Intro to Chem

Tuesday, September 19, 2006
7:59 AM

Chemistry is the science of the composition, structure

Ira Remsen – experimented w/ Nitric Acid + Copper, and discovered its dangerous effects

Solid copper $Cu_{(s)}$

Nitric Acid $HNO_{2(aq)}$

$$Cu_{(s)} + 4H^+_{(aq)} + 2NO_3^-{}_{(aq)} \rightarrow 2NO_{2(g)} + Cu^{2+}_{(aq)} + 2H_2O_{(l)}$$

<u>Mass</u> - the amount of matter an object has
<u>Temp</u> - the ave. kinetic energy of atoms (K, C, F)
0K = -273.15 C

$t(°C) = \frac{5}{9}(t(°F)) - 32$ look up F-C conversion b/c this isn't right.

Centi + milli used a lot. Check prefixes.

Intensive properties do not change. For example, the density of lead will not change. However, mass changes depending on how much mass you have.

<u>HW</u> Read 1, 2 p:
1, 2, 7, 9, 12, 13, 14, 15, 16, 17, 21, 23, 27, 29, 31, 33, 37, 40, 43, 56, 61, 65, 69

Elements, Units, Density

Wednesday, September 20, 2006
7:59 AM

107 elements, 91 occur in nature. Others are manmade
Mark Ratner NANO 4017
↑
NMSA

Chemistry - comp, structure, reaction of matter

<u>Units</u>

T ← K, °C

m, V, N
↑ ↑ ↑
kg or g — L or mL — 10 units → #

ε dielectric constant

ρ density kg/m³ or g/cm³

ρ water = 1.0 g/cm³
4°C - 40°C

$\boxed{\text{water achieves its max. } \rho \text{ at } 4°C}$

Unit conversions Appendix A

6.0 ft = x cm?

$(6\,ft)\left(\frac{12\,in}{1\,ft}\right) = (72\,in)\left(\frac{2.54\,cm}{1\,in}\right) = 182.88\,cm$

unit conversion facto

sig figs!
180 cm
<u>183 cm</u> just round it. No one cares.

1.2
1.22
1.222
3.642
= 3.6

180 lb = x kg?

$(180\,lbs)\left(\frac{.454\,kg}{1\,lb}\right) = 81.7\,kg$

1 kg has an infinite # of sig figs b/c it's a definite known quantity

this is okay b/c 180 lbs could be 180.0.

90 sumo wrestlers. Each weigh 410 lbs kg of sumo?

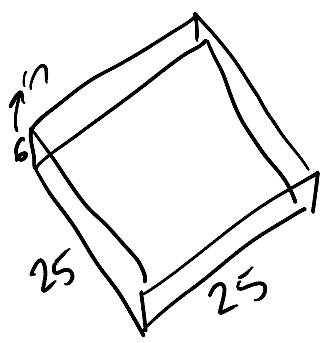
$(90\,sumos)\left(\frac{410\,lbs}{1\,sumo}\right)\left(\frac{.454\,kg}{1\,lb}\right) = 16752.6\,kg$

$= 17{,}000\,kg$

<u>HW</u>

1 piece of paper, write down 2 questions about chemistry you want to know the answer to.

2 <u>Mass in tons of snow on a roof.</u> Roof = 25ft × 25ft
6 in of snow. 11 in snow will melt into 1 in of water.



6 in

$25\,ft\left(\frac{12\,in}{1\,ft}\right) = 300\,in$

$V = (300)^2(6) = 540{,}000\,in^3$

$540{,}000\,in^3\,snow\left(\frac{1\,in\,water}{11\,in\,snow}\right)\left(\frac{16.387\,cm^3\,H_2O}{1\,in^3\,H_2O}\right)\left(\frac{1\,g\,H_2O}{1\,cm^3\,H_2O}\right)\left(\frac{1\,kg\,H_2O}{1000\,g\,H_2O}\right)\left(\frac{1\,lbs\,H_2O}{.454\,kg}\right)\times\left(\frac{1\,ton}{2000\,lbs}\right)$

$= .895\,tons$

$= .89\,tons$

Mass, Cmpd, Mixture
Thursday, September 21, 2006
7:57 AM

$V\rho = \text{mass}$

(Volume)(density) = mass

$$\left[\left[25\,ft\left(\frac{12\,in}{1\,ft}\right)\right]^2(6\,in)\right]\left(\frac{1\,in\,H_2O}{11\,in\,Snow}\right)\left(\frac{16.387\,cm^3\,H_2O}{1\,in^3\,H_2O}\right)$$

$$\rightarrow \left(\frac{1\,g\,H_2O}{1\,cm^3\,H_2O}\right)\left(\frac{1\,kg\,H_2O}{1000\,g\,H_2O}\right)\left(\frac{1\,lbs\,H_2O}{.454\,kg\,H_2O}\right)\left(\frac{1\,ton}{2000\,lbs}\right)$$

= .885 tons but you can do it in
= .89 tons of snow Metric tons & it's faster.

