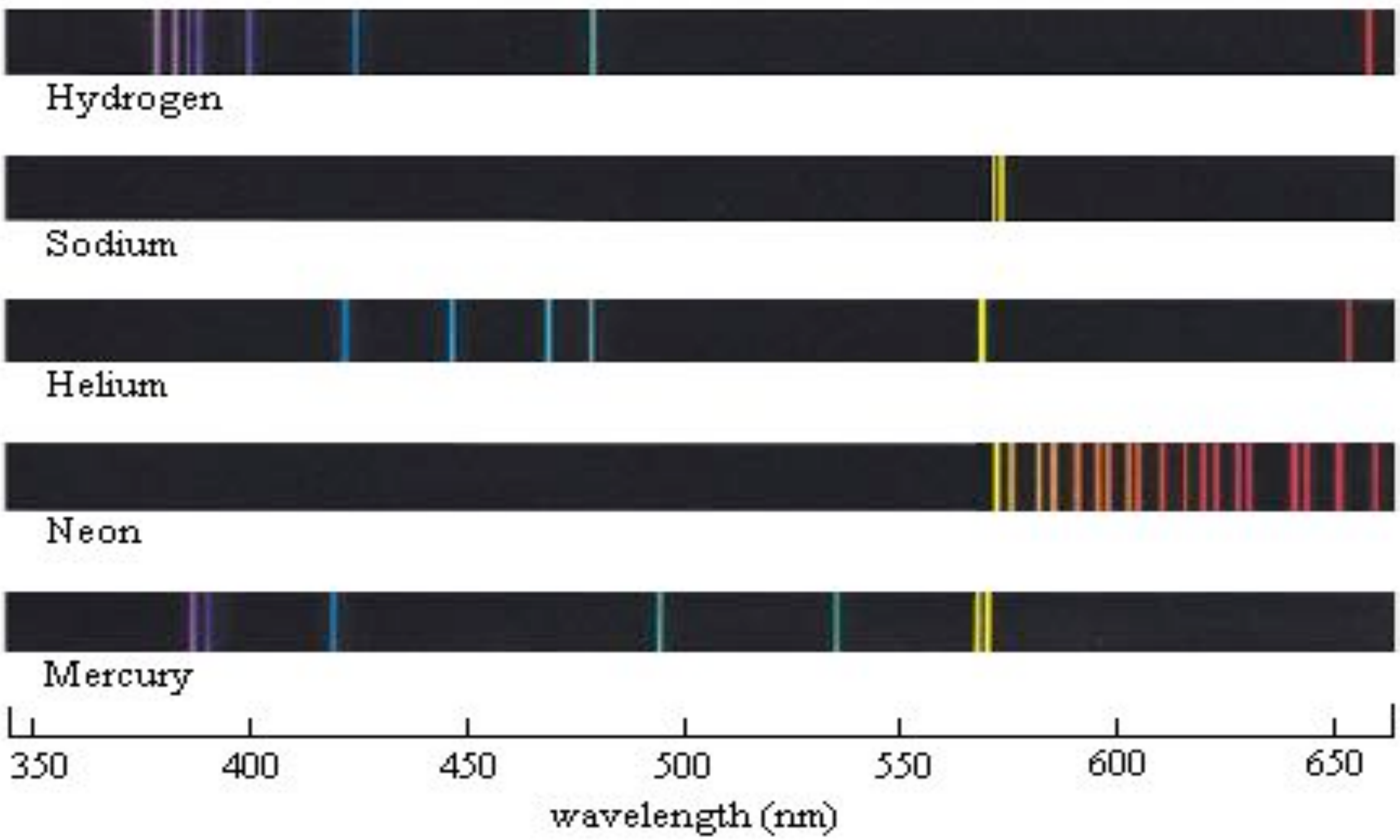
Objective 11

Light and Atomic Structure:
Apply quantum numbers to write electron configuration of atoms,
Identify valence electrons,
Draw Lewis dot symbols,
Draw Lewis structures,
Distinguish isomers.

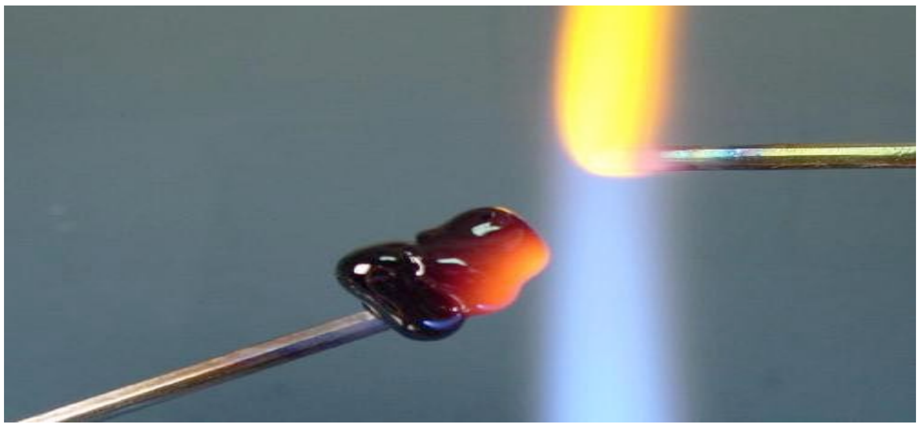
Several Experiments Involving Light Led to the Elucidation of the ***Structure of the Atom*** and to the Development of ***Quantum Theory***:

(i) Bunsen: "*spectrum analysis*" - emission spectra of heated elements (1860) ==> **line spectra** (*not* continuous spectra)



http://wolfstone.halloweenhost.com/Lighting/colvis_ColorVision.html

(ii) *Black body radiation*: a heated solid radiates (emits) light ==> Planck (1900): a minimum amount of energy (***quantum***) is required for atoms in a solid to start vibrating ($E = h\nu$)



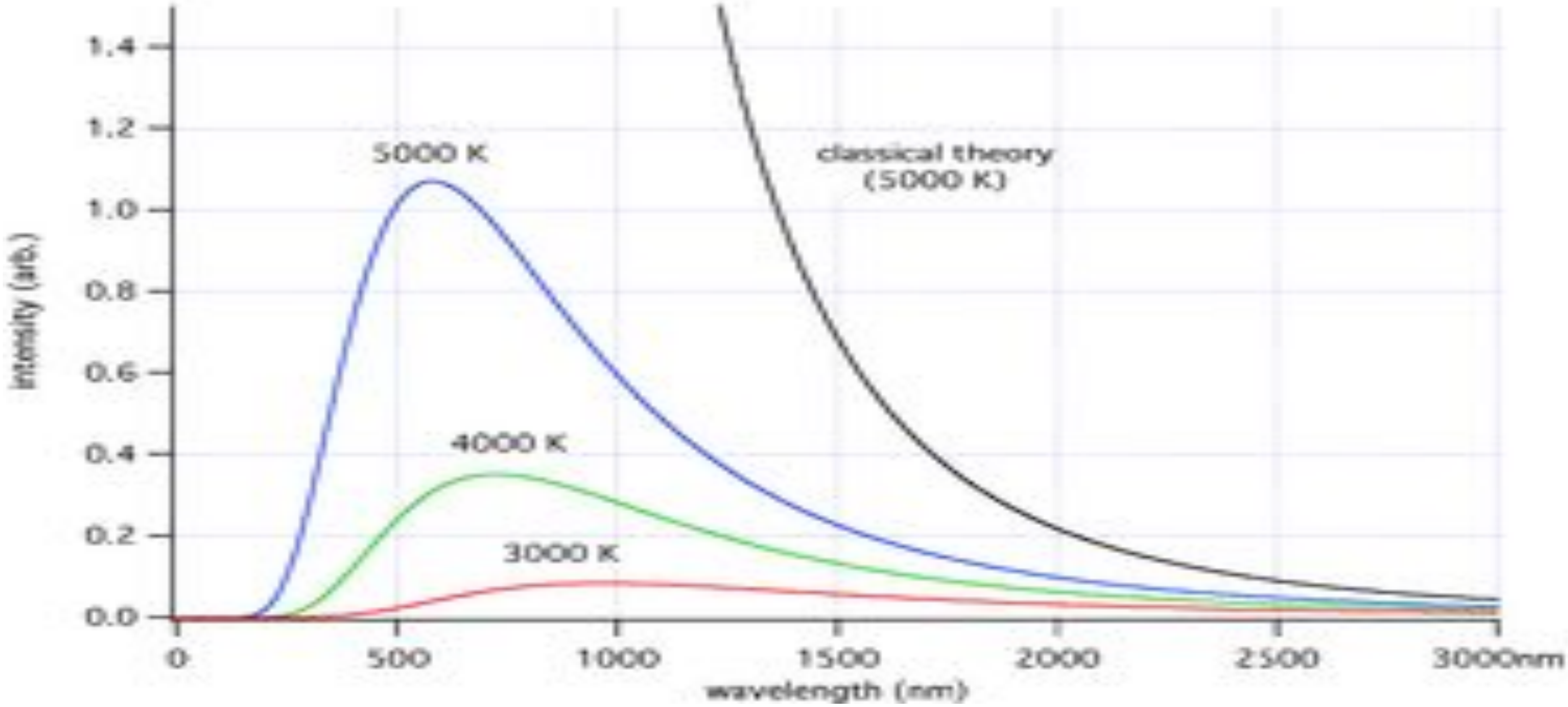
http://www.wetcanvas.com/forums/showthread.php?t=130654

Tutorial: Color Temperature in a Virtual Radiator

http://www.micro.magnet.fsu.edu/primer/java/colortemperature/index.html

http://members.optushome.com.au/terrybrown/HeatTemperChartEtc.html

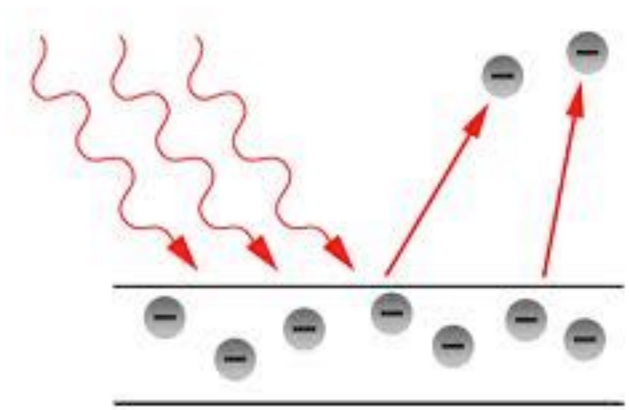
Black Body Radiation



http://en.wikipedia.org/wiki/Uv_catastrophe

The Ultraviolet catastrophe is the error at short wavelengths in the Rayleigh–Jeans law for the energy emitted by an ideal black-body. The error, much more pronounced for short wavelengths, is the difference between the black curve (the wrong curve predicted by the Rayleigh–Jeans law) and the blue curve (the correct curve predicted by Planck's law).

(iii) ***Photoelectric effect***: when light of certain λ hits a metal, an e^- is ejected

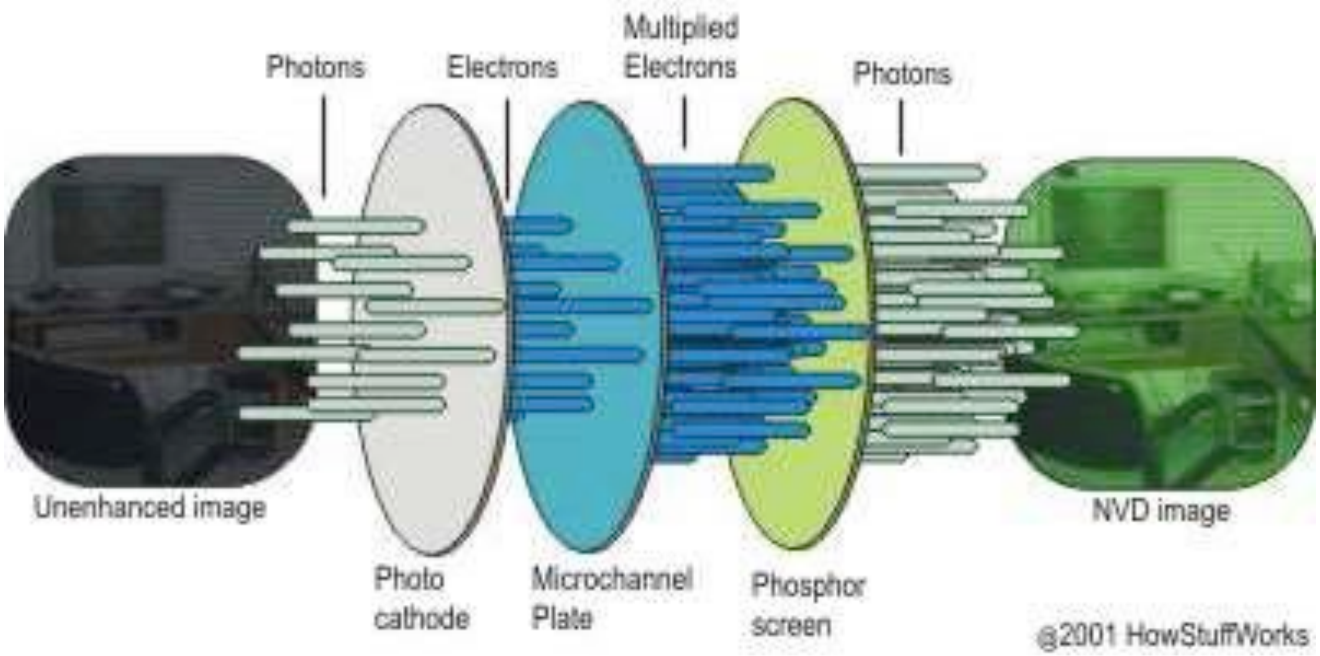


http://www.physicsforums.com/mgc_gloss/30/img_1.png

Einstein (1905): light behaves like a **wave** and **particle** (***photon***). Light has a **DUAL NATURE**.
http://jchemed.chem.wisc.edu/JCEDLib/WebWare/collection/open/JCEWWOR006/

