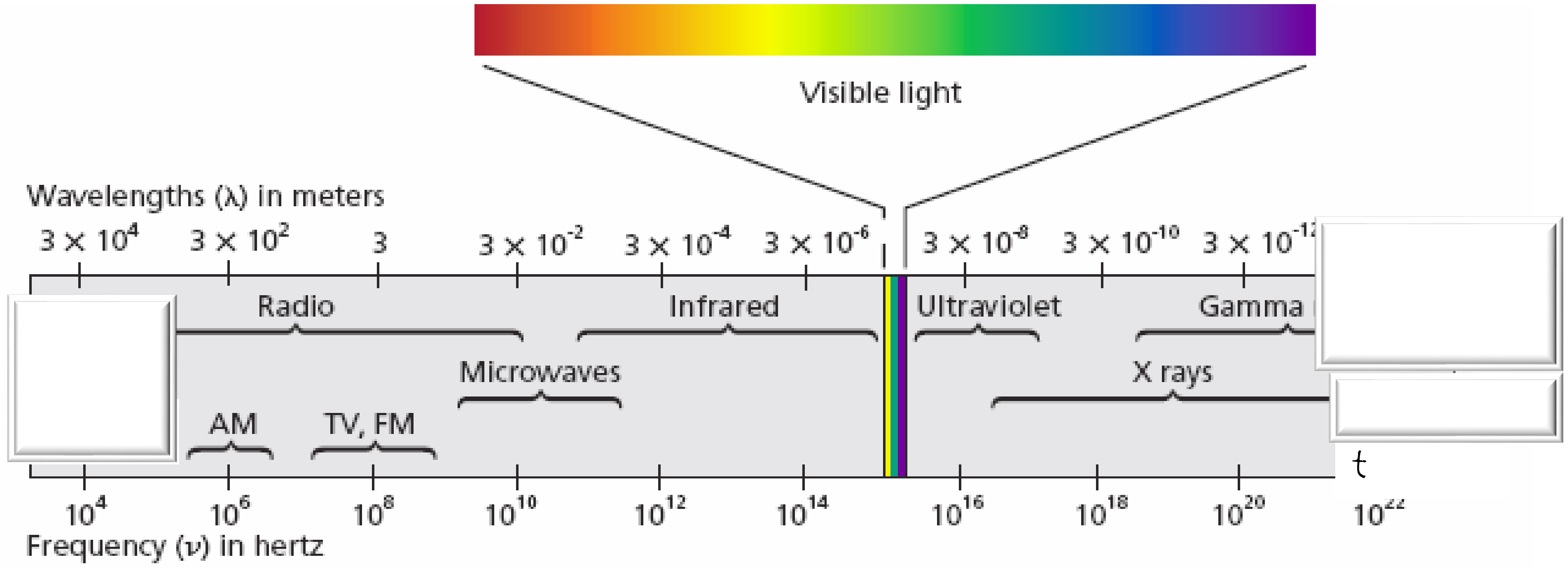


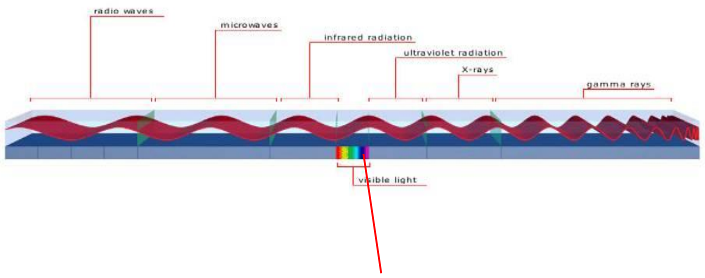
what is the wavelength of violet light in nanometers; f = 7.23 x 10^{14} s^{-1}?

What is the frequency of green light, which has a wavelength of 4.90 x 10^{-7} m?

the electromagnetic spectrum

so much you don't see

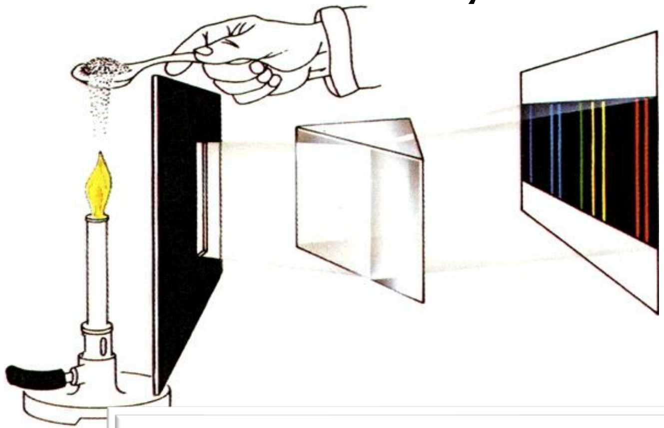


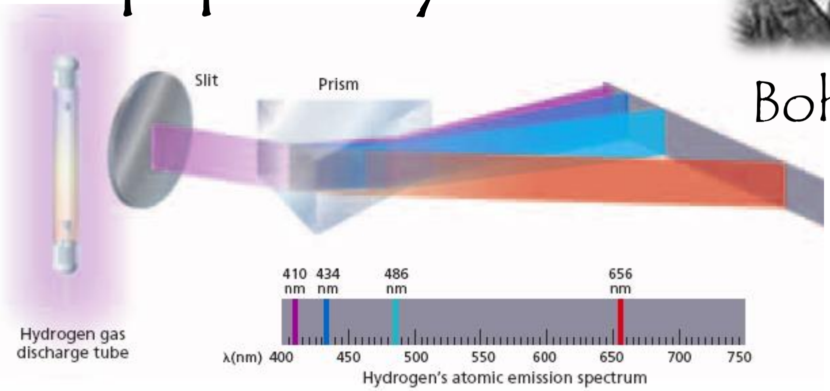


656 nm

where are the electrons?:

the story of bohr's epiphany





Bohr

w_{nm} = 656, 486, 434, 410…what number is next??