<u>Compound</u> - single entity that can't be separated by chemical means.

<u>Mixture</u> - can be separated by chemical means. Saltwater - you pour it on the ground, it evaporates and leaves salt behind. Physical separation - saltwater is a mixture.

compound

$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta}$ chemical reaction.

To separate a compound, a reaction takes place. Chemical change, not a physical change

$$\xrightarrow{\Delta} N_{2(g)} + 4H_2O_{(l)} + Cr_2O_{3(s)}$$

Matter comes in diff phases. 3 stable phases, one unstable phases.

Gas is least dense.

Ice floats on H_2O b/c in H_2O, the solid is less dense than the liquid

<u>Exams</u>

Oct 5th Thurs
Oct 26th Thurs
Nov 16th Thurs

Lab Lecture
Friday, September 22, 2006
8:00 AM

Lab Lecture

Coke vs. Diet Coke Measure mass & Volume of Coke & Diet coke.
We're going to find density.

To measure mass, we'll use a balance. Analytical balance.
Put empty beaker on 1st, press TARE, and then go back & put the 10mL in that beaker & find the mass by subtracting mass of beaker.

To measure volume, we'll use a graduated cylinder, a pipet, & a buret.

To get a "real value" for the density to compare to the theoretical value we're going to use the serving size = 240mL, and get the mass to calculate the density. The density of diet coke (theoretically) is that of water, b/c it's mostly water. $1 g/cm^3$

in reg. coke, there are 27g sugar in 240mL. We don't know what the mass of 240mL is. We could measure it, but we want a theoretical value.
If we look up the density of a sugar solution.
$29/240 mL$ = a % solution. Find density

Handout is posted on the website. Arch site, under resources "lab materials"

Density can't be measured so we have to do it this way.
At least, it can't be measured yet.

Part B is apparently vague and will be made clear in the lab. Office Hrs Wed 11AM-1PM THURS 1PM-2PM, 4PM-5PM
HG10 is a good place to look though.

Take Safety Quiz online before come to lab.

All necessary info is in the lab manual.
The chemical spills # is ext 1-5581

There's a list of equipment you're supposed to have in the back of the lab manual.

Next week we're going to determine toxic metals found in fish. ICP Mercury has been a prob. Tuna have

the most toxic metals b/c of the food chain. smaller fish don't have as much time to accumulate much, but a large fish like tuna eats smaller fish already contaminated and accumulates a lot of toxic stuff. Think about what kinds of metals we should compare, what kinds of fish we should test, what fish are most dangerous.
Seaweed has this problem too. FORMAL REPORT

Then we do analysis of Vitamin C by Titration, so we'll compare how Vitamin C degrades over time. We look at diff orange juices & stuff.

Then copper lab. How much of original copper will we recover at the end of the exp.

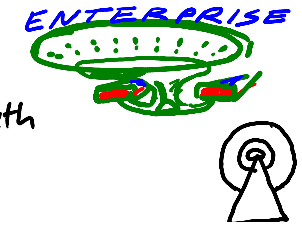
- Scientific Calc
- Ziploc Baggies
- Sunflower Seeds
- Sticky Tack, more posters

Pre-Lab
Late nite labs (online pre-labs)
Reactor Log in, buy virtual lab - you buy an access code.

Reports due 24 hours after completion of the lab.
Pre-lab consists of 1st portion of lab report.
Header, Objective, Procedural outline.

Subatomic Particles, Scientists

Monday, September 25, 2006
7:58 AM



Boyle 1661 "The Skyptical Chemist"
- found a vacuum pump to experiment with
- Begon modern experimental chem.

Lavoisier
- Mass conservation
- Quantified ideas that had been qualified before.