Applications of Photoelectric Effect:
Photocells – automatic doors
Solar cells – pocket calculators

Night vision goggles



http://electronics.howstuffworks.com/gadgets/high-tech-gadgets/nightvision3.htm

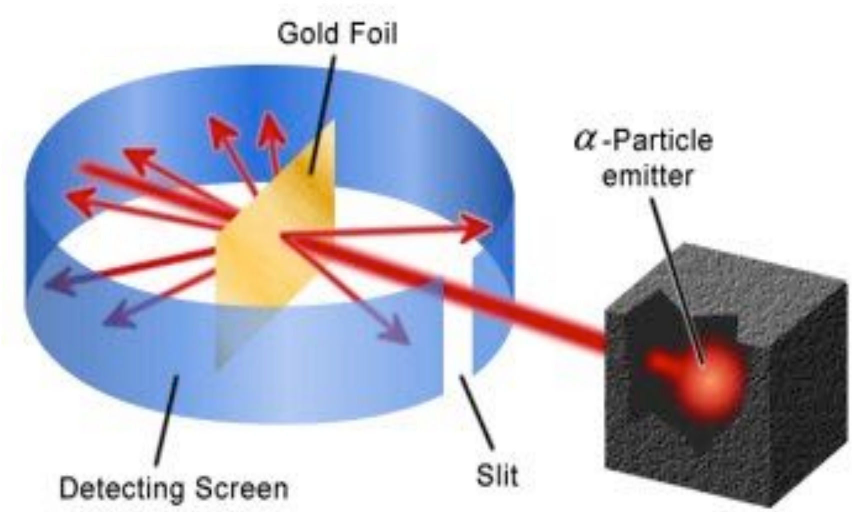
Star Trek TV show applies science!

Photon torpedo

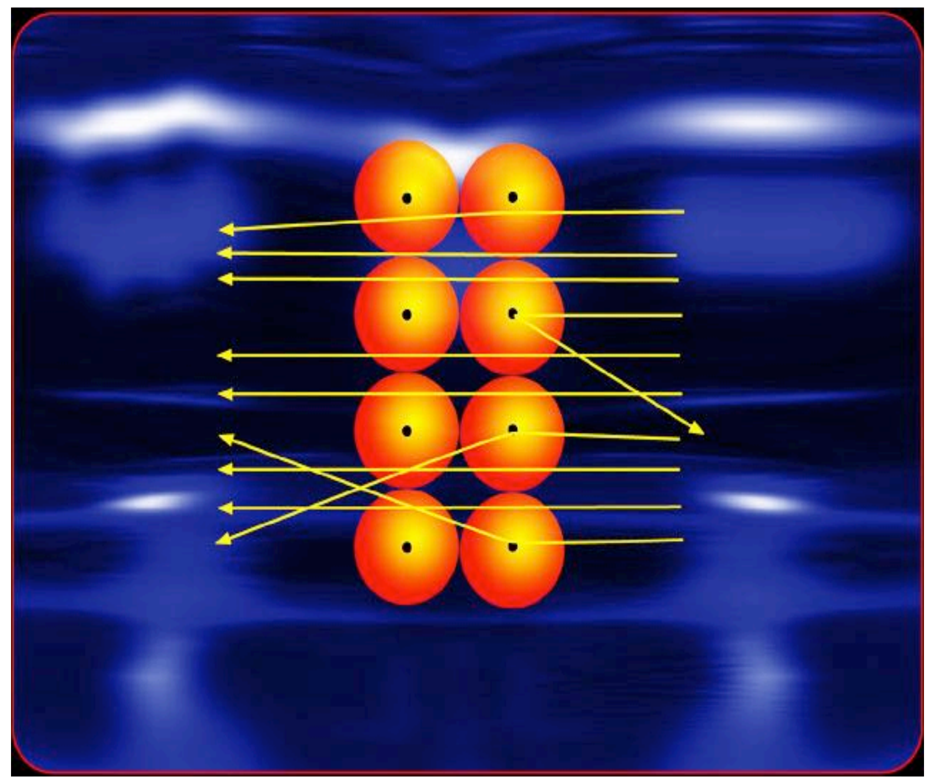
Phaser

http://klingonweapons.com/blog/2009/12/top-5-star-trek-ship-handheld-weapons/

(iv) Rutherford's gold foil experiment (1911) ==>
Atomic Structure: very small nucleus with most of mass surrounded by electron cloud with most of volume
http://www.wwnorton.com/college/chemistry/chemistry3/ch/02/chemtours.aspx



http://www.daviddarling.info/encyclopedia/R/Rutherfords_experiment_and_atomic_model.html



http://www.rsc.org/chemsoc/timeline/pages/1911.html

(v) Bohr model of the H atom (1912) ==>

electron energies are ***quantized*** ($E = -R_H/n^2$)

http://dwb4.unl.edu/ChemAnime/atomic_orbits.htm

(vi) DeBroglie duality hypothesis (1924) ==>

matter behaves like a **particle** and **wave**.

Matter has a DUAL NATURE.

Confirmed in 1927 by electron diffraction observation.

Evolution of our understanding of matter:

http://www.hyperhistory.com/online_n2/people_n2/science_n2/atomic_theory.html

Objective: describe light as a wave and particle

Light is a Wave

Einstein: From photoelectric effect, light behaves like a particle. (Light has a *Dual Nature*)

Electron is a Particle

deBroglie: From electron diffraction, if light, which is a wave, can behave like a particle, then an electron, which is a particle, can behave like a wave. (Matter has a *Dual Nature*)

deBroglie equation: $\lambda = h/mv$

Wave part

Particle part

A Microscope Uses the Wave Property of Light or Electron

1. a. How does a light microscope work?
b. Calculate the size of the smallest object that can be observed using visible light.

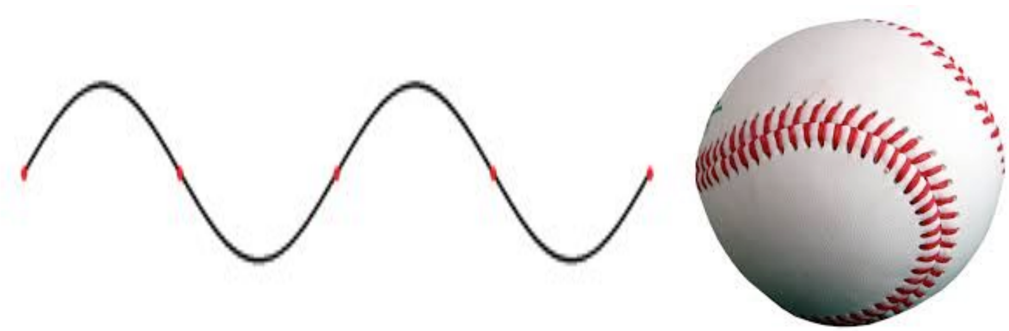
$$\text{Resolution} = 1/2\ \lambda_{\text{observation}}$$

c. How does an electron microscope work?
CEN, 9/20/04, p. 13 electron microscope resolution limit = 0.6 A.
Calculate the wavelength of an electron in an electron microscope.
Calculate the velocity of electron in this microscope.

Wave Nature applies to small objects moving very fast

Calculate the wavelength of baseball (m = 5 oz = 0.145 kg, v = 60 mph = 27 m/sec).

deBroglie equation: $\lambda = h/mv$



Velocity of an Electron

$$v = \frac{(6.63\text{x}10^{-34} \text{ J sec})}{(9.11\text{x}10^{-31} \text{ kg})(1.2 \text{ x } 10^{-10} \text{ m})}$$

$v = 6.0 \text{ x } 10^{6}$ m/sec

Is this velocity possible?

Wavelength of a Baseball

$$\lambda = \frac{(6.63\text{x}10^{-34} \text{ J sec})}{(0.145 \text{ kg})(27 \text{ m/sec})}$$

$\lambda = 1.7 \text{ x } 10^{-34}$ m

Can this wavelength be measured?

Objective: distinguish between classical physics and quantum theory

Classical Physics: a particle is a ***particle***
Quantum Theory: a particle (electron) is a Wave

Classical Physics	Quantum Theory
Particle	Wave
Arbitrary values	Discrete values (Quantized)
Newton's laws	Wave function
Trajectory	Probability, statistics
Position and energy known	Uncertainty principle
"large" and "slow" objects	"small" and "fast" objects

Quantum Theory is Based on Quantization and Probability

1. A line emission spectrum is observed for a gas source. A continuous spectrum is observed for a solid source. Which spectrum fits classical physics? Which spectrum fits quantum theory?

2. What do these have in common? Egg, baseball, electricity, photon torpedo

3. What is the probability of you being in this room?

4. What does electron cloud mean?
Compare Bohr model to quantum atom.
http://dwb4.unl.edu/ChemAnime/atomic_orbits.htm

1. According to classical physics,
(a) a particle behaves like a ________.
(b) ________ describes a particle's energy and position.

2. According to quantum theory,
(a) a particle behaves like a ________.
(b) The wave function of an electron in an atom is called a _______.

3. An electron in an atom is described by ___ quantum numbers.

4. For an electron in a 1s atomic orbital, n = ______, ℓ =_______.

5. What are the quantum numbers for an electron in a 4d atomic orbital?

6. According to quantum theory, does a 2d atomic orbital exist?

<u>Applications of Quantum Theory</u>:

Color, e.g., blue LED (2014 Nobel Prize in Physics)

MRI

Quantum computers – “qubits”

Cryptography and communication – quantum entanglement

Atomic Orbital = Wave Function of an Electron

The ***4 Quantum Numbers*** Tell Us All the Information We Need to Describe an Electron

Quantum Number	Symbol	Information	Possible Values	Relate to Atomic Orbital
Principal	n	Relative Energy	1, 2, ..	Low n means low E
Angular Momentum	ℓ	Shape of Orbital	0, 1, 2, n-1	$\ell=0$ s orbital $\ell=1$ p orbital
Magnetic	m_ℓ	Orbital Orientation in Space	0, 1, -1, 2, -2, $\pm\ell$	$2\ell+1$ s orbital = 1 type p orbital = 3 types
Spin	m_s	Spin Orientation	1/2, -1/2	

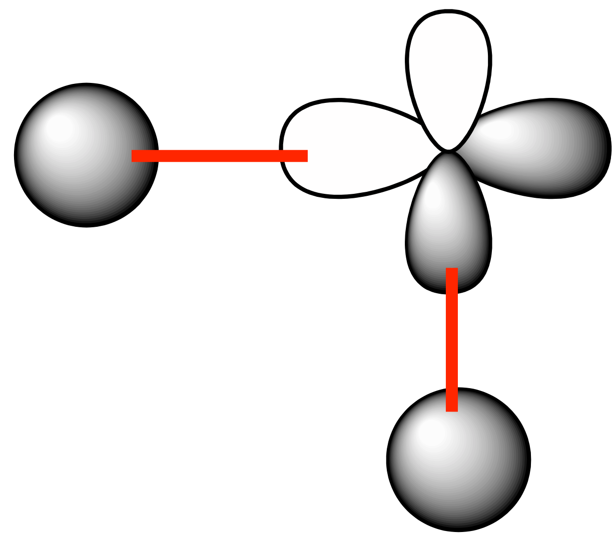
Example: 3p AO quantum numbers: $n = 3$, $\ell = 1$, $m_l = 0, 1, -1$

What are the quantum numbers for an electron in a 4s AO?

Why Do We Have to Learn about Orbitals?