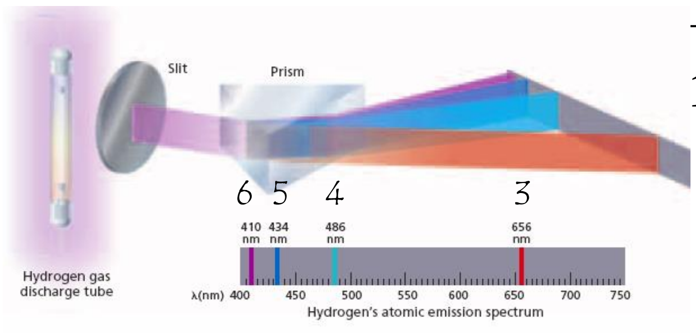
Try it for 3 → 2

outer inner

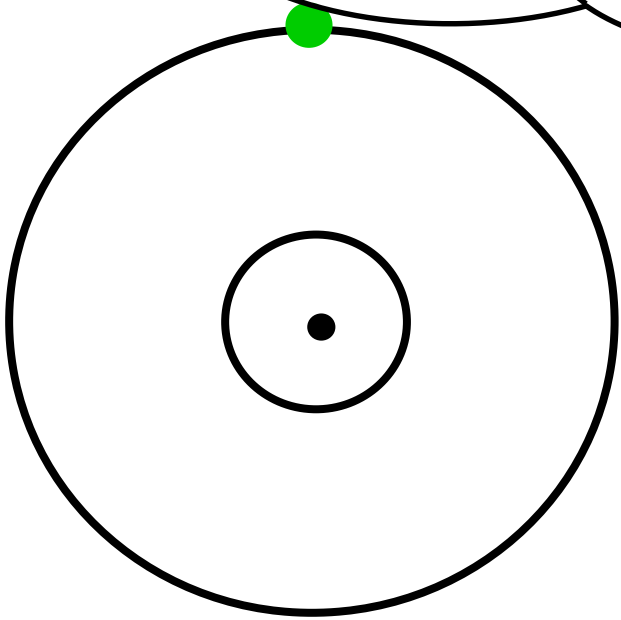
Balmer

Rydberg

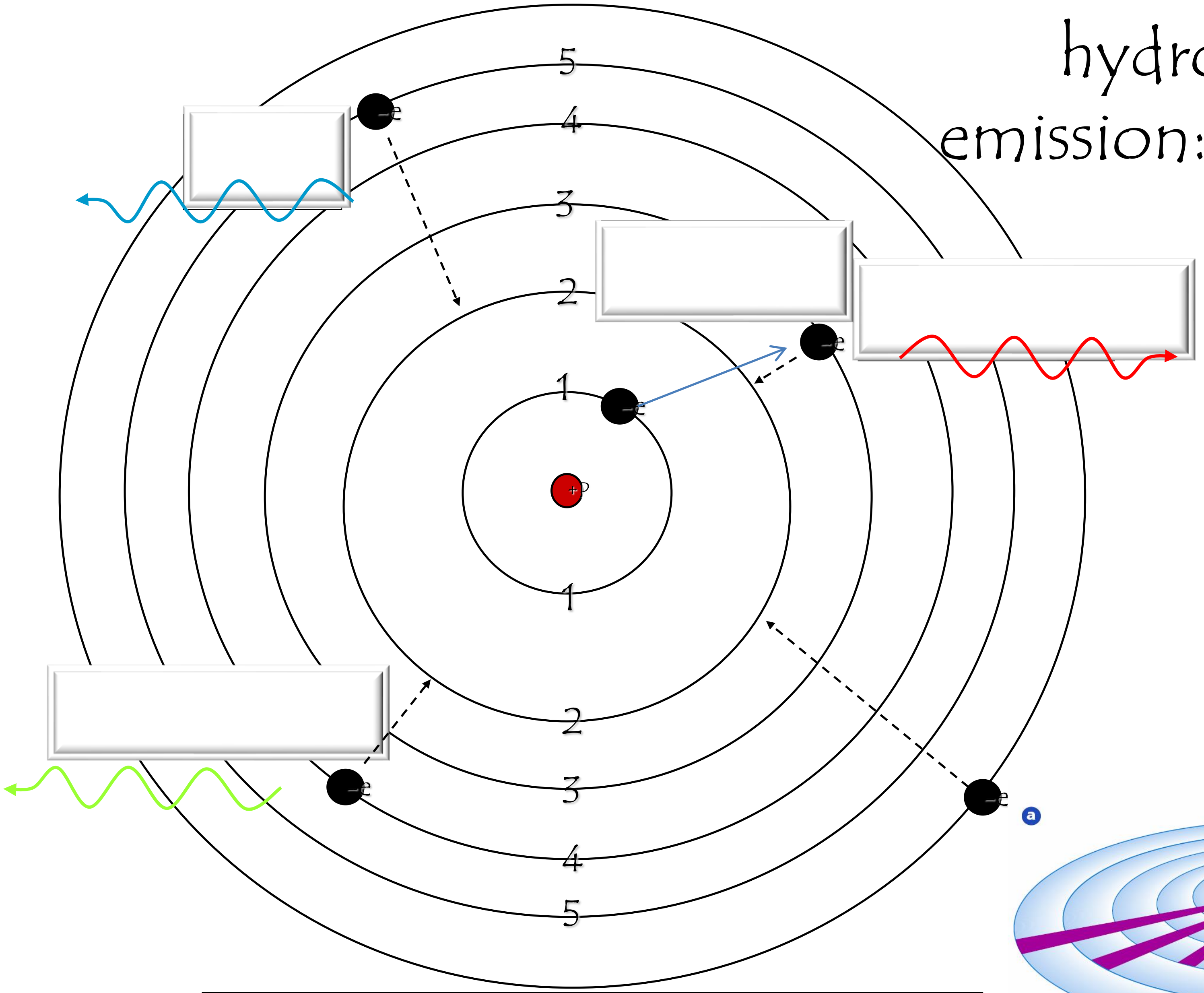
bohr sees the connection between light and the electron

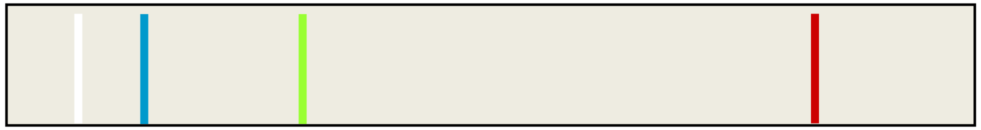


$$\frac{1}{1097\left(\frac{1}{2^2}-\frac{1}{n^2}\right)}$$



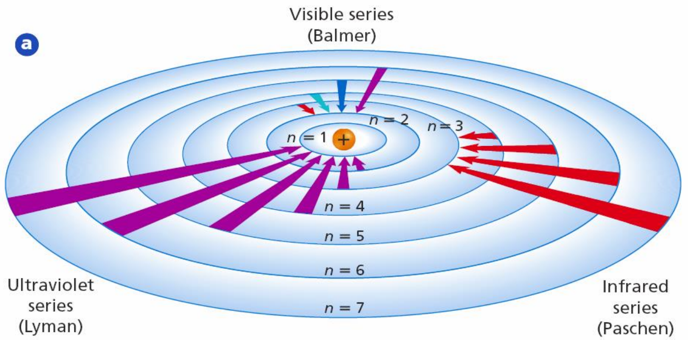
hydrogen emission: it all fits





400 nm

700 nm



energy of hydrogen photon emission

Planck found the energy of a photon is proportional to it's frequency:

where his Planck's constant

frequency is related to wavelength

where s is the speed of light

so hydrogen photon energy can be re-expressed by wavelength

and since the wavelength of hydrogen electron emission is known:

the energy of hydrogen photon emission can be calculated directly:

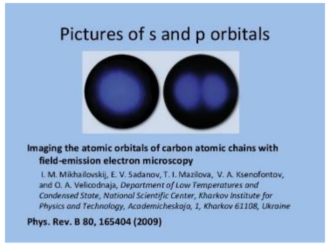
atomic orbital theory (to argon)

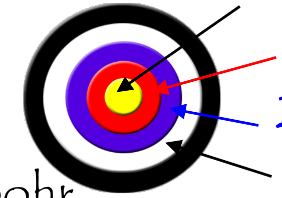
atomic orbitals:
"subshells" of paired electrons
paired electrons = orbital

electron configuration
level · orbital · # e's

shell	# electrons total	atomic orbitals	electron configuration

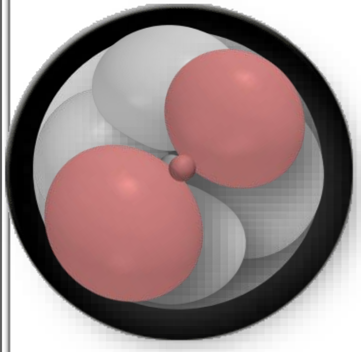
igor mikhailovskij





bohr shells

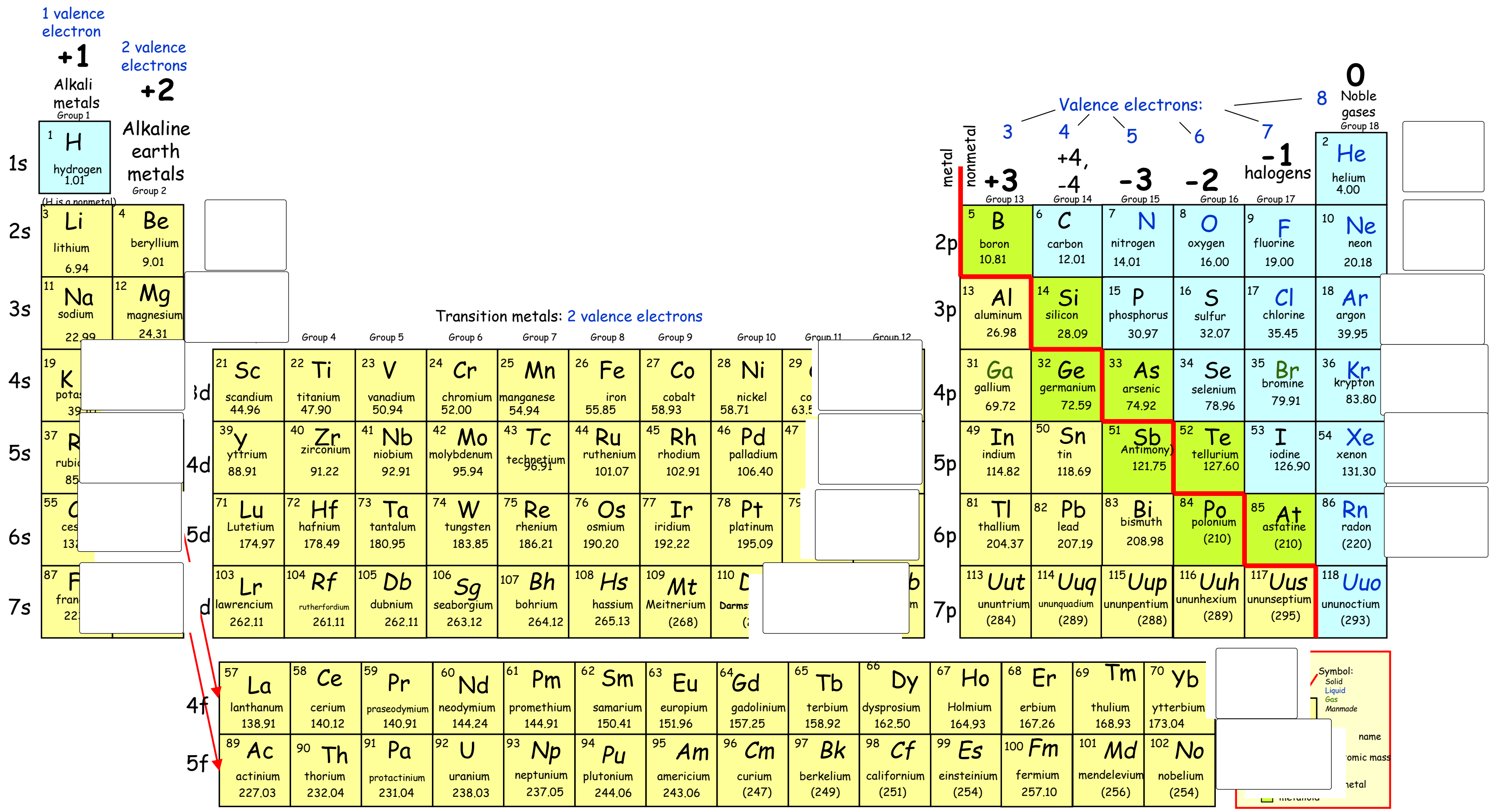
after: schrodinger, mikhailovskij, others