Proust d. 1828
- Ratios of elements & compounds
- Definite Proportions

Dalton d. 1844
- Called Proust's idea "law of definite proportions" and invented multiple proportions – ratios of masses, combined with the mass of the 1st thing is a definite #. ratio. of a 2nd thing

$4P_{(s)} + 5O_2 \rightarrow 2P_2O_{5(s)}$ Barking Dog Demo (when it blew up after a few min)

Noise came from change in pressure

Obs 6.194 g of P reacts w/ 4.80 g O_2

$\frac{4.80}{8.00}$ should be a small whole # ratio. or 8.00 g O_2

$= \frac{.6}{1} = \frac{6}{10} = \frac{3}{5}$

- Definite Proportions:

$2H_2 + O_2 \rightarrow 2H_2O$ or $H_2 + \frac{1}{2}O_2 = H_2O$

$\frac{\text{mass } H_2}{\text{mass } O_2}$ = small whole # ratio

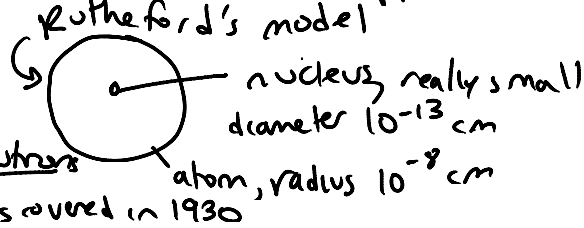
$4P_{(s)} + 3O_{2(g)} \rightarrow P_2O_{3(s)}$

If you mix C, H, & O at high temps, it becomes CO_2 & H_2O. Combustion rxns.

Avogadro 1811
- Equal volumes of any gas equal #s of particles

For very dilute systems like gases, this is approximately.

Rutherford's model



JJ Thompson d. 1940
Plum Pudding Model

Electrons, Protons, Neutrons
discovered in 1930

Subatomic particles have mass & charge. Neutrons have no charge. E have (-) & P have (+).

Protons = 1.67 E-27 kg. Neutrons = 1.67 E-27 kg
e^- = 9.11 E-31 kg

JJ said e^- were in circular orbit. Circular density.
Protons & e^- in nucleus.

1 unit of charge = 1.60 E-19 C (coulombs)
Same # of e^- & p^+. b/c n^0 have no charge. So (−) outside & (+) inside.

(19) — # of p^+ + n^0 = mass
(8)

# of protons = # of electrons.

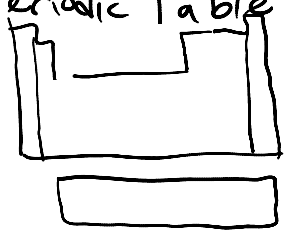
$^1_1H + ^2_1H \rightarrow ^3_2He$ + energy simplest fusion rxn. 1 normal H + 1 heavy H = helium & energy.

If we could do this, we could make free energy.

$^{14}_6C \rightarrow ^0_{-1}e + ^{14}_7N$ Radio-carbon dating comes from this.

β − comes out of the nucleus. Beta particle.

Periodic Table



8 groups.
rows

Elements arranged like this b/c Mendeleal noted that Group 8 were all gases. Group 1 were al soft metals. Group 2 were harder metals. Group 6 all liked to be in a charge of −2

Noble Gases in the last column. They're not inert. They just aren't very reactive.
The Alkali Metals are in the 1st column. Very reactive.

Each group has similar chemical properties.

Periodic Table

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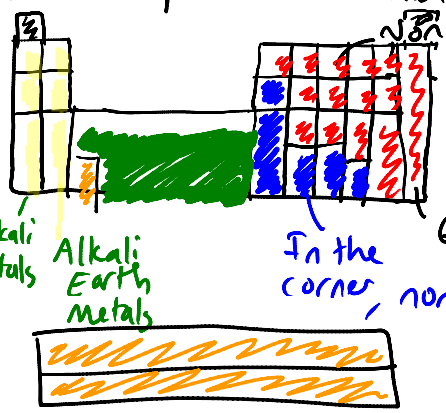
8:01 AM

Columns on Periodic Table = Groups

Everything but rec is a metal



Main group elements

Gases that don't like to react

In the corner, non-metals. Transition metals

<u>ion</u> - charged <u>atom</u> or <u>molecule</u>

look like

F^- is an ion — 10 electrons. Atomic # = 9
$9e^- + 1e^- = 10e^-$

O^{2-} is an ion. — 10 electrons. Atomic # = 8

N^{3-} is an ion — 10 electrons. Atomic # = 7

→ Ne is not an ion. 10 electrons.

look like

Li^+ is an ion — $2e^-$

Be^{2+} is an ion — $2e^-$

B^{3+} is an ion — $2e^-$

→ He is not an ion. $2e^-$

These ions are stable b/c they all look like a noble gas.

Na^+ is an ion — $10e^-$

Mg^{2+} is an ion — $10e^-$

Al^{3+} is an ion — $10e^-$

S^- is not a stable ion b/c it doesn't look like a noble gas.

K^+ is an ion — $18e^-$ — Ar has $18e^-$.

Ca^{2+} is an ion — $18e^-$

The charges tell us which group the elmt is in. 1+ = group 1
2+ = group 2 3+ = group 3.