Energy of an electron tells us about color (Ne = red, W = x-rays)
Energy of an electron tells us about reactivity (higher E ==> more reactive)
Shape and orientation tell us where to find electron (shape)

Orbitals tell us how atoms bond together
Orbitals tell us about shape of molecules

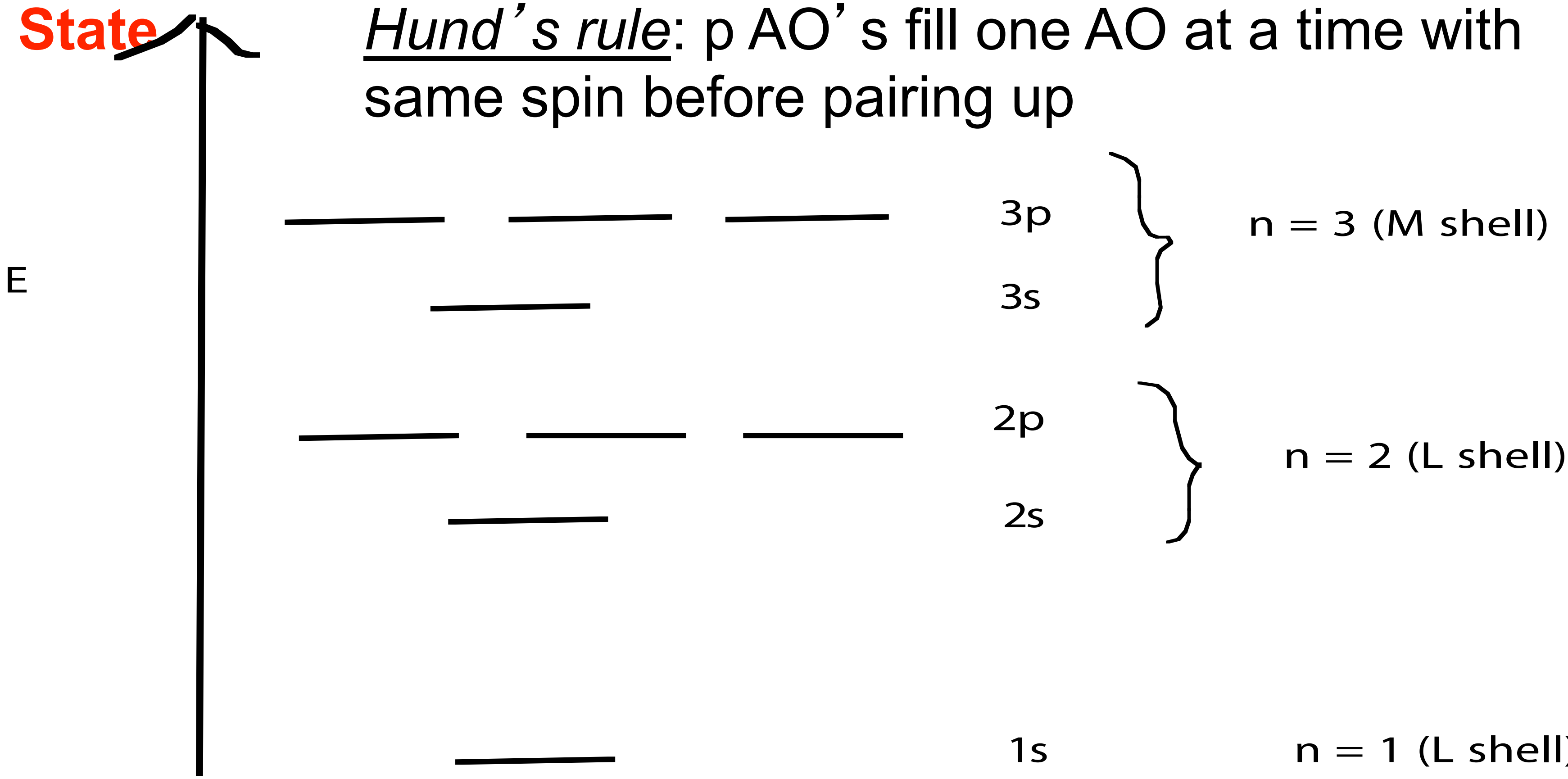


What quantum number tells us about magnetism?

Electron Configuration of an Atom Tells Us How Electrons Are Distributed Around the Nucleus

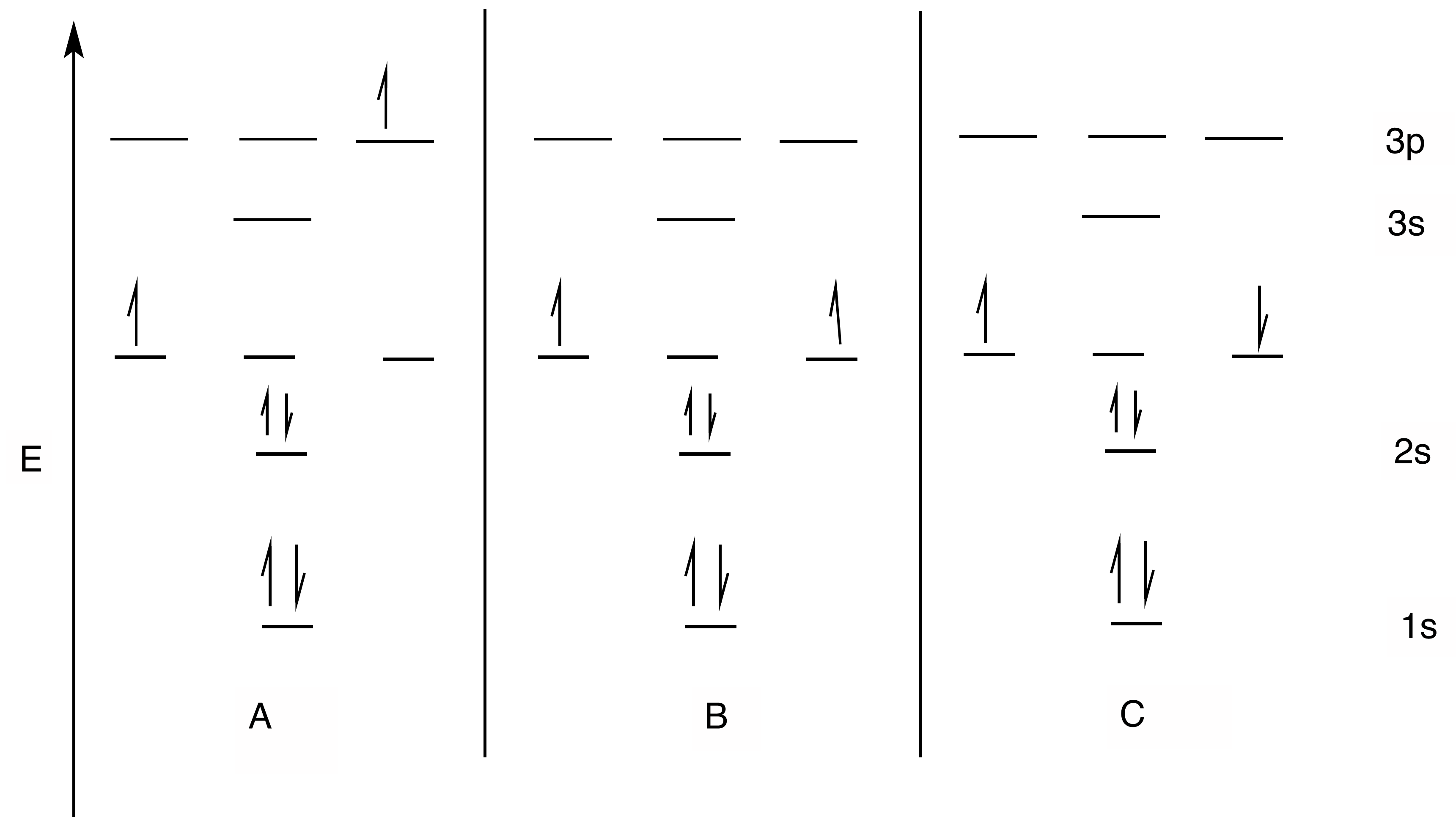
4 rules – for **Ground State**

- *Aufbau*: AO's fill from lowest to highest
- *2 e⁻ max in each AO*
- *Pauli exclusion*: AO with 2 e^- has opposite spin
- *Hund's rule*: p AO's fill one AO at a time with same spin before pairing up



Objective: determine electron configuration

Objective: determine electron configuration
Three energy level diagrams are shown below.
Which element is represented in each diagram?
Which diagram represents a ground state electron configuration?



Objective: identify valence electrons

What Information or Use Does Electron Configuration Tell Us?

What is the electron configuration of N?
Which electrons are the ***valence*** electrons?

Objective: identify valence electrons

What Information or Use Does Electron Configuration Tell Us?

What is the electron configuration of Fe?
Which electrons are the ***valence*** electrons?

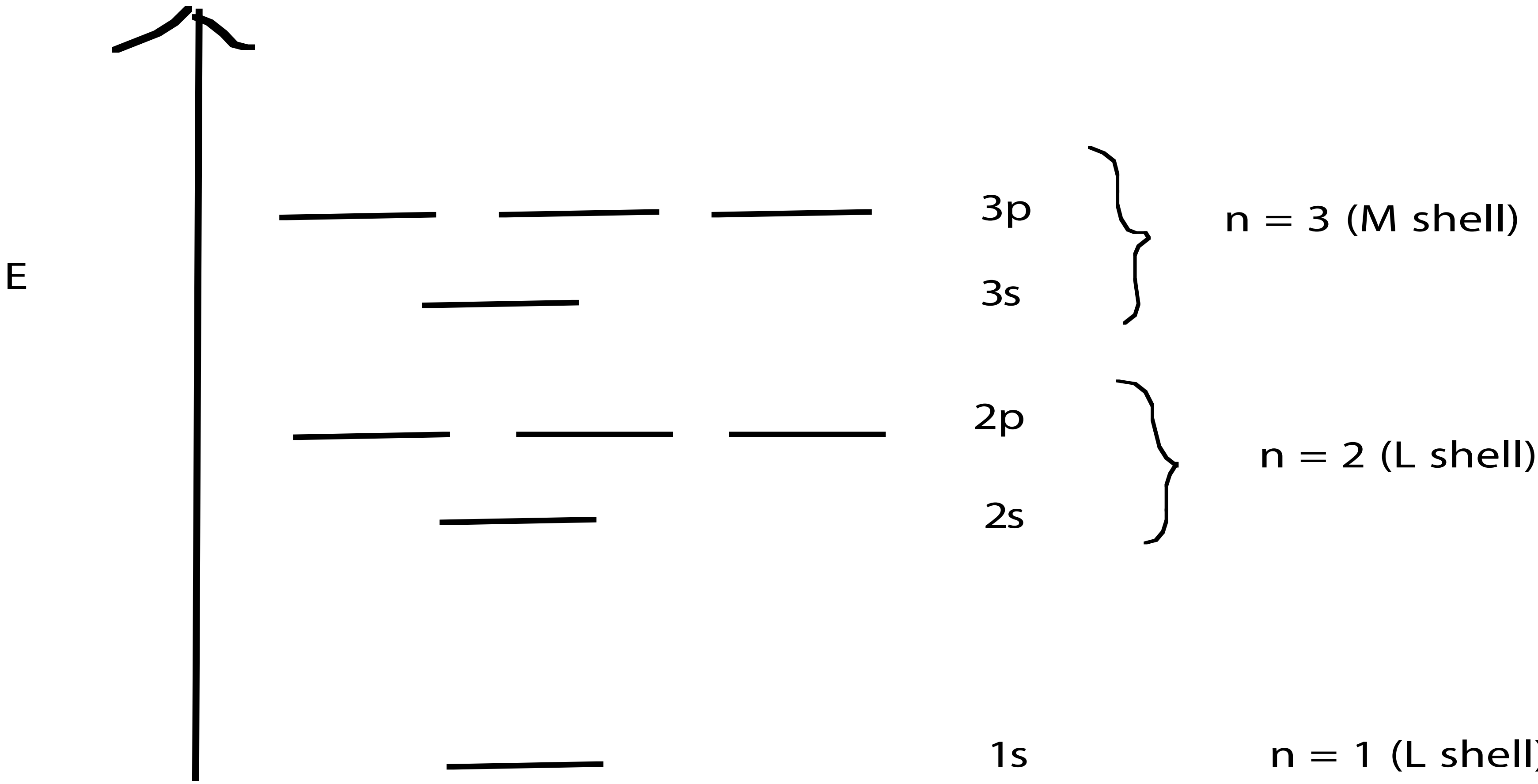
Main group elements (Group # = ___ A): partially filled **p** AO

Transition elements (Group # = ___ B): partially filled **d** AO

CHM 1A: Focus on Main Group Elements

Objective: Use Energy Level Diagram and 4 rules (***Aufbau, 2 e^-/AO, Pauli exclusion, Hund's rule***) to determine ground state e^- configuration of an atom and ion

What is the charge on O in a compound?
Why does O have this charge?



Elements are classified by <u>Properties</u>

Which element type has the following Properties?

(a) soft, shiny, conductors

(b) hard, dull, insulators

Which group of elements are soft, reactive metals?

(a) Li, Na, K (Group 1A)

(b) F, Cl, Br (Group 7A)

Mendeleev's original Periodic Table (1869)

http://chemistry.about.com/od/periodictables/ig/Periodic-Tables/Mendeleev-s-Periodic-Table.-0ET.htm

ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

			Ti = 50	Zr = 90	? = 180.
			V = 51	Nb = 94	Ta = 182.
			Cr = 52	Mo = 96	W = 186.
			Mn = 55	Rh = 104,4	Pt = 197,4.
			Fe = 56	Rn = 104,4	Ir = 198.
			Ni = Co = 59	Pl = 106,6	Os = 199.
H = 1			Cu = 63,4	Ag = 108	Hg = 200.
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112	
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?
	C = 12	Si = 28	? = 70	Sn = 118	
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?
	O = 16	S = 32	Se = 79,4	Te = 128?	
	F = 19	Cl = 35,5	Br = 80	J = 127	
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204.
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207.
		? = 45	Ce = 92		
		?Er = 56	La = 94		
		?Yt = 60	Di = 95		
		?In = 75,6	Th = 118?		