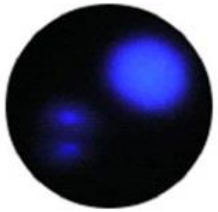
orbitals

aufbau order is a powerful tool

$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$ $4f^{14}$ $5d^{10}$ $6p^6$ $7s^2$ $5f^{14}$ $6d^{10}$…



conclusion:




electrons

aufbau order is infinite


$1s^2$									
	$2s^2$								
$2p^6$		$3s^2$							
	$3p^6$		$4s^2$						
$3d^{10}$		$4p^6$		$5s^2$					
	$4d^{10}$		$5p^6$		$6s^2$				
$4f^{14}$		$5d^{10}$		$6p^6$		$7s^2$			
	$5f^{14}$		$6d^{10}$		$7p^6$		$8s^2$		
$5g^{18}$		$6f^{14}$		$7d^{10}$		$8p^6$		$9s^2$	
	$6g^{18}$		$7f^{14}$		$8d^{10}$		$9p^6$		$10s^2$

$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$ $4f^{14}$ $5d^{10}$ $6p^6$ $7s^2$ $5f^{14}$ $6d^{10}$…

electron configuration with orbital notation

tells us where the electrons are in an atom in great detail

$_{3}$Li:

Pauli Principle::

try it for carbon:

$_{6}$C:

please give the electron configuration with orbital notation for sulfur

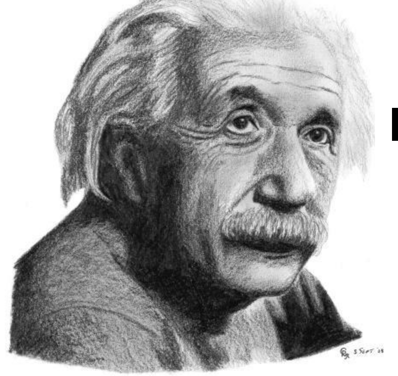
$_{16}$S:

hund's rule: electrons spread out within orbital groups

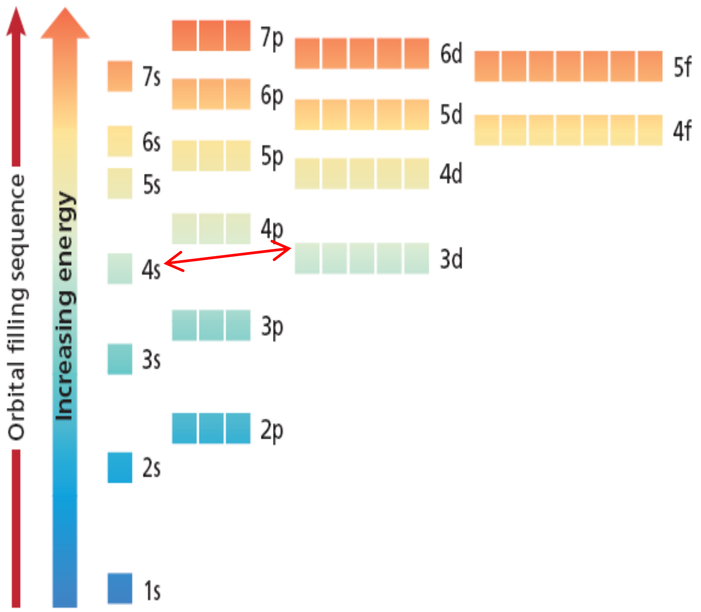
heisenberg's uncertainty proposal

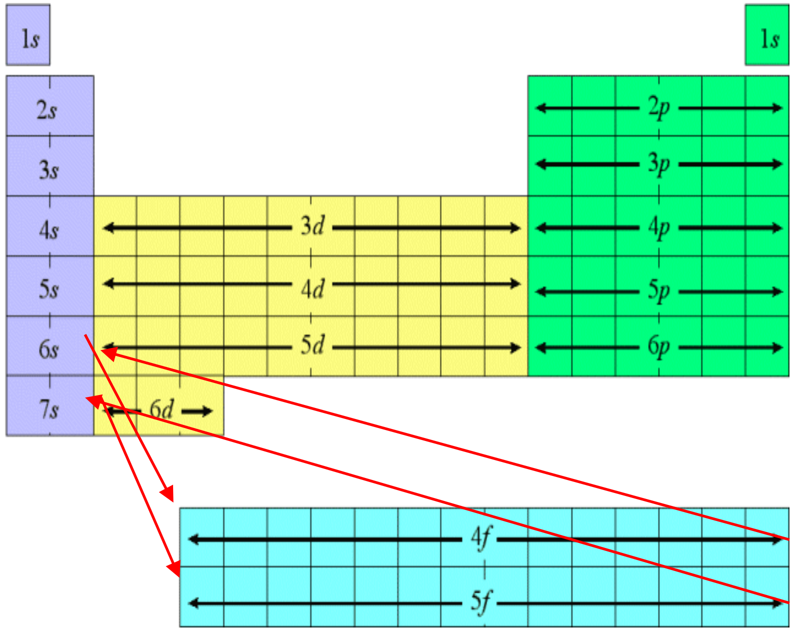
heisenberg:

einstein:



aufbau order; shorthand notation





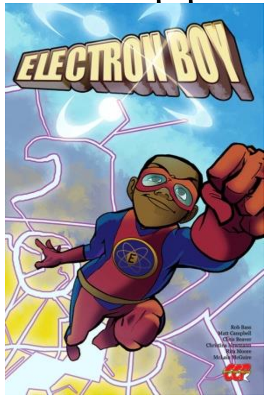
shorthand notation

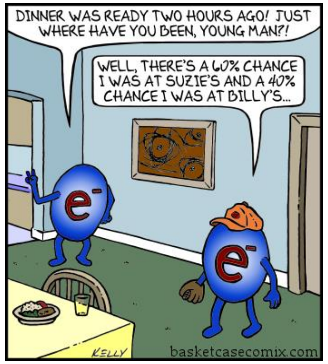
$_{12}$Mg:

$_{21}$Sc:

principles and rules of electron configuration

principle or rule	bad	good
heisenberg (e-position uncertain)		
aufbau (build up)		
hund's rule (spread out)		
pauli (opp. spins)		





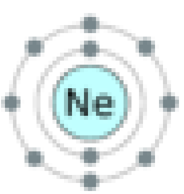
it's all about the valence electrons

(outer shell)

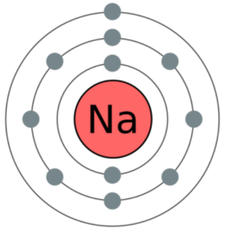
the big idea:

atoms want full outer shells.

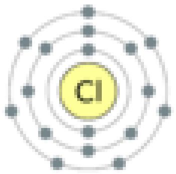
(almost always 8 electrons)



neon:
stable☺



sodium:
unstable:
will lose 1



chlorine
unstable:
will gain
one…

…or share

lose 1

lose 2

lose….

complex: unfilled inner shells

…or share

lose 4

or gain 4

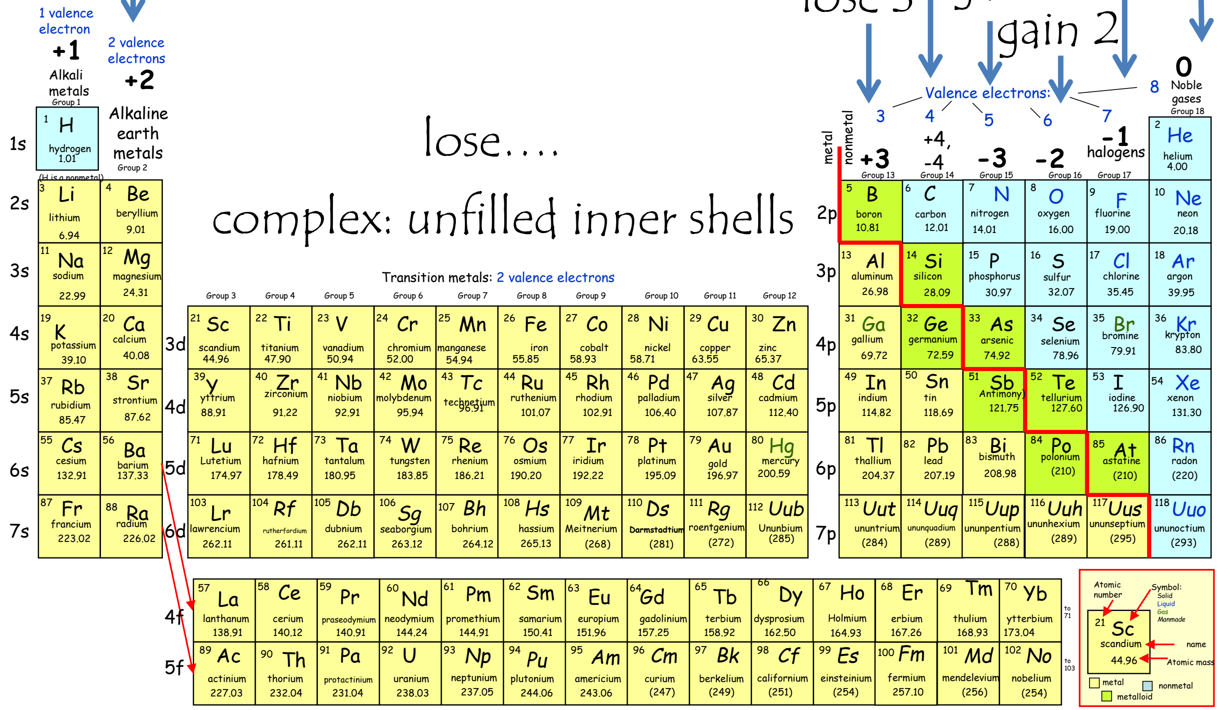
lose 3

gain 3

gain 2

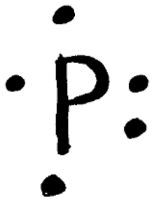
gain 1

stable



electron dot structures:

a quick look at valence electrons



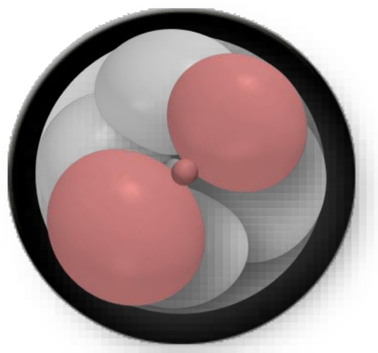
no…always spread
out valence electrons

try H,O,N,C

valence electrons are the key to understanding:

fortunately, it is nicely categorized in our next topic:

The electron: fact sheet



exists

- is located:
- Outside the nucleus
- In shells
- In subshells (s p d f)
- In orbitals
- With opposite spins

is an elementary particle.

doesn't have much mass (10^{-28} g; 1836x lighter than a proton)

what is the world made out of?   the development of the periodic table

9000 BC | 1790 | 1810 | March 6 1869 | 1929 | 2011

device

fire

quantitative instrumentatio
n

Volta's pile

Newland's law of octaves

1st particle accelerator

large hadron collider

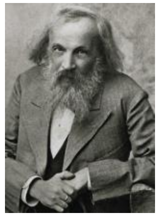
contributors

cavepersons

Lavoisier

Volta

Newlands



Mendeleev
famous lecture 1869

Seaborg

Stark
(just kidding)

results

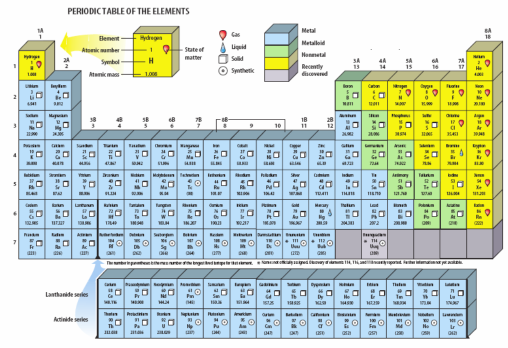
ancient copper
9000 BC

ancient lead

early elemental

Period \ Group	I	II	III	IV	V	VI	VII	VIII
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
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
7	Ag=108	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=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
11	Au=199	Hg=200	Tl=204	Pb=207	Bi=208			
12				Th=231		U=240		

by the 1860's. elements were being
predicted based on properties of



modern periodic table

summary

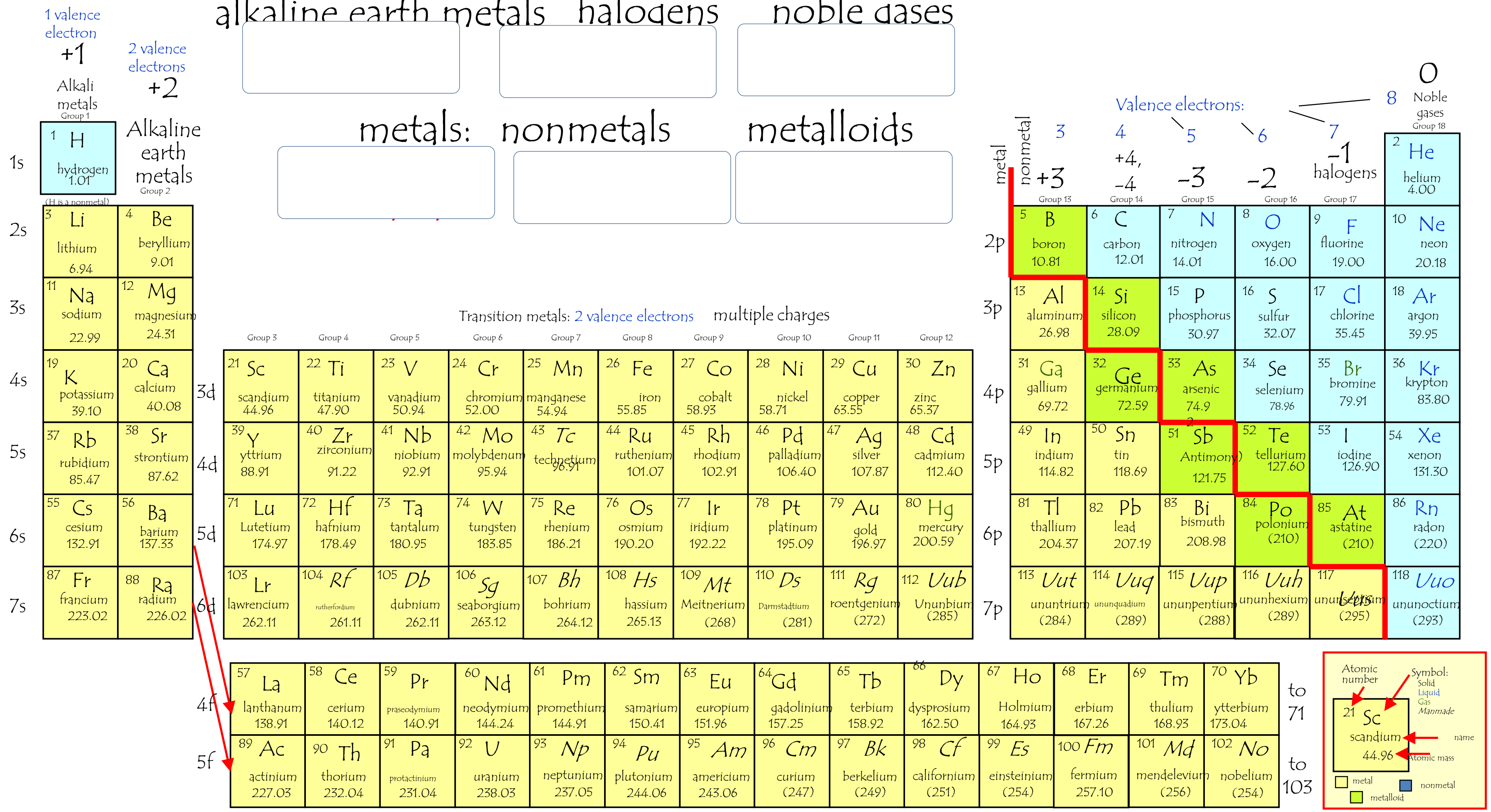
organization of the periodic table

it's about the electrons:

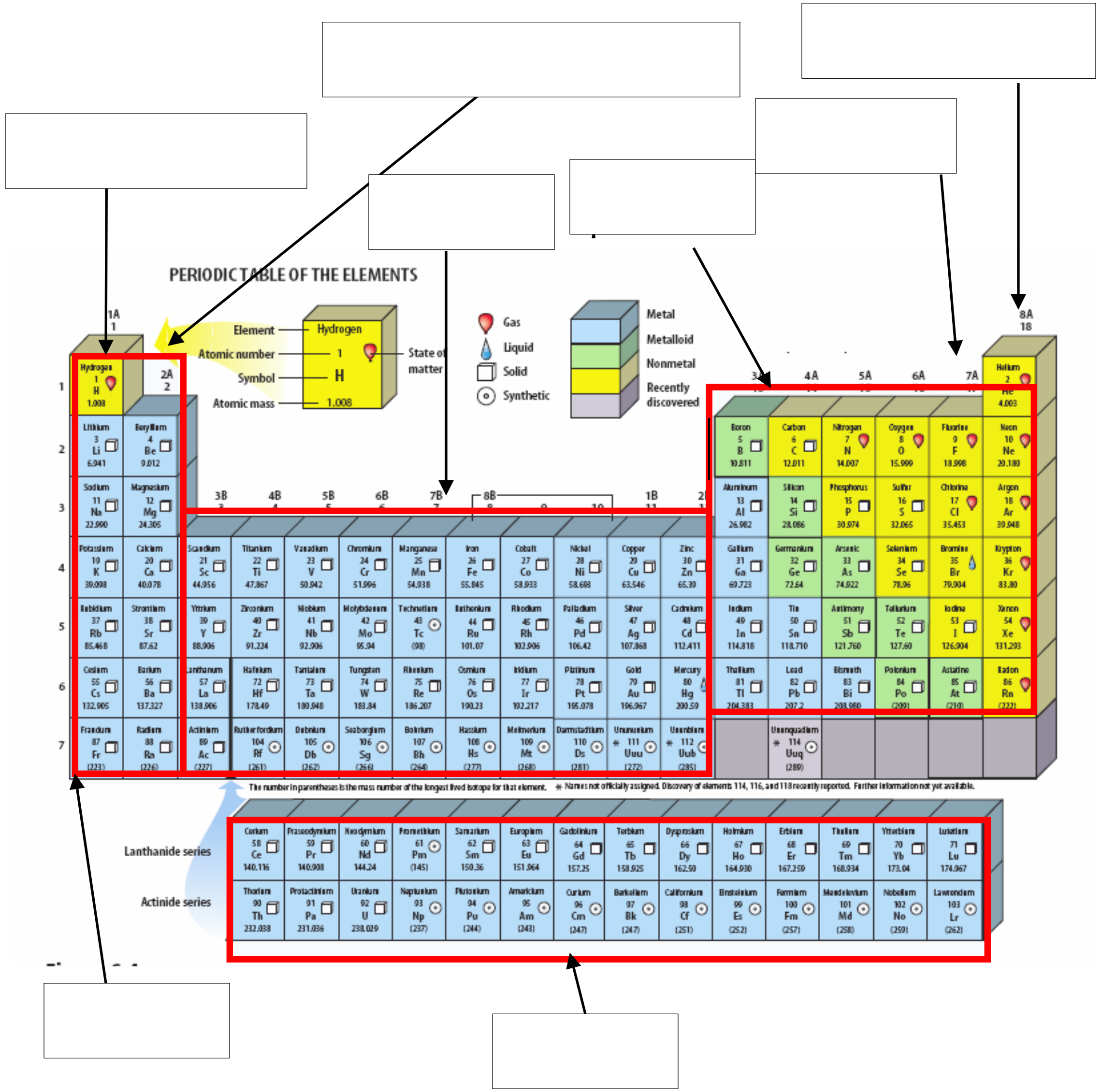
valence electrons: charge orbitals blocks periods groups or families: alkali metals