$Li^+ + F^-$ <u>Coulomb's Law</u> - they'll come together.

LiF is an ionic material. It doesn't share e^-;
SALTS - ionic materials.

Hydrogen balloon made a big "boom" & there was clearly a chem reaction.
Helium just popped when heated
Hydrogen & Oxygen combined made a <u>huge</u> BOOM! and that's because there was an O_2 & H for every H & O_2 that it wanted to react w/ when heated.

$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$$

$$O_{(8e^-)} + 2H_{(1e^-)} \rightarrow H_2O_{(10e^-)}$$

WE LOVE EXPLOSIONS!

mole = 6.022E23 dozen = 12.
one mole of X = 6.022E23 X. one dozen of X is 12X.

one atom of ^{12}C has a mass of one atomic mass unit = 1amu
A mole of ^{12}C has a mass of 12.000g.
What the mole allows us to do is go back and forth between moles/particles and amu's & grams.

$\frac{\text{one mole of Ca}}{\text{6.022E23 atoms Ca}}$ = unit factor.

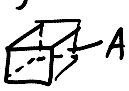
$\frac{\text{one mole } H_2}{\text{2.016 g } H_2}$ = unit factor

Stoichiometry.

$\frac{\text{2.016g } H_2}{\text{6.022E23 atoms } H_2}$ = unit factor.

Quantitative Concept.
1 Å (angstrom) = 10^{-8} cm =
= 10^{-10} m
= 10^{-1} nm

How big is a water molecule?
1 g/mL = density of H_2O $\frac{1 \text{ mol } H_2O}{} = 18 \text{ g } H_2O = 18 \text{ mL } H_2O$



$V_{cube} = A^3 = V_{molecule}$
$V_{mol} = (6.022E23)\,A^3 = 18\text{ mL}$

A is approx. size of the water molecule. Linearly, at least.

$A^3 = \frac{18\text{ mL}}{(6.022E23)}$

$A = \sqrt[3]{\frac{18\text{ mL}}{6.022E23 \text{ atoms}}}$

$A = \sqrt[3]{3E-23 \text{ mL}}$

$A = \sqrt[3]{3E-23 \text{ cm}^3}$

A = 3ish E-8 cm

$A \approx 3E-8$ cm

3E-23
= 30E-24

And now we kind of know how

big a molecule is.

Mole, Valence e-

Thursday, September 28, 2006
7:59 AM

Thurs Oct. 17 is the Exam At 7PM :(

ϕ = mole

$\frac{1\ \phi\ Ra}{226\ g\ Ra} = 1$ b/c Ra's atomic mass = 226g

$\boxed{1\ g = 6.022\ E23\ amu}$ Relation between Atomic Scale & between molecular/visible scale.

20.38g Ne = 6.022E23 (amu) – atomic mass neon
= 6.022E23 Ne atoms

What is the mass of $2 \cdot 10^{24}$ atoms of Cu?

$(2\ E24\ Cu\ atoms)\left(\frac{1\ \phi\ Cu}{6.022E23\ atoms}\right)\left(\frac{63.6g\ Cu}{1\ \phi\ Cu}\right) = 212g\ Cu$
$= 2.12\ E2\ Cu$
$= 2E2\ Cu$

F/E Cmd. center holds propulsion and Super-Comp. Choice, SCC, which "controls" operation w/ input from user, Setag.

PCl_3 31 g P
PCl_5 combine w/ 3 35.5 g Cl
31 g P combine w/ 5 35.5 g Cl

$\frac{m\ Cl\ in\ compd.\ 1}{m\ Cl\ in\ cmpd.\ 2} = \frac{3 \cdot \cancel{35.5}}{5 \cdot \cancel{35.5}} = \frac{3}{5}$ which is a small whole # ratio.

.100 mg sample of Re contains 2.02E17 atoms of ^{187}Re
What is % abundance of that particular isotope?

$2.02E17\ atoms\ ^{187}Re\left(\frac{1\ mol\ ^{187}Re}{6.022E23\ atoms\ ^{187}Re}\right)\left(\frac{187\ g\ ^{187}Re}{1\ mol\ ^{187}Re}\right) = 6.27E-5\ g\ ^{187}Re$

$.1\ mg \cdot \left(\frac{1\ g\ Re}{1000\ mg\ Re}\right) = 10^{-4}\ g\ Re$

$\frac{6.27E-5\ g\ ^{187}Re}{10^{-4}\ g\ Re} = .627$ $\boxed{67.7\%\ ^{187}Re}$

We can see visual proof of the atom now, b/c that dude made those pictures w/ the tip of the electron pen.

8 electrons in the oxygen atom. 6 electrons are in the outer shell – 6 valence e⁻

outer shell - 6 valence e^-.