Д. Менделѣевъ

Are Li, Na, and K grouped together in this table?

What other elements are grouped with Li, Na, and K?

Which elements are the metals?

What do the ***numbers*** on each column tell you?

PERIODIC TABLE OF THE ELEMENTS

1A	2A	3B	4B	5B	6B	7B	|--------8B--------|			1B	2B	3A	4A	5A	6A	7A	8A
1 H 1.008																	2 He 4.003
3 Li 6.939	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.183
11 Na 22.99	12 Mg 24.312											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.9	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.71	29 Cu 63.546	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.8
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc [97]	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.4	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.91	56 Ba 137.34	57* La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po 210	85 At 210	86 Rn 222
87 Fr 215	88 Ra 226.03	89** Ac 227.03	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [269]	109 Mt [268]	110 [271]	111 [272]	112 [277]		114 [289]		116 [289]		

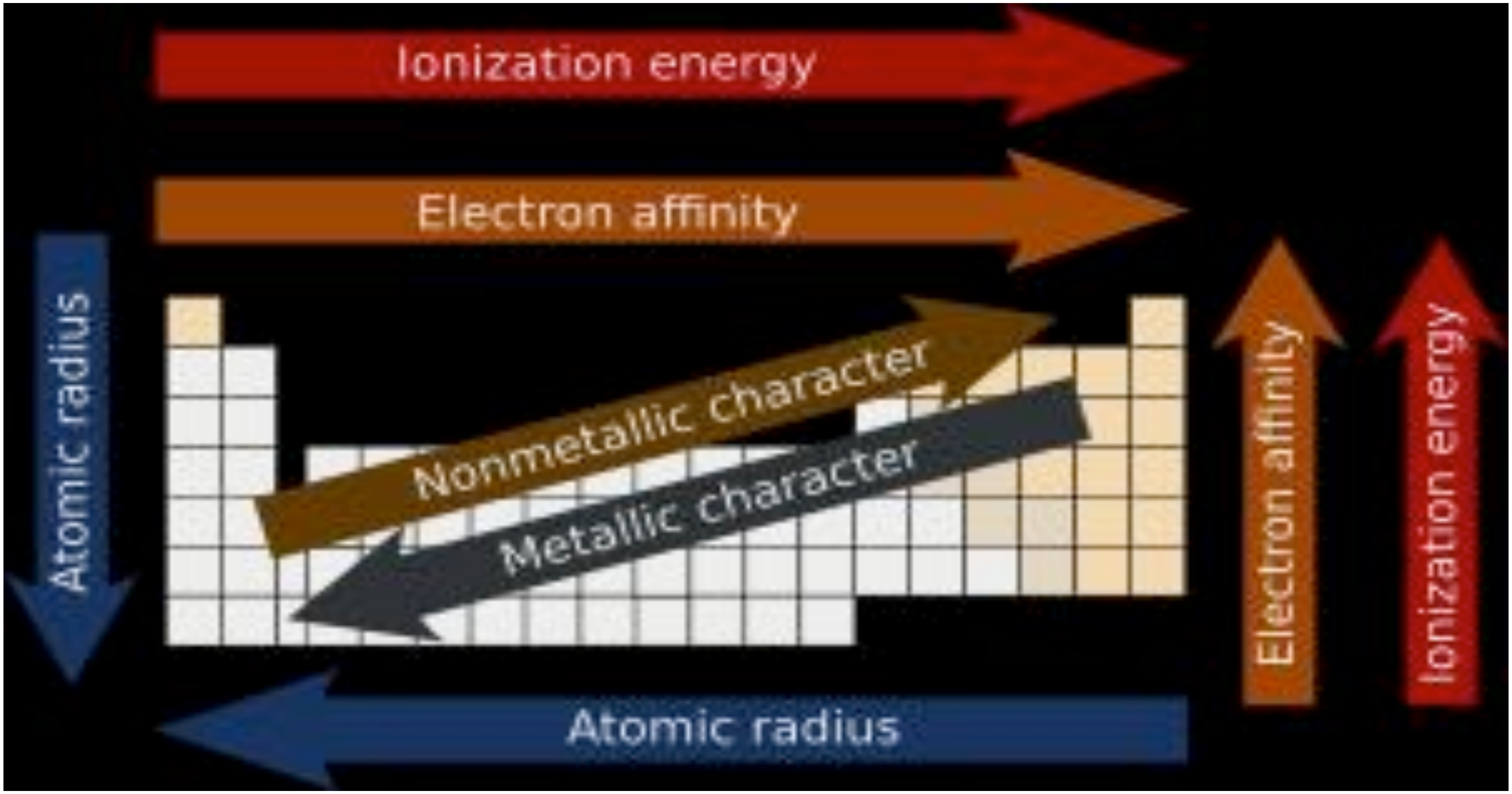
*Lanthanides	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 145	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.5	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
**Actinides	90 Th 232.04	91 Pa 231	92 U 238.03	93 Np 237.05	94 Pu 239.05	95 Am 241.06	96 Cm 244.06	97 Bk 249.08	98 Cf 252.08	99 Es 252.08	100 Fm 257.1	101 Md 258.1	102 No 259.1	103 Lr 262.11

Gaseous at room temperature
Liquid at room temperature
Gallium melts at 29.78 deg. C.
Synthetic elements
All other elements are solid at room temperature

Group # = # of valence electrons

http://www.csudh.edu/oliver/chemdata/periodic/periodic-1.htm

The Periodic Table shows Trends (***Patterns***) in Properties of Elements. (http://en.wikipedia.org/wiki/Periodic_table)



How is atomic radius related to ionization energy?

Color is Used to Identify Substances

Bunsen noticed different colors in factory fires (1860)

Ionic salts are added to fireworks to give different colors.

a. What ionic salt produces a green color? What salt produces a red color?

b. Is there a trend in color and element position in the Periodic Table?

Li (red)
Na (yellow)
K (violet)

Ca (red)
Ba (green)

Cu (blue-green)

c. How is the color emitted by each salt quantified?

METALS LOSE ELECTRONS (oxidized – Lab 6)

When a metal loses an electron, a positively charged ion (cation) is formed.

E.g., $Na - e^- \; \text{--->} \; Na^+$

What is the electron configuration of Na^+?

Why does Na^+ have a +1 charge?

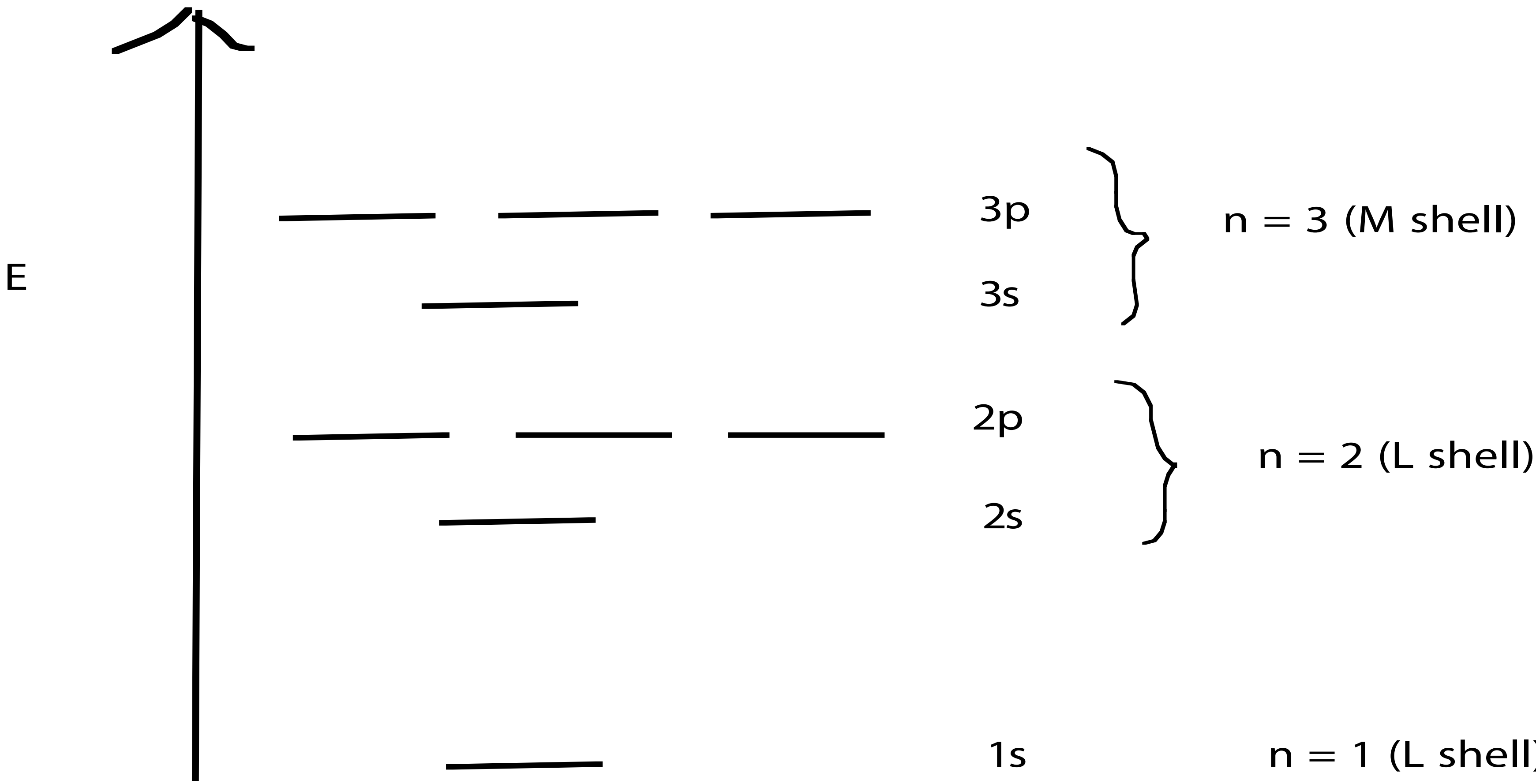
How is charge related to group number?

Is Na more reactive or less reactive than Na^+?

Is the size of Na larger, smaller, or the same size as Na^+?

Rank Li, Na, and K (Group 1A) in order of reactivity. How is your ranking related to size and ionization energy?

Objective: Use Energy Level Diagram and 4 rules (***Aufbau, 2 e^-/AO, Pauli exclusion, Hund's rule***) to determine ground state e^- configuration of an atom and ion



Group 1A metals (Li, Na, and K) react with water:

Li + H_2O --->

Na + H_2O --->

K + H_2O --->

What is the product(s) of each reaction?
Which metal is the most reactive?

Li Na K

Alkali metals reacting with water - see World of Chemistry video on the Periodic Table (10 minute mark).

Group 1A metals (Li, Na, and K) react with water:

$Li + H_2O \longrightarrow$ *least* reactive

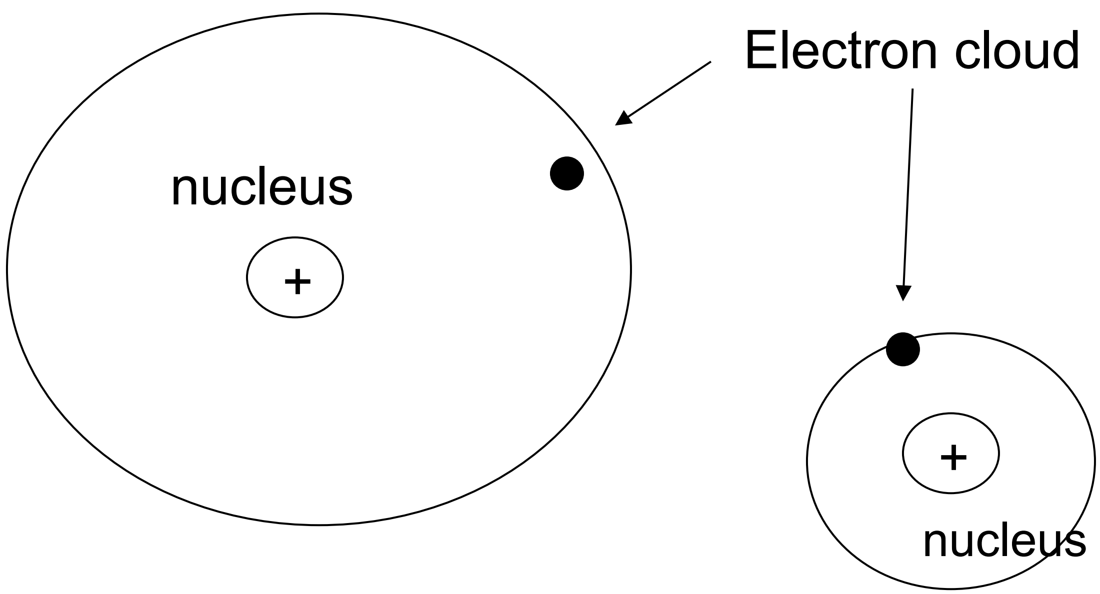
$Na + H_2O \longrightarrow$

$K + H_2O \longrightarrow$ *most* reactive

Larger size ===> electrons farther from nucleus

Farther from nucleus ===> less attraction ==> lower IE

Lower IE ===> more reactive



Coulomb's law:

$$F = \frac{k\, q_1\, q_2}{r^2}$$

Which atom is more easily oxidized?