alkaline earth metals halogens noble gases

metals: nonmetals metalloids

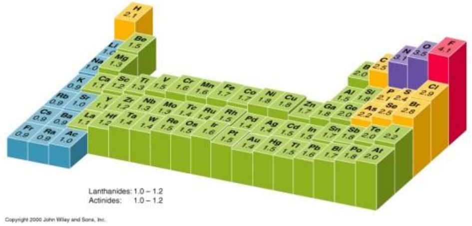


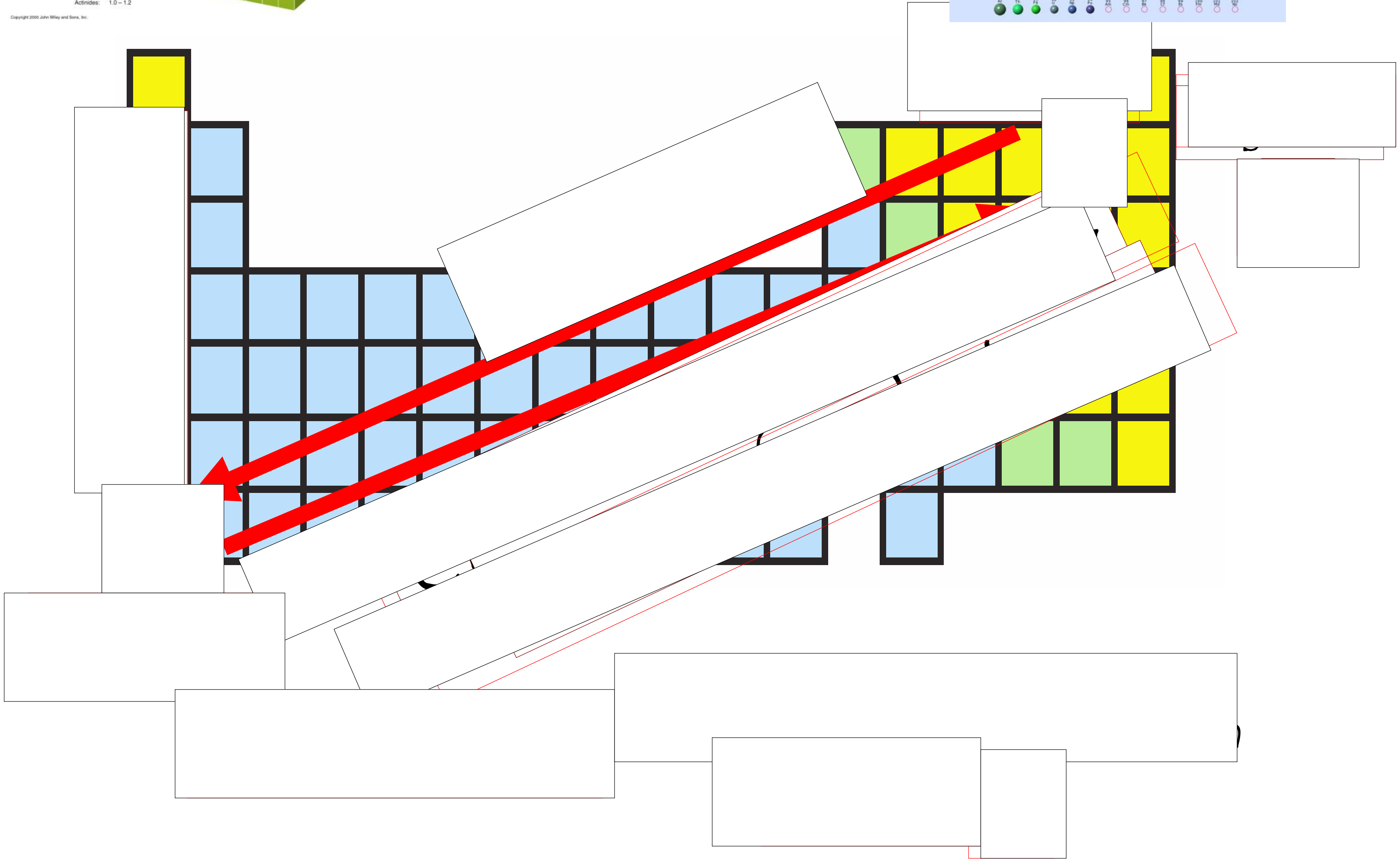
periodic table feature check



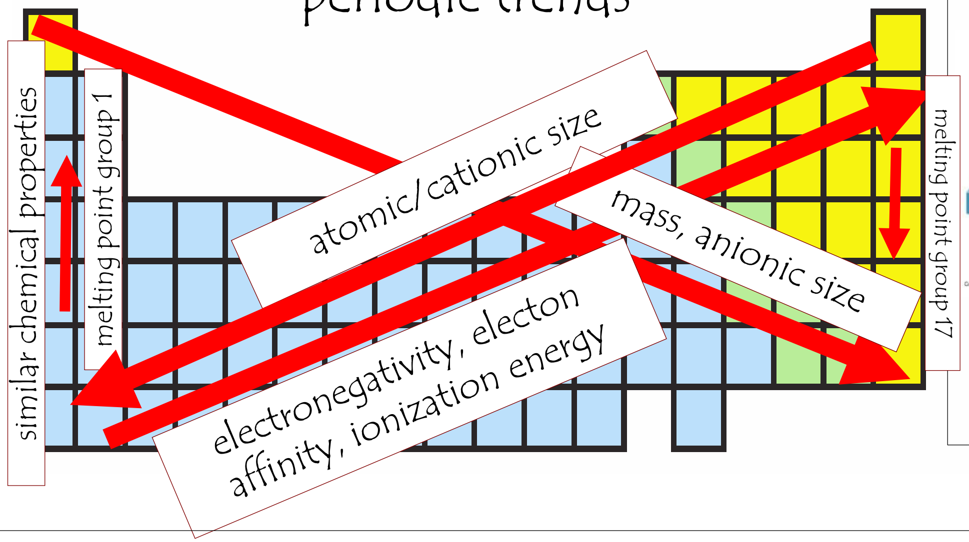
	oxygen	tungsten	silicon
metal?			
block			
valence electrons			
charge			
period			
largest			
most electro-negative			
most massive			

periodic trends



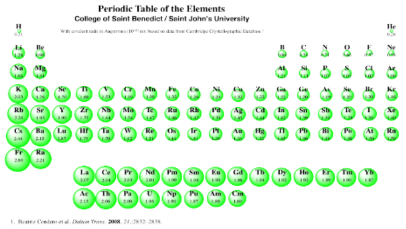


periodic trends

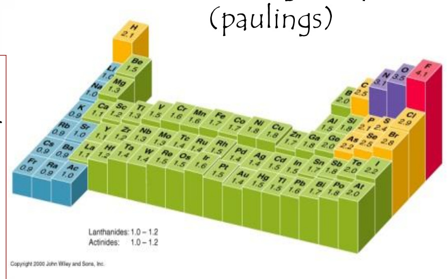


atomic radius (nm)

the size of an atom increases as with each shell, but decreases in a shell with charge.

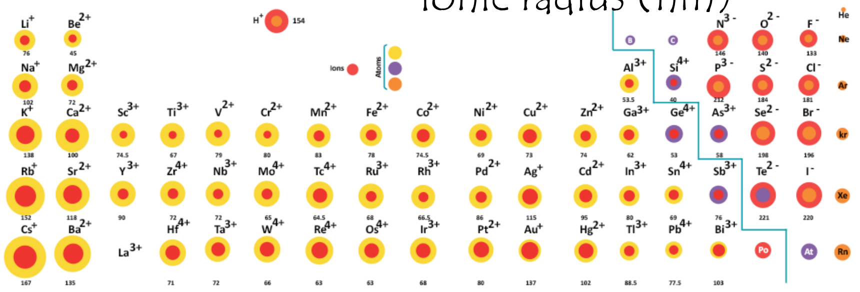


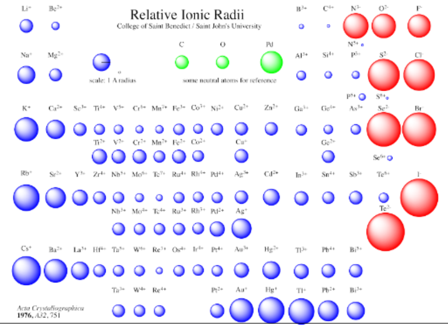
electronegativity (paulings)

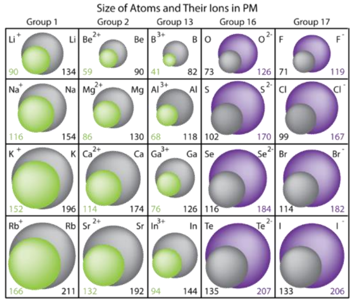


increases as valence shell becomes closer to full, decreases with shielding

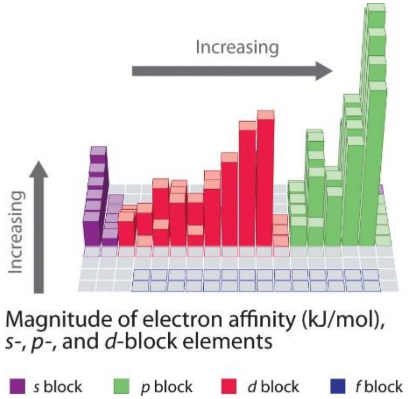
ionic radius (nm)