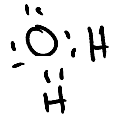
it wants to have 8. 10 total, b/c it wants to look like Ne.

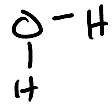
H. one e^-.

they <u>share</u> the e^-. <u>Covalent</u> bond.

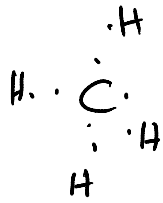
OH^-.

It seeks out another hydrogen and seeks out this:

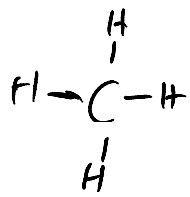




covalent bond

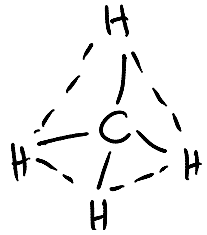


4 valence. Total 6.
Inner 2. 6-2=4



And everyone's happy

Tetrahedron



Lab Preview

Friday, September 29, 2006
8:03 AM

When energy is given off, emission takes place. When some kind of energy is put into a system, the electrons jump to a higher energy level and you see light as a biproduct of this.
The particular colors you see depend on the exact element that is there.
If the energy state is higher than something in the visible range, it would be ultraviolet

# of transitions for Hydrogen is limited b/c it's a limited element - it only has 1 electron.

Inductively Coupled Spectrometer can detect any specific emission through the UV & visible regions. You can identify any elmt. in the sample.

In the next lab, the fish are the sample & they contain mercury, lead, etc. We can compare how intense the light sample is vs. the original sample, and find out how much Hg is in the fish.

Next lab uses concentrated Nitric Acid. Bring something old to school.

Safety - work only in the hood
- don't wear baggy clothing
- wear gloves
- 15 min. in running water if you spill it on yourself

The next lab has a template for the lab report. Due one week after results are posted.
Reports must be submitted online by 5 pm one week after results posted. Hard copies, including pages from lab notebooks (prelab + observations) gets turned in w/ hard copy (stapled) to the TA. Any change in procedure should be noted in formal typed write-up.

1) Choose what sample you want. Tuna (fresh (steaks) & canned), Swordfish, Mahi-Mahi
2) Choose hypothesis. Like 'tuna has higher concentrations of Hg than swordfish'.
3) [illegible]

3) Gain data – and then be prepared to analyze results in a real-life context.
4) Digest fish using nitric acid. Use procedure in lab handout
5) Testing for Hg, Cassic, Cadmium, & Iron.

You're told to use 10g nitric acid.

Louis Dot Structures

Tuesday, October 03, 2006
8:02 AM

Exam Prof Ratner says it's easy!

1, 2, & 1st 2 sections of Ch. 3
Section 3-7 → read for culture (no exams, but you should know it)
Chapter 10 sections 1 & 2 → ON EXAM

The standard mass units $\frac{1}{12}$ of Carbon-12 atom.
C mass = 12.00 ... amu
Carbon is really important and so they chose Carbon.

There are subatomic particles that come together to form nuclei, which are part of atoms, which come together to form molecules or compounds.

metal + metal
intermetallics very important to society.

metal + nonmetal
$CaCl_2$ salt.
ionic materials, often ↑

nonmetal + nonmetal
H_2O molecules C_2H_5OH, $C_6H_{12}O_6$
DNA

When you combine metals, they conduct electricity b/c e^- flow freely.
In metal + nonmetal, each of the atoms want to look like a rare gas. They become ions by giving & receiving electrons and then they conduct electricity. They are soluble in water.

Where you are in the periodic table means you get particular kinds of stuff

Louis Dot Structures

Gave #s = louis dot #s &

Na Mg Al Si P S Cl

how many valence electrons they have (meaning # of electrons the elmt has minus # of electrons the last rare gas has)

$MgCl_2$

Mg^{2+} looks just like Neon

$(Cl^-)_2$ now it's balanced. ionic compound

ionic <u>salt</u> — Charge is the major reason for bonding.

Al F

metal nonmetal = salt.

Al^{3+} F^-

AlF_3 it will be white b/c most salts are white.

Al O

Al_2O_3 it will be white, & a salt.

These are binary compounds.

NaK_2AlF_6 Na_2KAlF_6 exists too

$Na^+ K^+ Al^{3+} F^-$

so NaK_2AlF_6 it's a salt, so is this

Nonmetal - nonmetal molecules

we love demos

$2Na_{(s)} + H_2O_{(l)} \rightarrow \frac{1}{2}H_{2(g)} + 2Na^+_{(aq)} + OH^-_{(aq)}$

this was the popping experiment Everhart showed us.