<u>NON-METALS GAIN ELECTRONS</u> (reduced – Lab 6)

When a non-metal gains an electron, a negatively charged ion (anion) is formed.
E.g., $Cl + e^- \text{--->} Cl^-$

What is the electron configuration of Cl^-?

Why does Cl^- have a -1 charge?

Is Cl more reactive or less reactive than Cl^-?

How is charge related to group number?

Is the size of Cl larger, smaller, or the same size as Cl^-?

Rank Cl, Br, and I (Group 7A) in order of reactivity (see Lab 6). How is your ranking related to size?

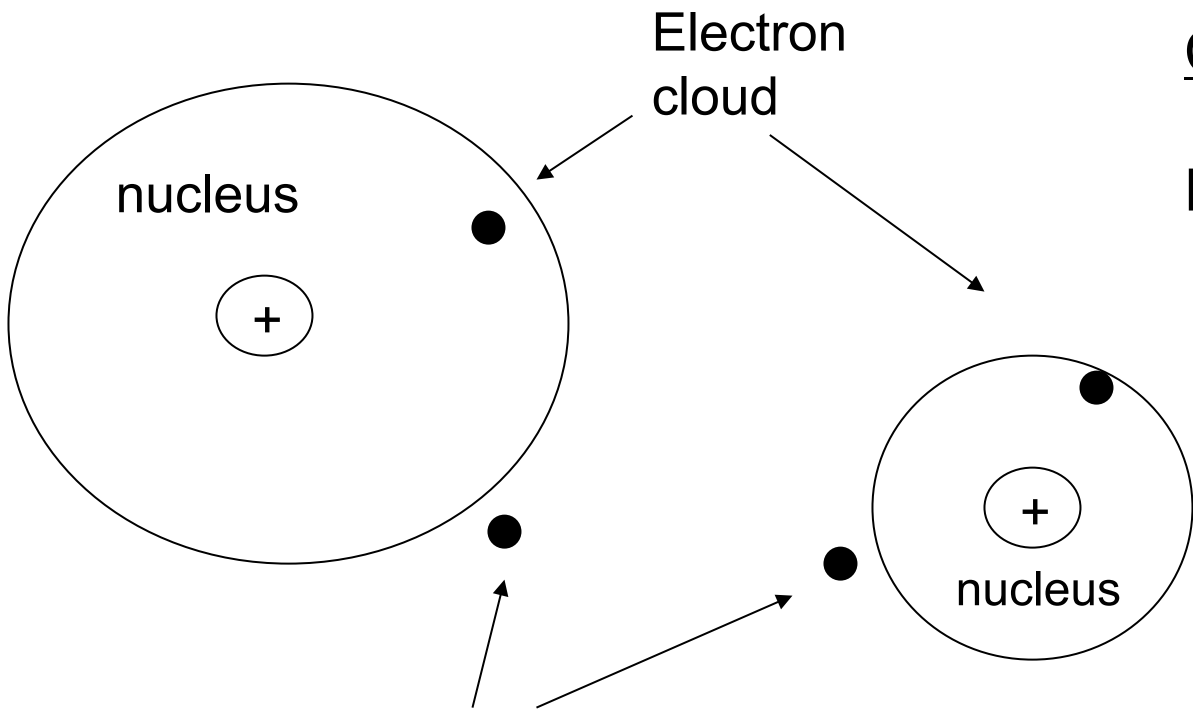
Group 7A non-metals (Cl, Br, I) are *Oxidizing Agents*:

Cl = best ox agent   I = worst ox agent

Smaller size ===> electrons more attracted to nucleus

Greater attraction ===> electron more easily gained

More easily gained ===> more reactive



Coulomb's law:

$$F = \frac{k\, q_1\, q_2}{r^2}$$

Electron from another atom: ***Which atom is more easily reduced?***

Lab 6. You placed an Fe nail in HCl. Three reactions occur:

$Fe + O_2$ -->

$Fe + HCl$ -->

$Fe_2O_3 + HCl$ -->

Predict the product of each reaction.
Which reaction(s) is/are an oxidation-reduction reaction?
For the oxidation-reduction reaction, which reactant gains electrons whereas the other reactant loses electrons?

Elements Follow Trends by Group or Period
Valence Electrons Determine Reactivity

Metals: Valence Electrons that are farther away from the nucleus are (***easier or harder?)*** to lose.
Non-metals: It is (***easier or harder?)*** to attract Valence Electrons if the nucleus is closer.

1. Why does the sodium ion have a +1 charge and not a +2 charge?
2. Why is K more reactive than Na which is more reactive than Li?
3. Why does the chloride ion have a -1 charge and not a -2 charge?
4. Why is fluorine the best bleach followed by Cl > Br > I?

(from Fall 2009 Exam 2) You place a piece of Mg metal in a beaker filled with water. You place a piece of Ca metal in a second beaker filled with water. See Practice Problem 4.

a. Which reaction occurs faster? In other words, which metal is more reactive? Give reasons.

b. For the reaction that occurs faster, write a molecular equation and net ionic equation.

c. Calculate ΔH of reaction for the reaction in part b. (Use your net ionic equation.)

d. If 2.5 g of the metal that reacts faster is added to 1 cup (240 ml) of water, calculate the final temperature of the water.

Chemical Forces

Strong
Interatomic Forces

- Ionic Bonds
  Transfer of e^-
- Covalent Bonds
  Sharing of e^-
- Metallic Bonds

Weak
Intermolecular Forces

- London Forces
  All substances
- Dipole-Dipole Forces
  Polar substances
- Hydrogen Bonds
  When a H is situated between 2 very EN atoms (F, Cl, O, N) on 2 different molecules

Lab 9. Bonding

Make a Lava Lamp

http://iwantdesi.com/lava-motion-lamp

What chemical will you use to clean a stain?

http://www.rsc.org/learn-chemistry/resources/chemistry-in-your-cupboard/vanish/2

Bring: white fabrics to lab

Classification of Stains

http://www.rsc.org/learn-chemistry/resources/chemistry-in-your-cupboard/vanish/2

Enzymatic	Oxidizable	Greasy	Particulate
blood	tea	vegetable oil	clay
egg	coffee	drippings	mud
grass	red wine	cuff and collar stains (on shirts)	ground in dirt
		motor oil	
		butter	

In 2010, an explosion occurred on the Deepwater Horizon oil rig and spilled oil in the Gulf of Mexico.

How is an oil spill cleaned up?

5 common methods:
(http://www.ceoe.udel.edu/oilspill/cleanup.html)

1. Leave it alone and let nature take its course.
2. Containment and collection with skimmers.
3. Burn it.
4. Use dispersants.
5. Use biological agents.

http://en.wikipedia.org/wiki/Deepwater_Horizon_oil_spill
http://cen.acs.org/articles/88/i20/Cleaning-Gulf-Oil-Spill.html

http://cen.acs.org/articles/91/i22/Deepwater-Horizon-Disaster.html

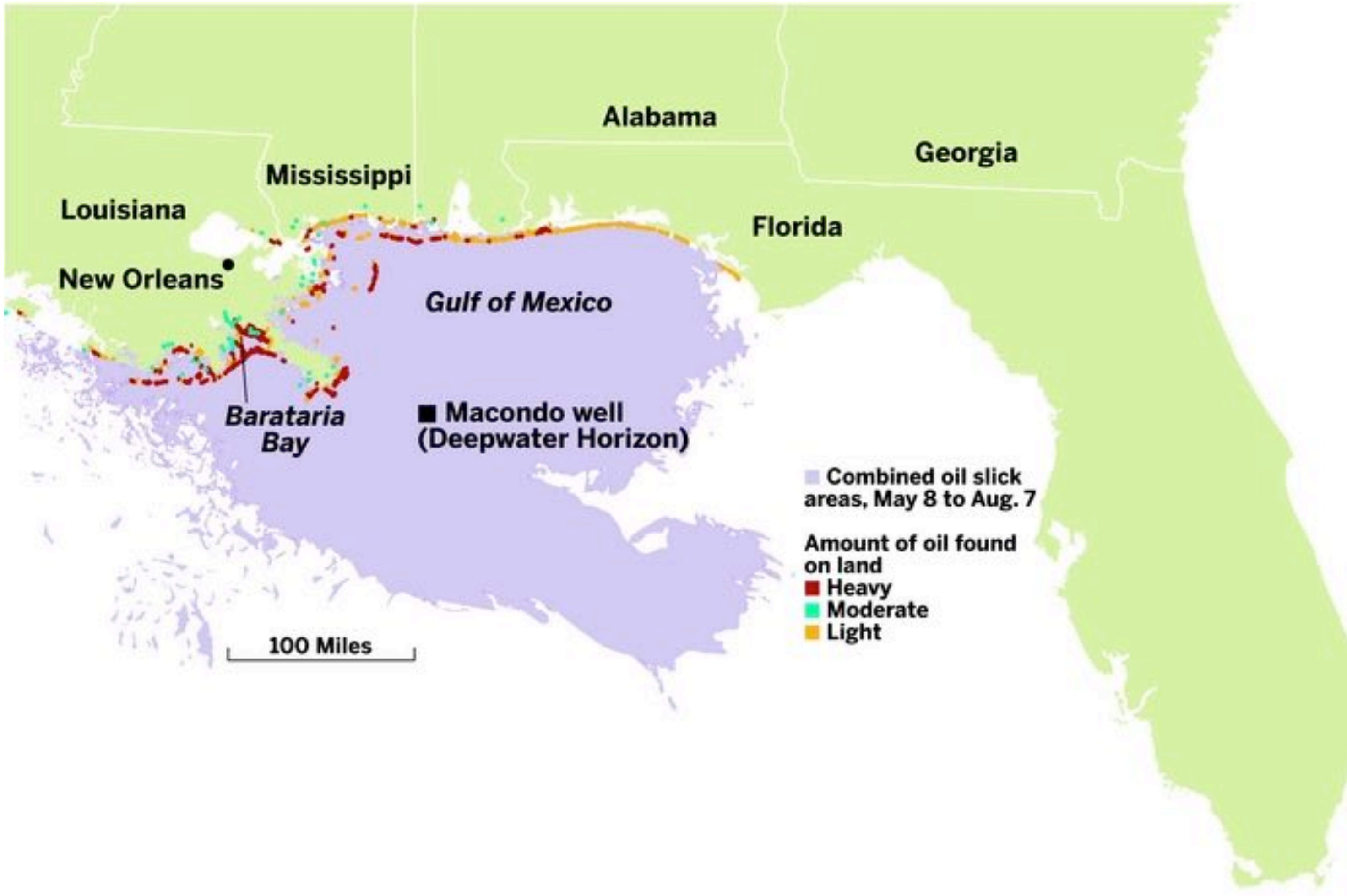
6/3/13, CEN, “After The Deepwater Horizon Disaster”, p. 12

FOULED

After the Deepwater Horizon oil rig exploded and sank, oil from the Macondo well coated marsh grass and containment boom in Barataria Bay in June 2010.