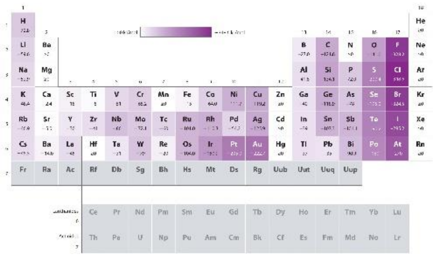




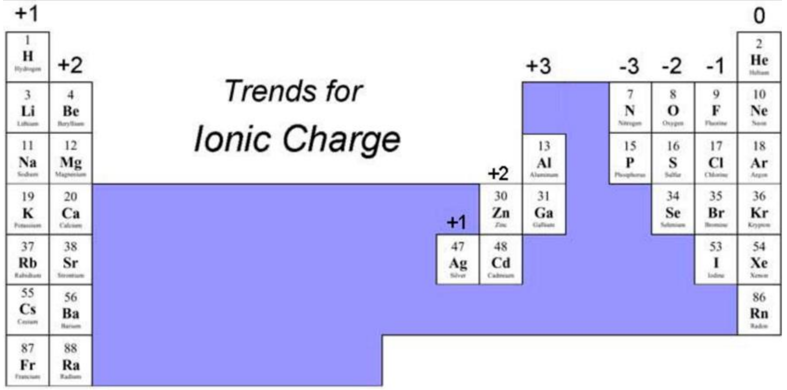


electron affinity (kJ/mol)

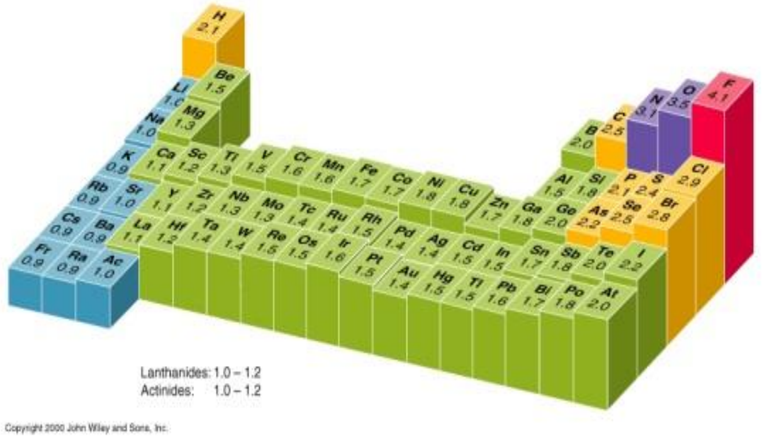


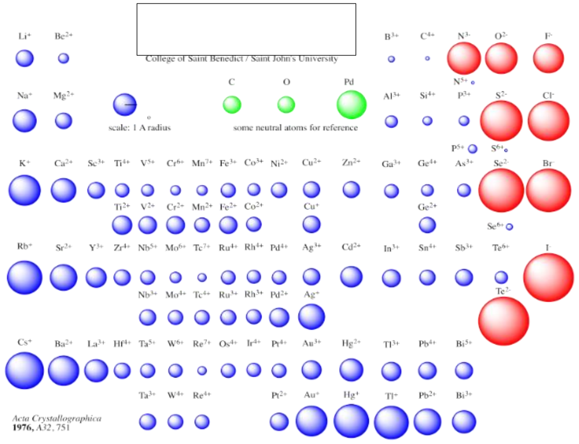


the energy released when an atom gains an electron increases toward fluorine but is very group-specific



name that trend



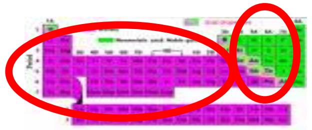


introduction to chemical bonds

what is a chemical bond?

which elements do not form chemical bonds?

why do elements form bonds?

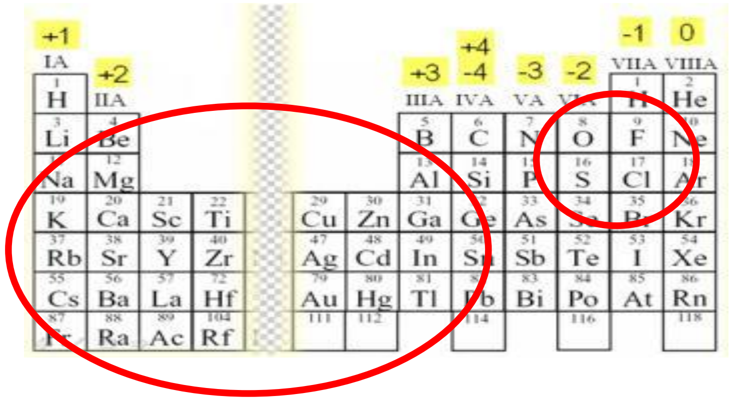
if the bond is between ________	it is a ____ bond	example
		
		
	or	

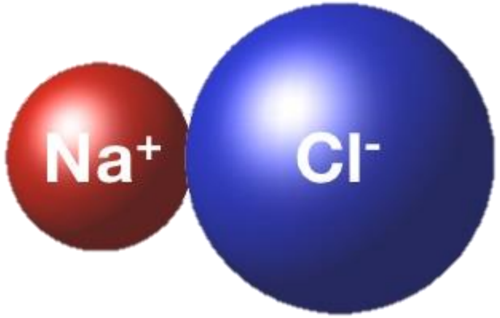
some added detail: polarity of covalent bonds	
bond	type
H_3C-CH_3 (same nonmetals)	
H_3C-OH (different nonmetals)	
H_3C-H (an exception)	

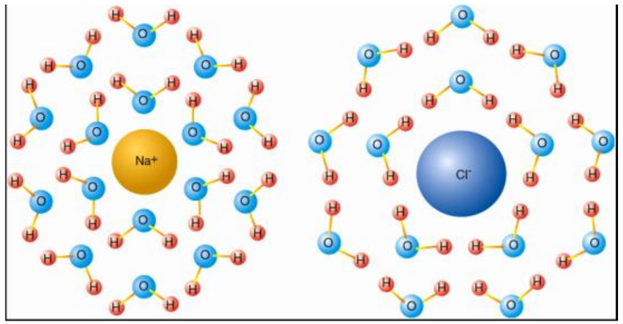
type of bond?

Na-Cl	F-F	P-O	Cl-Mg-Cl	O=C=O	Na-OH	Fe-Fe	C-C (graphite)

properties of ionic bonds (salts)







melting point 801 ^{O}C

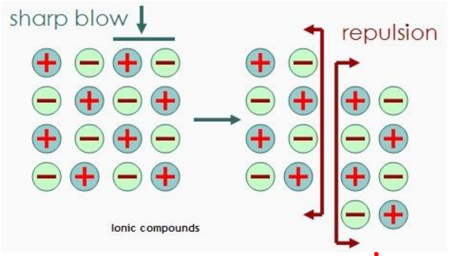
~~bond~~ lattice energy 787 kJ/mol

metal^{+}-nonmetal^{-} oppositely charged ions not individual molecules dissolve in water

chemical equation for table salt dissolving in water:

Na-Cl (s) $\xrightarrow{H_2O}$ $Na^{+}(aq)$ + $Cl^{-}(aq)$

(aq)? aqueous



ionic compounds are brittle

names and formulas

cation	anion	name	charges	formula: switch the charge numbers
Na	Cl	sodium chloride	Na^{+1} Cl^{-1}	NaCl
Mg	F	magnesium fluoride	Mg^{+2} F^{-1}	MgF_2

a couple of things about ions

ions are not always from single atoms:

ions can be

rock =

chemical name

charges

formula

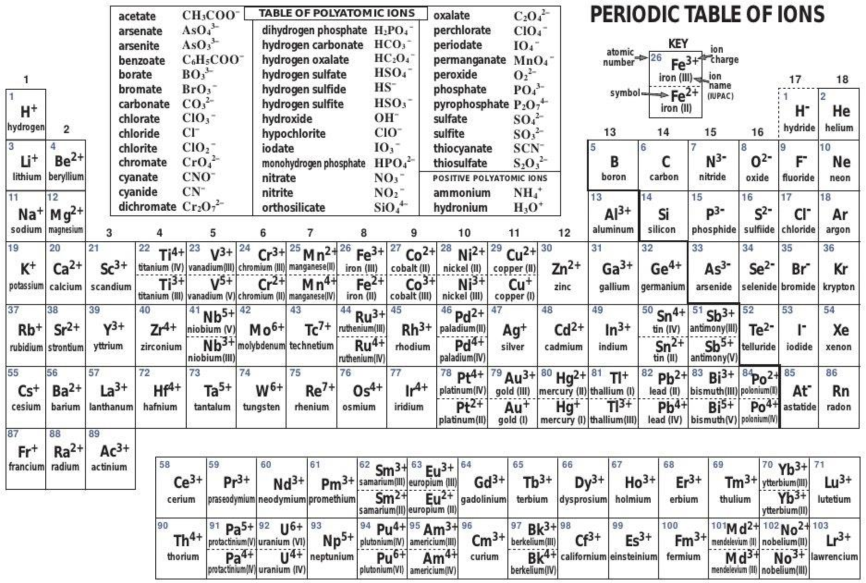
polyatomic ion =

Other examples: sodium cyanide

calcium hydroxide

many ions have multiple charges

ions can be



acetate	CH_3COO^-	dihydrogen phosphate	$H_2PO_4^-$	oxalate	$C_2O_4^{2-}$
arsenate	AsO_4^{3-}	hydrogen carbonate	HCO_3^-	perchlorate	ClO_4^-
arsenite	AsO_3^{3-}	hydrogen oxalate	$HC_2O_4^-$	periodate	IO_4^-
benzoate	$C_6H_5COO^-$	hydrogen sulfate	HSO_4^-	permanganate	MnO_4^-
borate	BO_3^{3-}	hydrogen sulfide	HS^-	peroxide	O_2^{2-}
bromate	BrO_3^-	hydrogen sulfite	HSO_3^-	phosphate	PO_4^{3-}
carbonate	CO_3^{2-}	hydroxide	OH^-	pyrophosphate	$P_2O_7^{4-}$
chlorate	ClO_3^-	hypochlorite	ClO^-	sulfate	SO_4^{2-}
chloride	Cl^-	iodate	IO_3^-	sulfite	SO_3^{2-}
chlorite	ClO_2^-	monohydrogen phosphate	HPO_4^{2-}	thiocyanate	SCN^-
chromate	CrO_4^{2-}	nitrate	NO_3^-	thiosulfate	$S_2O_3^{2-}$
cyanate	CNO^-	nitrite	NO_2^-	POSITIVE POLYATOMIC IONS	
cyanide	CN^-	orthosilicate	SiO_4^{4-}	ammonium	NH_4^+
dichromate	$Cr_2O_7^{2-}$			hydronium	H_3O^+

TABLE OF POLYATOMIC IONS

how to name them?

name	formula
titanium (IV) chloride	
	$TiCl_2$
iron (II) cyanide	

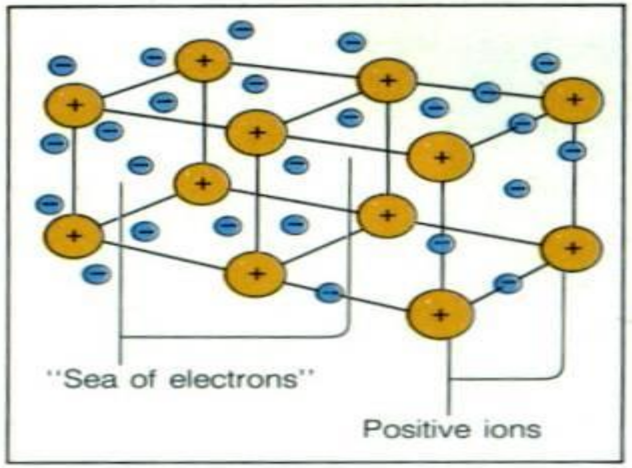
Ex: $_{22}$titanium

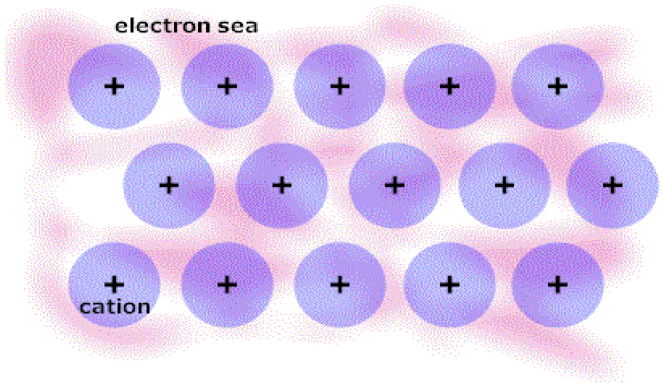
configuration?

why are these elements polyvalent?

Formula: NaCl. Name?

metallic bonds

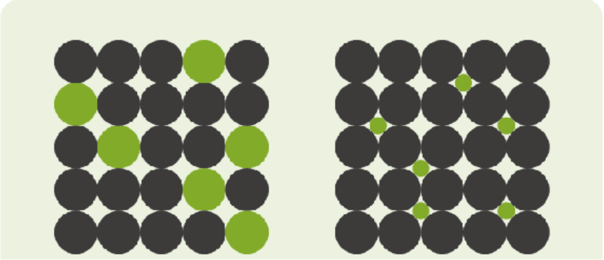




metallic bonds are in general

examples:

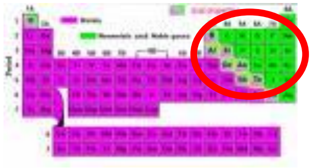
alloys

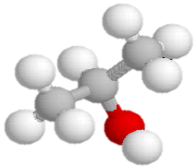


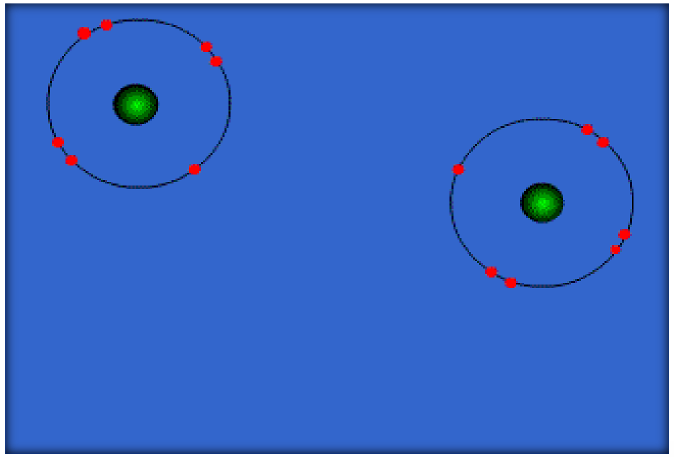
two types of alloys:

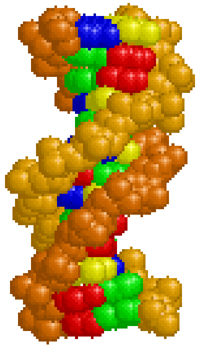
covalent bonding:

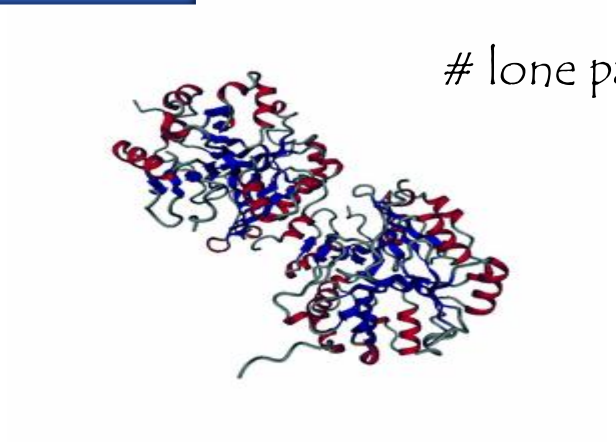
a bond based on ______ electrons











how does electron sharing work?

atoms share electrons to:

electron dot structures: the outer shell

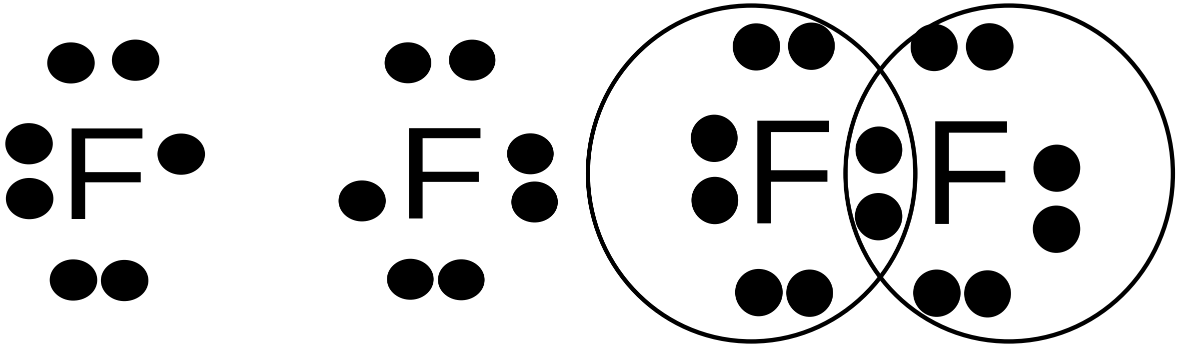
8 electrons (except H, He)
Paired (Pauli), spread out (Hunds).

neon:
8 valence electrons

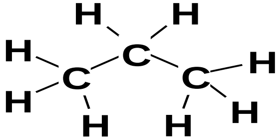
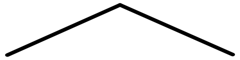
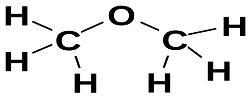
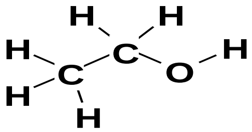
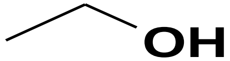
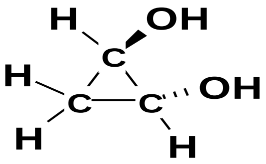
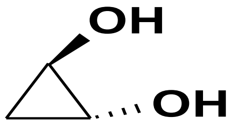
write the electron dot structures of H, O, N, and C:

bonds:

lone pairs:



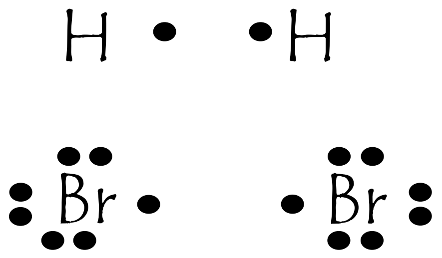
common chemical formula types

molecular formula	structural formula	skeletal formula	condensed formula
C_3H_8			$CH_3CH_2CH_3$
C_2H_6O (2 isomers)	 	 	CH_3OCH_3 CH_3CH_2OH
$C_3H_6O_2$ (1 isomer)			- - - - - - -

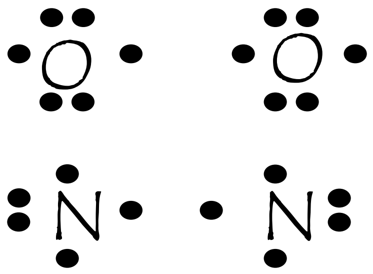
the diatomic elements

H. BrONClIF

combine them to form octets (except H, which only needs 2);
multiple bonds are possible.