$2H_2 + O_2 \rightarrow 2H_2O$

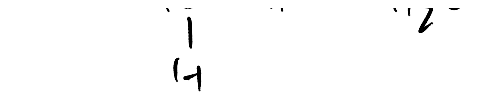
$Ca_{(s)} + 2H_2O \rightarrow H_2 + Ca^{2+} + 2OH^-$

Phenophthalene + calcium pellets = pink solution.

Nonmetal - nonmetal molecules

you can't distinguish electrons from each other

$O - H$ H_2O

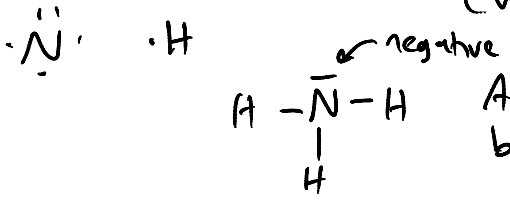


These oxygens can share e^-.

$O=O$ O_2 oxygen. Stronger than single bond.

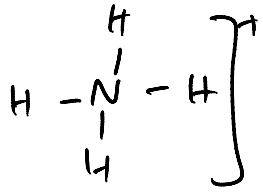
They can share. Triple bond.

$N \equiv N$ Stronger than double bond. One of the 2 strongest bonds in chemistry. N_2, nitrogen.



Ammonia. 3 single covalent bonds.

$NH_3 + H^+ \rightarrow NH_4^+$



Ammonium

An ion. Polyatomic ion b/c more than one atom.

There are 8 e^- b/c the noble gases are stable. And everything wants to be stable b/c of chemistry. But the "why 8" goes along w/ quantum mechanics. Stay tuned.

Oxidation States

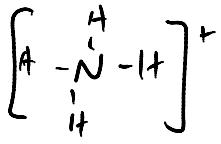
Wednesday, October 04, 2006
8:03 AM

Tesla Coils generate a lot of static electricity. You can hear & see electrons going from one charged thing to another.

Electrons look like waves — not like little blue dots.

Next week on thurs
www.iinano.com Conference

Roger Cornberg won the Nobel Prize in Chemistry this morning. Investigated the fundamental dogma of biology — DNA makes RNA, RNA makes protein. He was editing the DNA that transcribes RNA structures.



Ammonium has 4 covalent bonds to make a perfect pyramid.

Oxidation state O.S. Rules p.82

NaBr , H_2O, HF, $KMnO_4$

1. =0 for elements
2. sum of O.S. for all atoms = charge.
3. Group 1 oxidation state = 1; G.2. O.S = 2; usually
4. Flourine is either O.S = 0 or −1 It is 0 only in the element.
5. Hydrogen usually O.S = 0 or +1. =0 in element.
6. Oxygen usually O.S. = 0 or −2
7. Group 7 O.S. = −1
   Group 6 O.S. = −2
   Group 5 O.S. = −3
) usually. Lots of exceptions.

Oxidation states tell us a lot about the properties.

+1 −1	+1 −2	−3 +1	+1 +7 −2	0
NaBr	H_2O	NH_4^+	$KMnO_4$	O_3

$\overset{+1}{Na}\overset{-1}{Br}$ $\quad H_2\overset{-2}{O}$ $\quad \overset{-3}{N}\overset{+1}{H_4}^{+}$ $\quad KMnO_4$ $\quad O_3$

$4-3=1$

$\overset{+1}{H}\overset{-1}{F}$ $\quad \overset{+1}{I}\overset{-1}{F}$ $\quad \overset{+3}{I}\overset{-1}{F_3}$ $\quad \overset{+5}{I}\overset{-1}{F_5}$ $\quad \overset{+7}{I}\overset{-1}{F_7}$

$\underbrace{\overset{+1}{K}\overset{-\frac{1}{3}}{I_3}}$ $= \overset{+1}{K}\overset{-1}{I} + \overset{0}{I_2}$

there's something weird about this. It's a salt + a molecule

sulfate sodium

sulfide sodium

sulfide has to have a positively charged ion potassium

CdS yellow

$CdSO_3$

$CdSO_4$

$\overset{+2}{Cd}\overset{-2}{S}$

transition metal it's almost always +2

$\overset{+2}{Cd}\overset{+4}{S}\overset{-2}{O_3}$

$\overset{+2}{Cd}\overset{+6}{S}\overset{-2}{O_4}$ good state for sulfur

How many grams of $MgCl_2$ is needed to contain 5E23 Cloride ions?

$$5E23\ Cl^- \text{ ions} \left(\frac{1 \text{ mol } Cl^-}{6.022E23\ Cl^- \text{ ions}}\right)\left(\frac{1 \text{ mol } MgCl_2}{2 \text{ mol } Cl^-}\right)\left(\frac{95.3 \text{ g } MgCl_2}{1 \text{ mol } MgCl_2}\right)$$

$= 39.6 \text{ g } MgCl_2$

$= 40 \text{ g } MgCl_2$

Lab Preview, Titration

Friday, October 06, 2006
8:15 AM

Next week's lab is a titration of vitamin C.