http://cen.acs.org/articles/91/i22/Deepwater-Horizon-Disaster.html

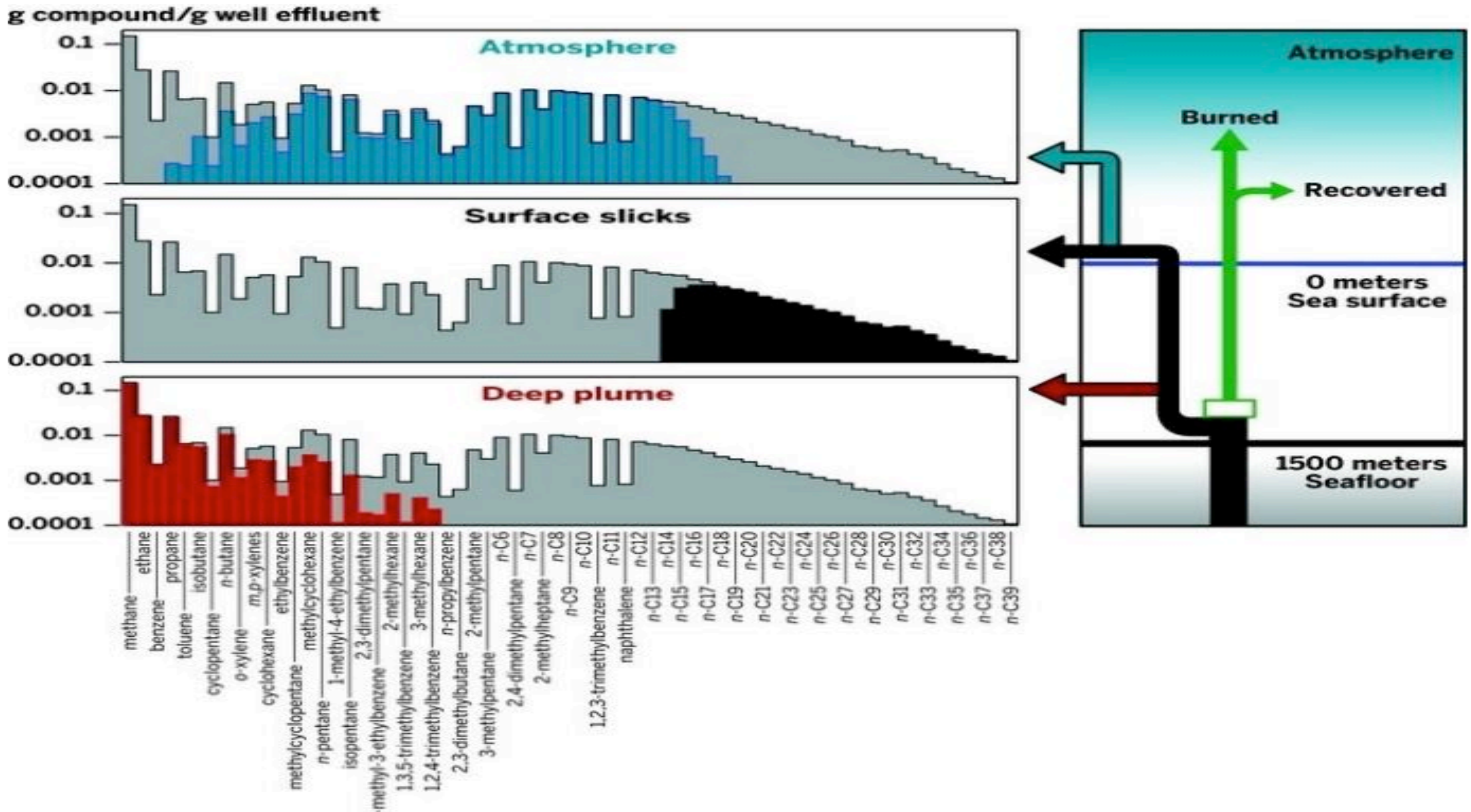
6/3/13, CEN, "After The Deepwater Horizon Disaster", p. 12



The maximum extent of the spill covered large swaths of the Gulf of Mexico and its coastline. SOURCE: National Oceanic & Atmospheric Administration

http://cen.acs.org/articles/91/i22/Deepwater-Horizon-Disaster.html

6/3/13, CEN, “After The Deepwater Horizon Disaster”, p. 12

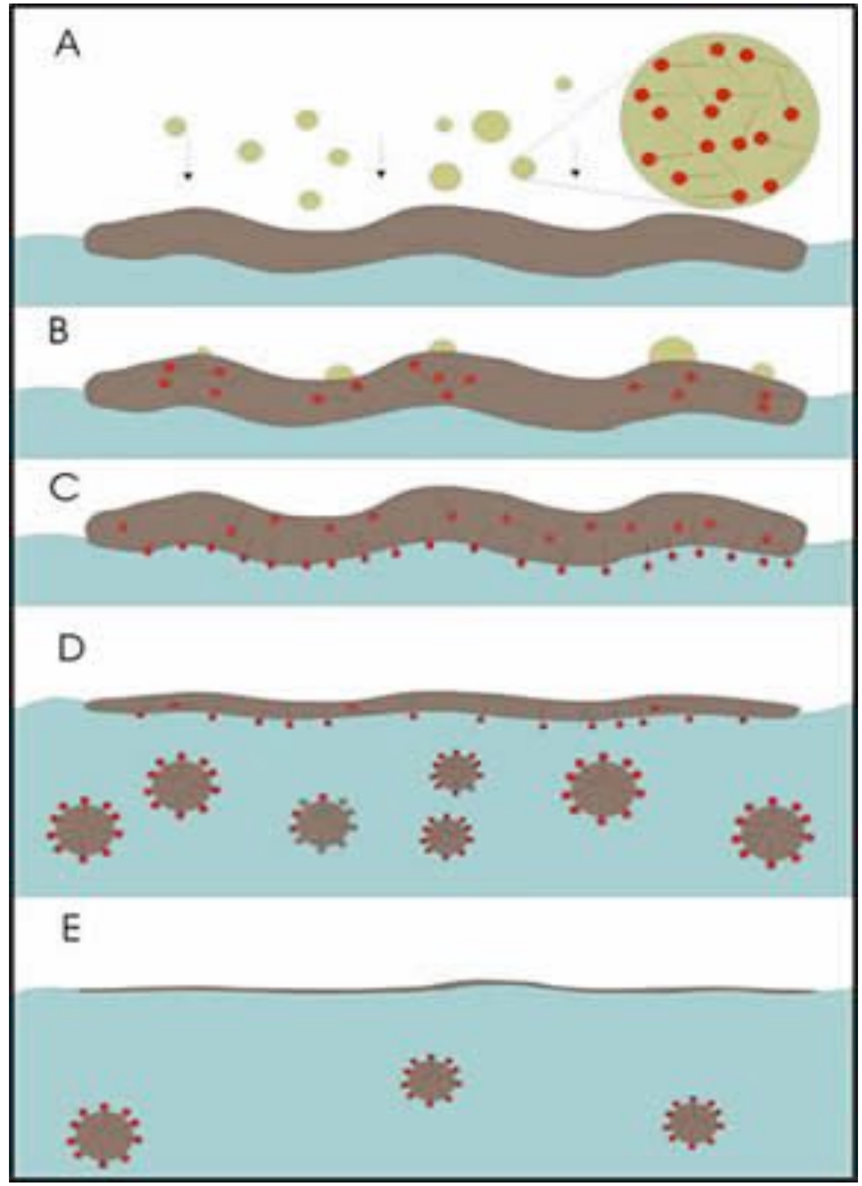


The gas and oil compounds that came out of the Macondo well (gray bars) partitioned between deep plumes (red), water surface slicks (black), and the atmosphere (blue).

Dispersants break the oil into smaller droplets

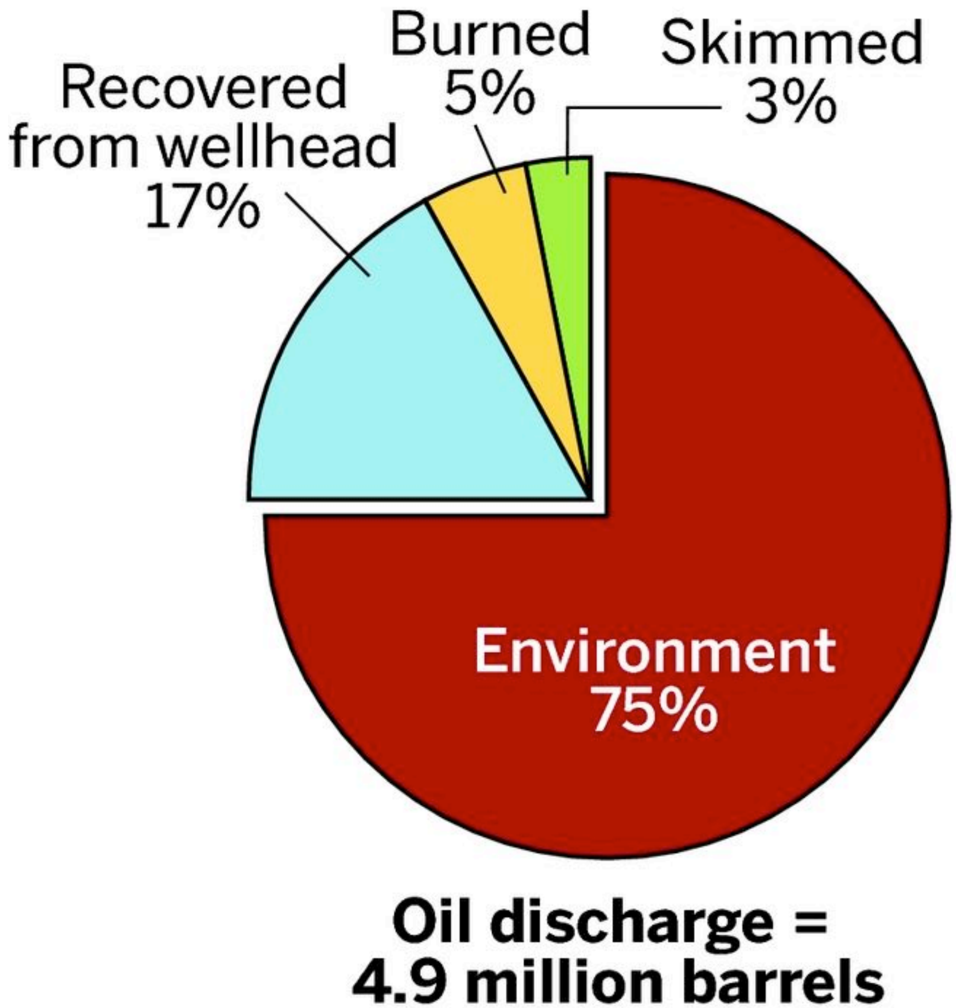
A: Dispersant droplets containing surfactants are sprayed onto the oil.
B: The solvent carries the surfactant into the oil.
C: The surfactant molecules migrate to the oil/water interface and reduce surface tension, allowing
D: small oil droplets to break away from the slick.
E: The droplets disperse by turbulent mixing, leaving only sheen on the water surface

http://www.itopf.com/spill-response/clean-up-and-response/dispersants/



http://cen.acs.org/articles/91/i22/Deepwater-Horizon-Disaster.html

6/3/13, CEN, “After The Deepwater Horizon Disaster”, p. 12



The vast majority of oil from the Macondo well ended up in the environment, including the water column, atmosphere, coastline, and seafloor.

Source: Proc. Natl. Acad. Sci. USA 2012

http://cen.acs.org/articles/89/i29/Testing-Gulf-Seafood.html

7/18/11, CEN, p.12 Testing Gulf Seafood

Gulf fishermen harvest ≈1.3 billion lb per year of fish, crabs, oysters, and shrimp (≈ 20% of U.S. commercial seafood production)

Of greatest concern were potentially toxic and carcinogenic polycyclic aromatic hydrocarbons (PAHs) and the chemicals in the dispersants.

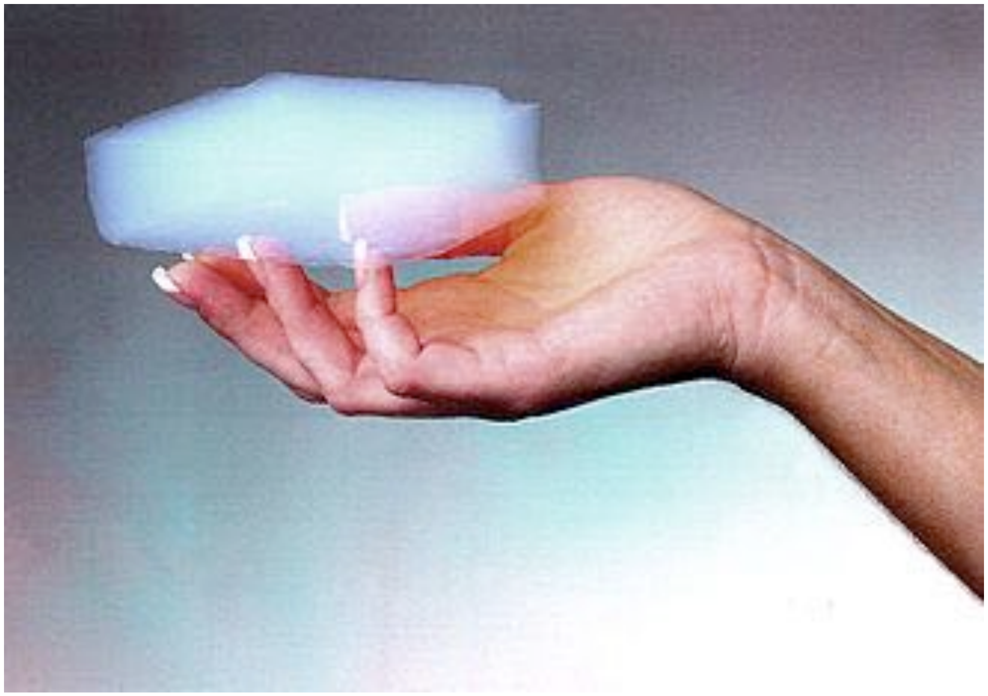
OPENING DAY

Parameters for reopening waters to fishing have differed among oil spills

OIL SPILL	SIZE (GAL)	CLOSURE PERIOD[a] (MONTHS)	ACCEPTABLE RISK LEVEL	EXPOSURE (YEARS)	LEVELS OF CONCERN[b] (PPB)
Deepwater Horizon, Gulf of Mexico, 2010	206 million	1–12	1:100,000	5	Fish: 35 Shrimp/Crab: 132 Oysters: 143
Dubai Star San Francisco Bay, 2009	400–800	1	1:10,000	30	Fish: 44 Shellfish: 44
Cosco Busan San Francisco Bay, 2007	58,000	1	1:10,000	30	Fish: 44 Shellfish: 44
New Carissa Oregon, 1999	70,000	0.7	1:1,000,000	2	Shellfish: 10 high, 45 average consumer
Kure California, 1997	4,537	1.6	1:1,000,000	2	Shellfish: 5 high, 34 average consumer
Julie N. Maine, 1996	180,000	0.5	1:100,000	10, 30	Lobster: 50 (10 years) and 16 (30 years)
North Cape Rhode Island, 1996	828,000	2.4–5.1	1:1,000,000	5	Lobster: 20
Braer Shetland Islands, 1993	25 million	2–72			> background PAH levels
Exxon Valdez Alaska, 1989	11 million	Season	1:1,000,000	10, 70	Salmon/Fish: 3/5 (10 years) and 0.3/0.5 (70 years) Crustaceans: 11 and 1.1 Bivalves: 120 and 12

a Ranges may be due to different closure periods for shellfish or finfish. **b** For polycyclic aromatic hydrocarbons considered potentially carcinogenic and based on cancer risk using benzo[*a*]pyrene equivalents.
SOURCE: *Environmental Health Perspectives*, DOI: 10.1289/ehp.1103507

Aerogels may be used to clean up oil spills (http://cen.acs.org/articles/92/i4/Soaking-Oil-Spills.html)



https://en.wikipedia.org/wiki/Aerogel

Aerogel is a synthetic porous ultralight material derived from a gel, in which the liquid component of the gel has been replaced with a gas. The result is a solid with extremely low density and low thermal conductivity.