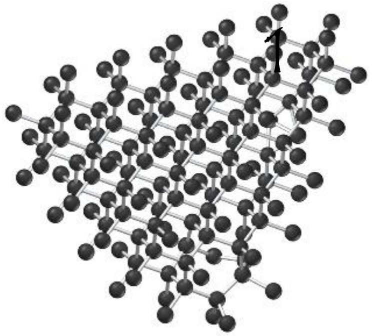
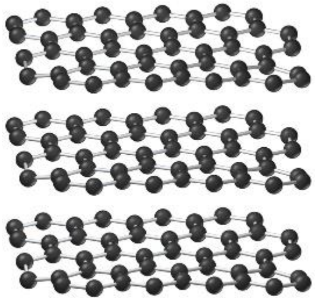
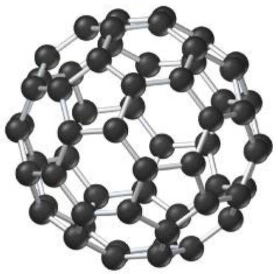


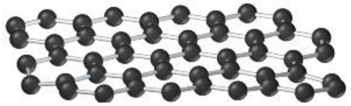
(Same for Cl, I, F



covalent network solids

1 2 3 4 5



Similar to metals but with nonmetallic elements.

graphite quartz buckminsterfullerene graphene diamond

name some others:

B

BN

ReB_2

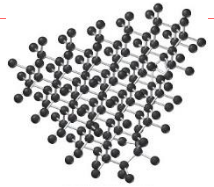
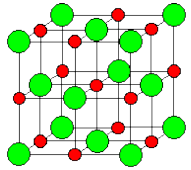
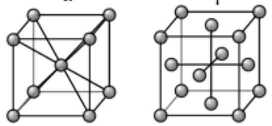
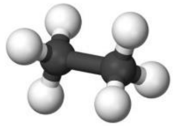
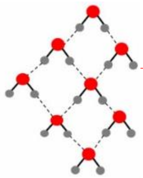
SiC

Si

Ge

chemical bonds and intermolecular forces

	bond or force	strength (kJ/mol)	example
networked substances (no individual molecules)	network covalent bond	300 – 5000	C-C (diamond)
	ionic bond	400-4000	Na^+-Cl^-
	metallic bond	100-500	Fe-Fe
intramolecular	covalent bond	150-1100	C-C (molecules)
intermolecular	ion-dipole force	40-600	Na+--OH_2
	hydrogen bond force F,O,N-H--:F, O, N	10-200	HO-H--OH_2
	dipole-dipole force	5-25	CO_2--CO_2
	london dispersion force (induced dipole)	0.05-40	N_2--N_2

substance	bonds/forces present
	
	
	
	
	

If the ionic bonds breaks but do not form new bonds the substance is ________

If the ions are in solution and the ionic bond forms the substance has ________

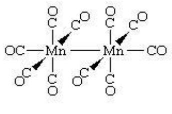
If the substance has no intermolecular forces it must be a ________

If the substance has intermolecular forces that are fixed it must be a ________

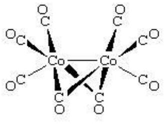
If the substance has fluid intermolecular forces it is a ________

Why is HF nearly a liquid at room temperature but HCl is a gas at room temp? ________

What is the strongest intermolecular force in N_2 ________ CO_2 ________ H_2O ________ HF ________ CH_3OH ________ CCl_4 ________



$Mn_2(CO)_{10}$



$Co_2(CO)_8$

naming binary molecules

H_2O

NH_3

N_2H_4

naming: covalent vs. ionic

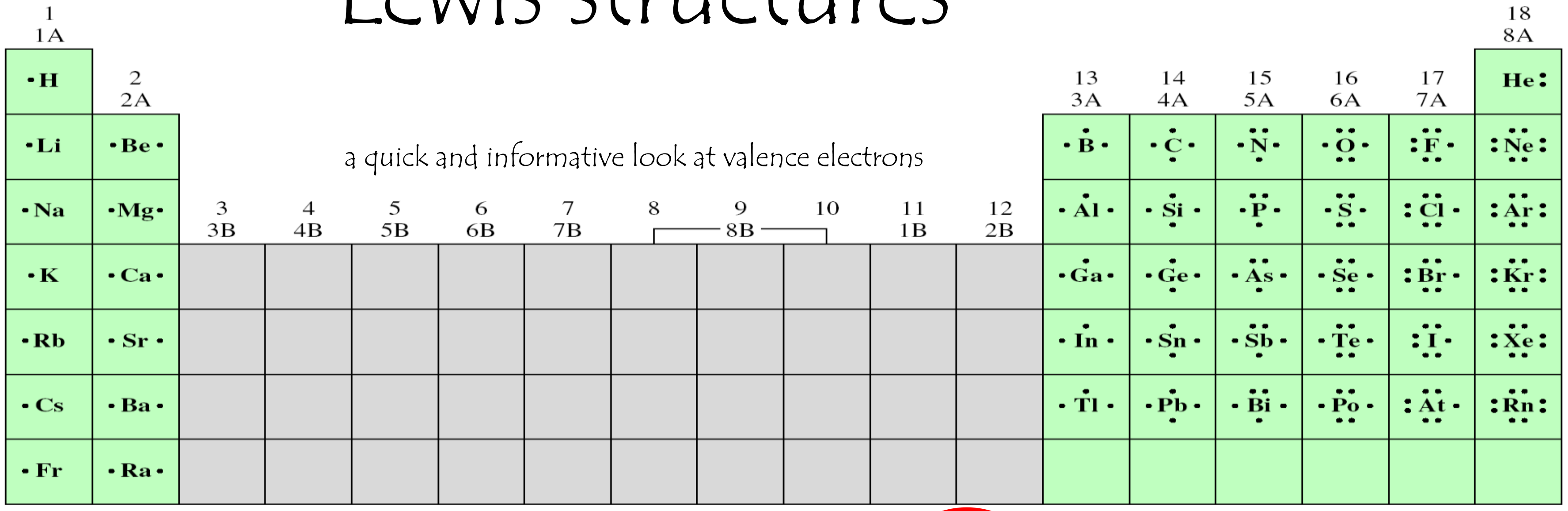
NaCl
CO
$AlCl_3$
SO_2
FeO_2
SiO_2

is first element a Metal?

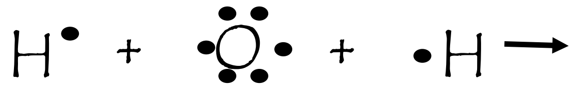
- no → covalent: use, mono, di, etc.
- yes → ionic: don't use mono, di, etc…is it polyvalent?
  - no → don't use (I), (II), etc.
  - yes → do use (I), (II), etc.

Lewis structures

a quick and informative look at valence electrons



Lewis structure of water: **Single bonds**

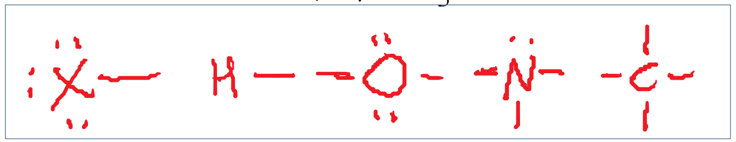


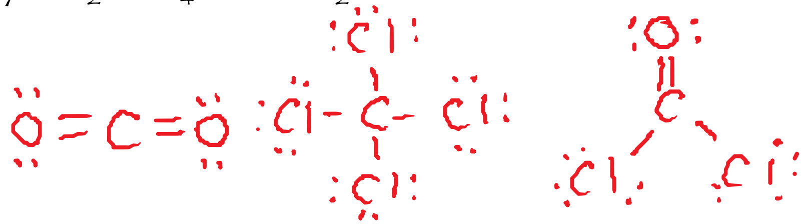
Double bond – two atoms share two pairs of electrons

Triple bond – two atoms share three pairs of electrons

how to determine the shapes of lots of molecules

1. If only X,H,O,N,C apply rules, done. (try CO_2, CCl_4, even Cl_2CO; fails for a few like CO and NO_3^-)





Otherwise:

1. Add up valence electrons
2. Create framework around a central atom; which can have up to 2-6 bonds (incomplete or expanded octet); add electrons to center or create double bonds until valence electrons match
3. Minimize formal charges by forming double bonds; note that only Al and higher can form expanded octets

.

Group 4A	Group 5A	Group 6A	Group 7A	Group 8
SiF_5^-	PF_5	SF_4	ClF_3	XeF_2
SiF_6^{2-}	PF_6^-	SF_6	BrF_5	XeF_4

VSEPR

valence shell electron pair repulsion theory

Number of Electron Dense Areas	Electron-Pair Geometry	Molecular Geometry				
		No Lone Pairs	1 lone Pair	2 lone Pairs	3 lone Pairs	4 lone Pairs
2						
3						
4						
5						
6						