Ppl started getting scurvy. If they ate fresh fruit (particularly limes, since they didn't go bad) they got better. Vitamin C deficiency.

Lots of different things have vitamin C in them. Oranges, tomatoes, broccoli, hot peppers, oxin.

How much vitamin C is in a glass of orange juice? Or vitamin C tablet
Titration is one of the oldest but most effective ways to determine the Vitamin C content.

L-ascorbic acid $C_6H_8O_6$
Molecular weight 176.2 g/mol
Stronger than acetic acid
Occurs naturally. White solid, sharp, sour taste, dissolves in H_2O
Strong reducing agent, oxidized by air
Essential to humans
Recommended daily allowance = 60-70 mg (FDA used RDA. Find out exact amount)

Vitamin C & the common cold

<u>Hypothesis</u>

1) Vitamin C reduces the liklihood of getting a cold (Preventative)
2) Vitamin C reduces the duration of the cold. (Therapeutic)

So in the study, 4 groups. They discovered that on average, the ppl who took vitamin C had less colds and shorter colds. Problem w/ this study was that ppl guessed which group they were in. Among the non-guessers, everyone had a cold that lasted 6 days. Among the guessers, those who thought they were in the placebo group, they had 8-day colds. If they thought they were taking vitamin C, they had 6-day colds. <u>Placebo effect</u> - based on what you think is going on.

Question is: is the amount in the capsule really what's in there

Question is: is the amount on the carton really what's in there and does it matter if the carton has been opened?

Type 1: Opened 9/22, not opened clear container.
Type 2: opened 9/22, not opened opaque container
Type 3: cheap brand

REDOX Rxn

Reduced elmts. gain electrons. LEO says GER
Oxidized elmts lose electrons
I_2, ascorbic acid } vitamin C
oxidizes
1:1 ratio between ascorbic acid & iodine.

Vitamin C oxidized. Iodine reduced.
1 mol iodine reacts w/ 1 mol vitamin C → 1 mol oxidized vitamin C, 2 mol iodine.

Performing a titration

I_2 in buret.
use funnel to fill buret
remove funnel after filled.

Juice goes into a flask

titrate to equivalence pt – it changes color.
Starch reacts with iodine. It is the indicator. Iodine turns blue.

Blue color only lasts for 30 sec.

3 titrations

1st is rough. Idea about how much I_2 it takes. If you go too fast, you can add more orange juice.
2nd is faster to get to equivalence pt. and slower at the end.

Measure to nearest .01 mL

Wash buret before use. Use small amt of iodine to wash.

Coulomb's Law, Solutions

Monday, October 09, 2006
8:02 AM

Coulomb's Law

$$E = (2.31E-19)(J\text{-}m)\frac{Q_1 Q_2}{r}$$

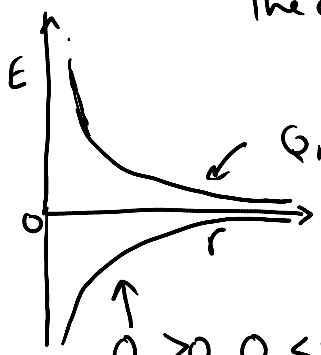
charges in Watts

distance

constant in Joule-meters

energy (potential) in J

The bigger the charge, the stronger the interaction.
The closer the charges, the stronger the interaction.

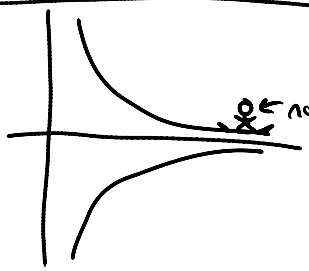


$Q_1Q_2 > 0$ or $Q_1Q_2 < 0$

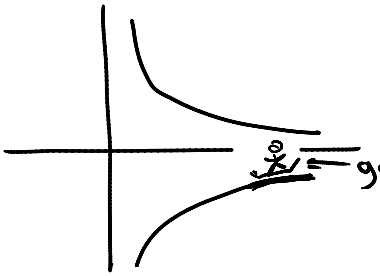
equal charges repel.