Valence Electrons are farthest away from nucleus and are responsible for ***Bonding***

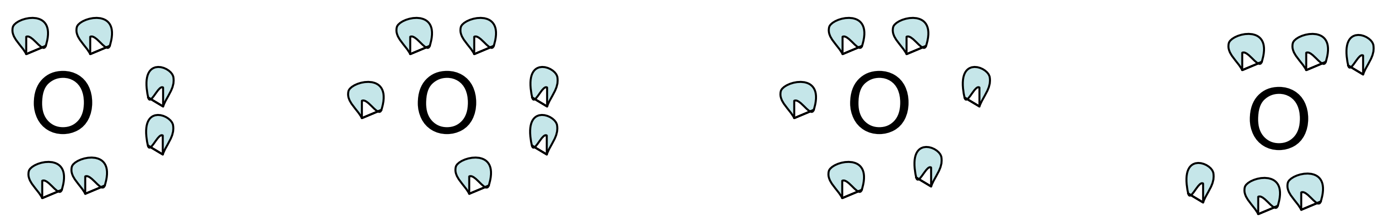
of Valence Electrons = Group

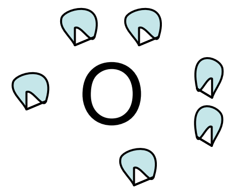
How many valence electrons does O have?

What is the valence electron configuration of O?

Lewis Dot Symbol shows **atomic symbol** and **valence electrons** by **dots**.
Electrons (dots) are either paired or unpaired. (*Why*?)

Draw the Lewis dot symbol of O.



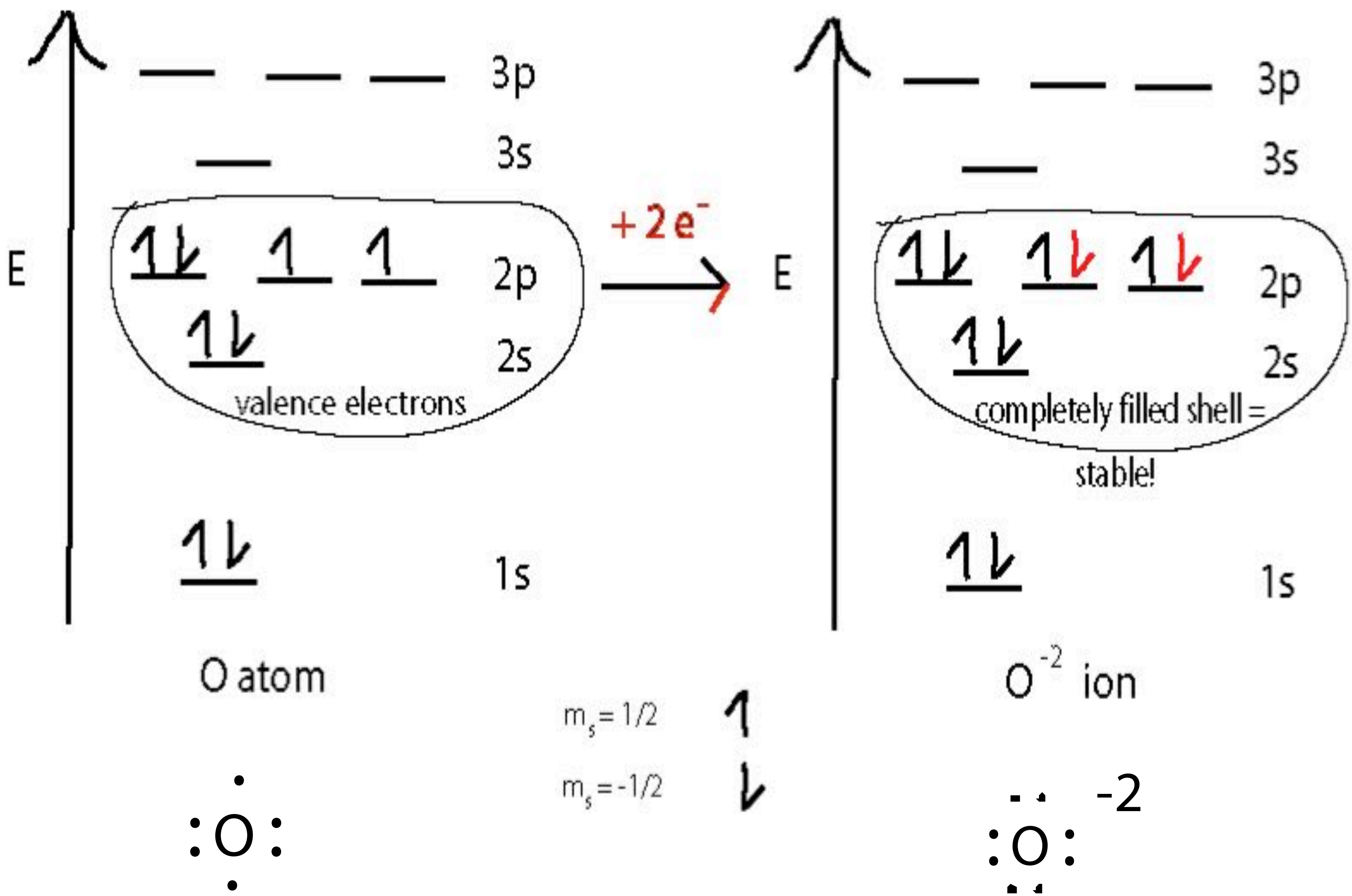


Octet Rule = 8 e^- in completely filled shell
A Completely Filled Shell is *STABLE*.

How many electrons does O have to gain or lose to have a completely filled shell?

Does this number match the ionic charge?

Determine the electron configuration of this O ion.


E
3p
3s
2p
2s
1s
valence electrons
O atom
+2e⁻
E
3p
3s
2p
2s
1s
completely filled shell =
stable!
O -2 ion
m_s = 1/2
m_s = -1/2
O
O
-2

Valence Electrons are Responsible for Bonding Atoms form BONDS to make a Compound

NaCl is a _____ compound.
Show the bonding in NaCl.

HCl is a _____ compound.
Show the bonding in HCl.

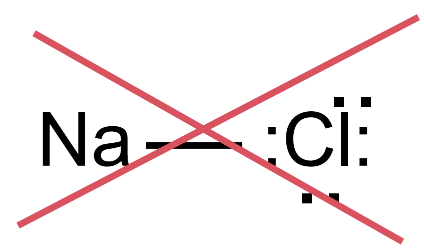
How many electrons does Na have to gain or lose to have a completely filled shell?
How many electrons does Cl have to gain or lose? Does this number match the ionic charge?

***An Ionic Bond** is Formed when Electron(s) Is/Are **Transferred** from a Metal to Non-metal*

Positive charge attracted to a negative charge (Coulomb's law).

Show how NaCl is formed from Na and Cl.

Na = giver, Cl = taker



*Do **NOT** use a line to show an ionic bond*

A ***Covalent Bond*** is Formed When One Unpaired Electron From One Atom Combines with One Unpaired Electron From Another Atom.

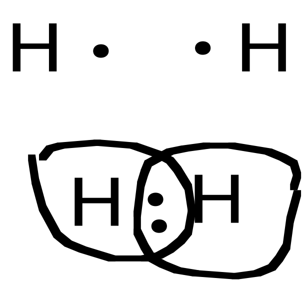
Bonding pair of electrons are ***Shared*** between two atoms.

Use ***Lewis Dot Symbols*** to ***connect*** the **dots**!

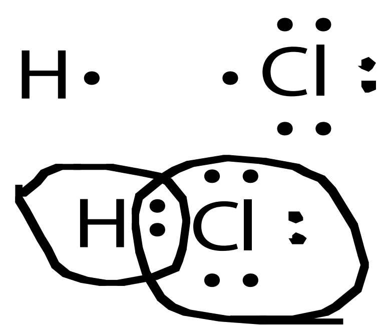
Electrons (dots) are either paired or unpaired (free radicals).

Electron pairs are either bonding pairs or lone pairs.

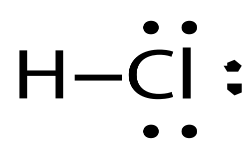
H_2 HCl CH_4

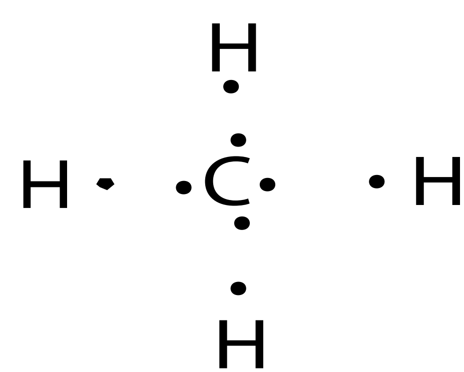


Duet Rule for H



Octet Rule for non-H





A ***Lewis Structure*** Represents the Structure of a Molecule

1. Draw Lewis dot symbol - see Group # on Periodic Table.
2. Combine one unpaired electron from one atom with one unpaired electron from another atom to form a covalent bond (**Connect the Dots**).

Single bond = one bonding pair = single line
Double bond = two bonding pairs = double line
Triple bond = _______________ = _______________

3. Check Duet rule for H and Octet rule for other atoms.
4. Account for all valence electrons.

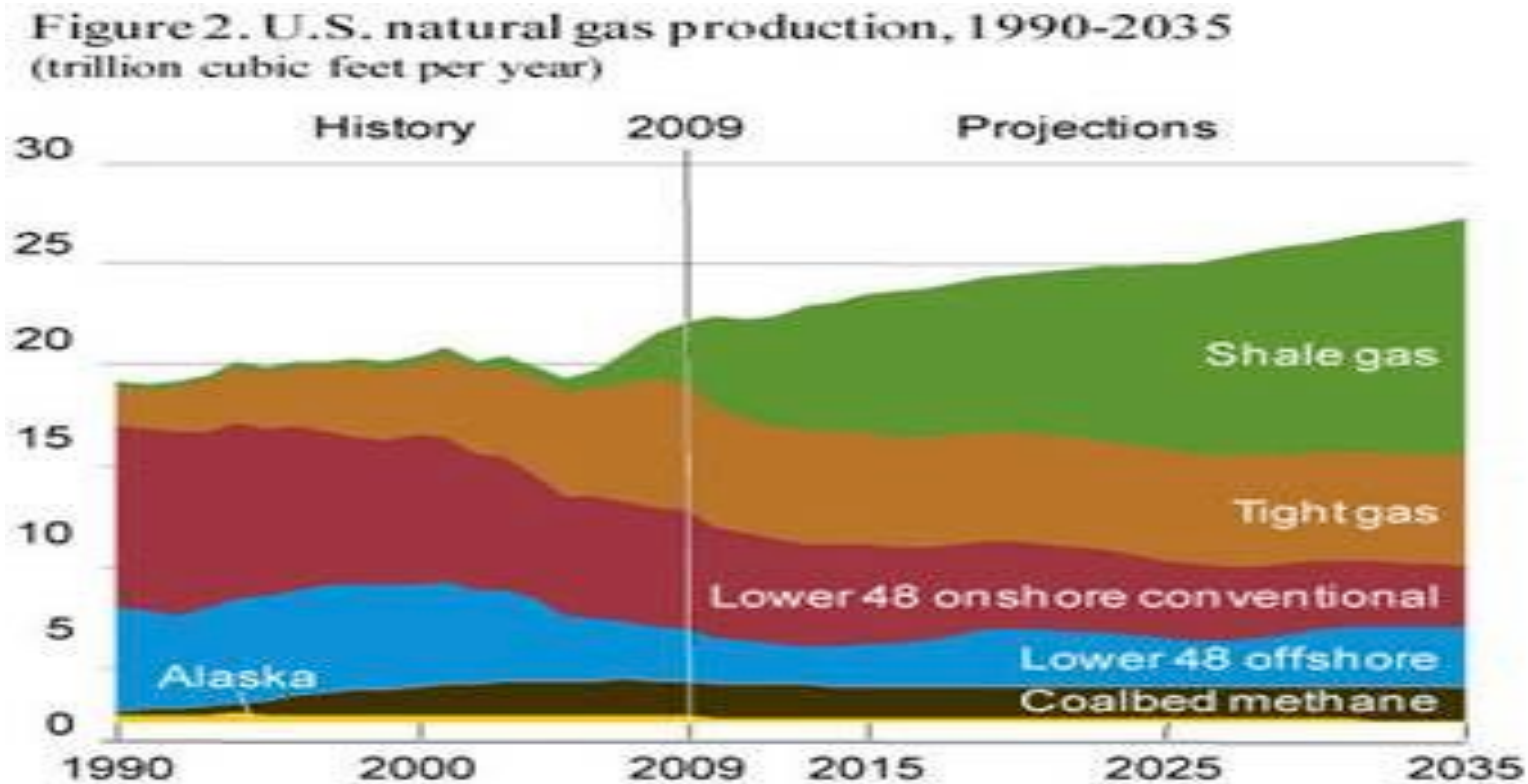
Tips: ***C*** has 4 bonds to it and 0 lone pairs.
N has 3 bonds to it and 1 lone pair.
O has 2 bonds to it and 2 lone pairs.
F, ***Cl***, ***Br***, ***I*** has 1 bond to it and 3 lone pairs.
H has 1 bond to it and 0 lone pairs.

The U.S. has vast reserves of natural gas.

http://www.eia.gov/dnav/ng/NG_ENR_DRY_A_EPG0_R11_BCF_A.htm http://www.theoildrum.com/node/5615

http://www.truebluenaturalgas.org/how-much-natural-gas-does-the-us-have/

http://www.naturalgas.org/overview/resources.asp



Natural gas contains methane, CH_4. Methane undergoes combustion to form CO_2 and water. Draw the Lewis structure of each reactant and product.

Energy is required to Break a Bond (Endothermic)
Energy is released when a Bond Forms (Exothermic)

Nitrogen Triiodide is a brown solid that decomposes with the touch of a feather! (See World of Chemistry video on Chemical Bonds)

$$NI_3 \text{ ---> } I_2 + N_2$$

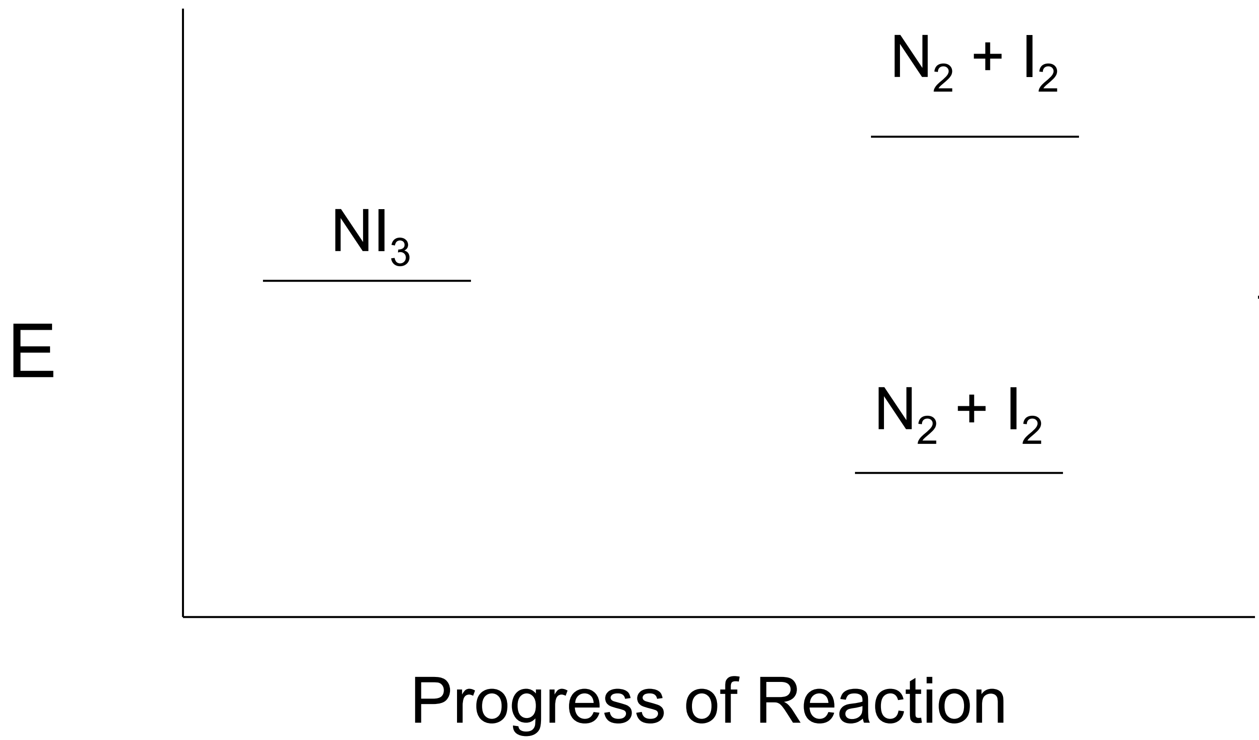
a. Is this reaction exothermic or endothermic?
b. Draw the Lewis structures of each reactant and product.
c. Identify the polar bonds.
d. Which bond(s) is/are strong? Which bond(s) is/are weak?
e. Is NI_3 stable or unstable? Explain why NI_3 is an explosive.

<u>Reaction Energy Diagram</u> tells us about:

Exothermic or *endothermic*

Stable or *unstable*

Reactive or *unreactive*



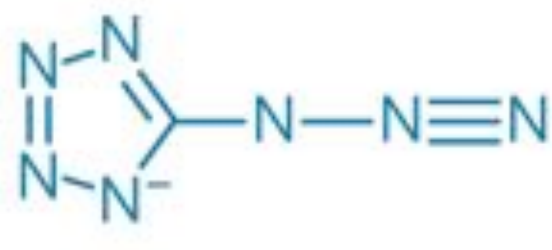
Is E of N_2 and I_2 **<u>higher or lower</u>** than NI_3?

Properties of Explosives: weak bonds, exothermic, fast reaction

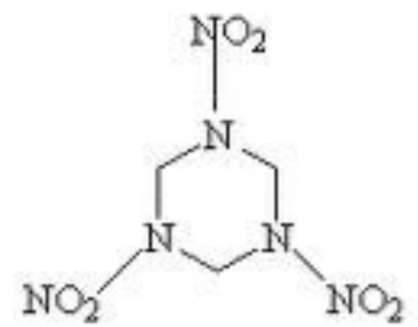
Environmentally friendlier and more powerful explosives (CEN, 1/12/09, p. 38)

Nitrogen-rich CN_7^- salts are considered "greener" than traditional explosives because they generate fewer carbon-based by-products that can damage artillery gun barrels and the environment.

The researchers' calculations indicate that $N_2H_5CN_7$ has the highest detonation pressure and velocity of the new compounds—values that exceed those of the powerful explosive RDX. Although hydrogen bonds help render $N_2H_5CN_7$ thermally stable at room temperature, the compound is still too sensitive to impact and friction for field use.



CN_7^-



RDX

Energy is required to Break a Bond (Endothermic)
Energy is released when a Bond Forms (Exothermic)

Nitrogen Triiodide is a brown solid that decomposes with the touch of a feather! (See World of Chemistry video on Chemical Bonds)

$$NI_3 \text{ ---> } I_2 \quad + \qquad N_2$$

a. Is this reaction **exothermic** or endothermic?
b. Draw the Lewis structures of each reactant and product.
c. Identify the polar bonds. N-I
d. Which bond(s) is/are strong? N≡N
Which bond(s) is/are weak? N-I
e. Is NI_3 stable or **unstable**? Explain why NI_3 is an explosive.

A Single Bond is Longer Than a Double Bond
A Double Bond is Longer Than a Triple Bond

Hydrocarbons are used as fuels. Draw the Lewis structures of:

Ethane, C_2H_6
Ethylene, C_2H_4
Acetylene, C_2H_2

Which carbon-carbon bond is the strongest?
Which carbon-carbon bond is the weakest?
Which carbon-carbon bond is the easiest to break?
Which carbon-carbon bond releases the most energy when formed?

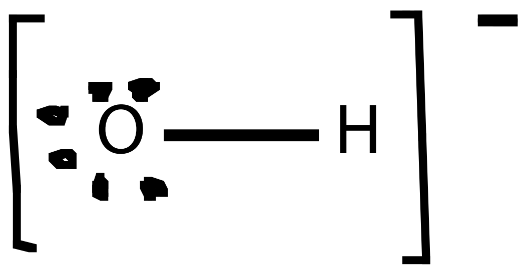
Lewis Structures are Used to Show the Bonding in Ions

For (-) ions, add # of e- that corresponds to charge

For (+) ions, subtract # of e- that corresponds to charge

E.g., Water loses a H^+ to form the hydroxide ion. Draw the Lewis structure of OH^-.

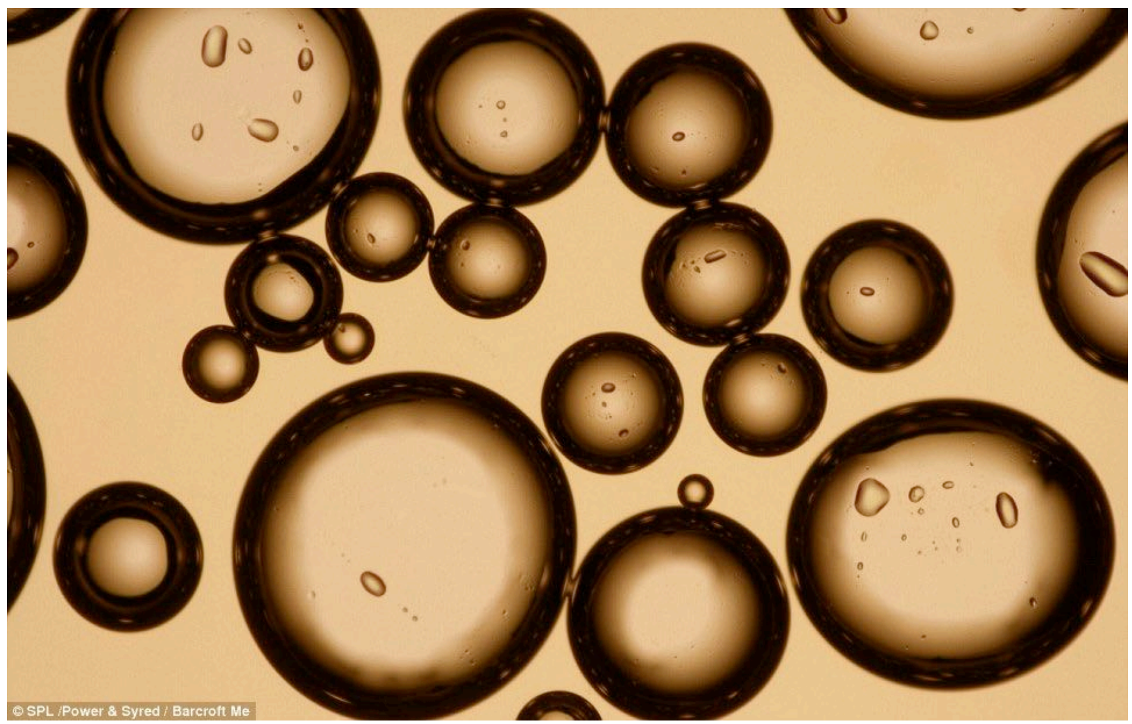
Total # of valence e^- = 6 (from O) + 1 (from H) + 1 (from -1 charge) = 8 e^-.



Water gains a H^+ to form the hydronium ion. Draw the Lewis structure of H_3O^+.

Carbonated beverages contain carbonic acid. Carbonic acid, H_2CO_3, loses a H^+ to form the bicarbonate ion. Draw the Lewis structures of H_2CO_3 and HCO_3^-.

http://www.topnews.in/healthcare/content/22804sugar-packed-fizzy-drinks-hazardous-health-tobacco



http://www.dailymail.co.uk/news/article-2193885/The-true-colours-fizzy-drinks-Stunning-pictures-taken-using-powerful-microscope-reveal-vibrant-crystals-multitude-different-patterns.html

Isomers – same chemical formula, different bonding.
Isomers have <u>different</u> properties.

<u>Example</u>: C_2H_6O
There are 2 different ways to connect (bond) the C's, H's, and O.