$Q_1 > 0$ $Q_2 < 0$ or $Q_1 < 0$ $Q_2 > 0$

Fundamental principle of nature — things spontaneously lower their energy. They want to be as low energy as possible. <u>Systems attain lowest available energy.</u>



← not going up.

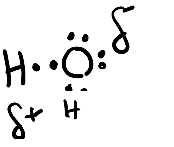


← going down!

Atoms & ions have finite size. If you lower r too much, then you can't lower it anymore. There is only so much E attainable.

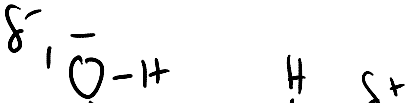
↑ Electrostatic energy

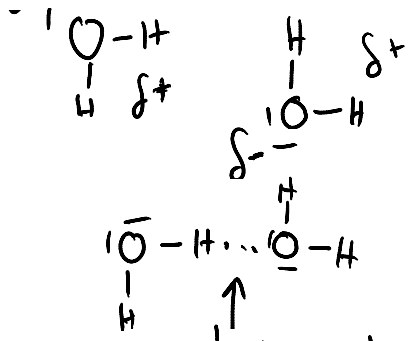
H_2O



Partial negative charge. δ− on Oxygen
Partial pos. charge on H. δ+

<u>polar molecule</u> – has a dipole (charge is asymmetrically distributed).





hydrogen bond. electrostatic interaction. Attraction between a bonded H-atom and a partial negative charge.

$\boxed{OH, N-H, S-H}$

DNA makes RNA. RNA makes protein. Hydrogen bonds hold base pairs together.

Hydrogen bonds also hold water together. <u>H-bond</u> weaker than covalent bonds.

Ammonia & water have roughly the same weight. Water is a liquid at room temp, whereas ammonia is a gas. Water has bonding by hydrogen bonds, which make it a liquid. Solid floats in the liquid. H-bonds hold ice together. Water's much denser than ice.

$3\,Fe_{(s)} + 2O_{2(g)} \rightarrow 2FeO + FeO_2$ More oxygen means it burns brighter. This was

$2\,H_2O_2 \rightarrow 2H_2O + O_2$ elephant toothpaste

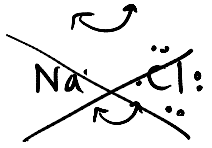
<u>Solutions</u>

1 phase of material is held in homogeneous mix by another phase.

Faraday invented most of the Chem language. Including the word solution.

Solute & solvent → solution.

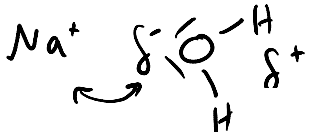
$Na^+ \; Cl^-$ ← works



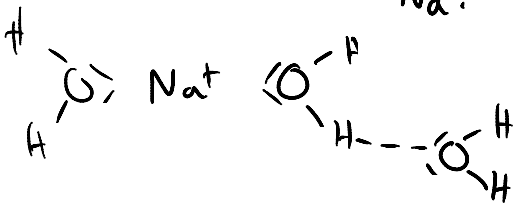
Chlorine has more protons than sodium, so the electrons will go over to the Cl, not the Na. Cl is more <u>electronegative</u> than Na.

doesn't work

You can dissolve salt in water. Like dissolves like.



Then another H_2O comes along & attaches itself to the other end of Na^+.



Usually between 4 & 6 H_2O's are around Na^+. Sodium becomes surrounded by solvent. That makes it a solvated ion. The process by which solvent surrounds the solute is <u>solvation</u>.

If you put a penny in H_2O, it doesn't dissolve b/c it's nonpolar. Polar dissolves polar.

Solute	Solvent	Dissolve?	
LiBr	H_2O	Yes	
KCl	gasoline	No	Gasoline is carbon & hydrogen — not polar.
Cu	H_2O	No	
grease	gasolne	Yes	Nonpolar & nonpolar

Like dissolves like

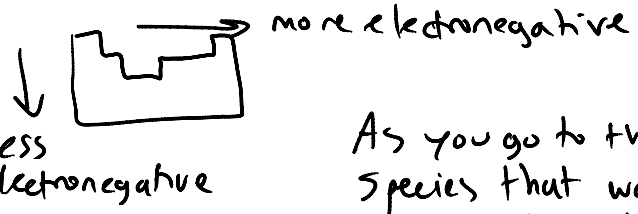
Electronegativity, Rxns, Concentrations

Tuesday, October 10, 2006
7:57 AM

LiI white, salt
ILi is incorrect because you always put the (+) 1st.

CO_2 is a covalent bond.
O_2C is incorrect because of electronegativity

<u>Electronegativity</u> (L. Pauling)



As you go to the right you go to species that want to be negatively charged (partially).

The Oxygen was more electronegative. The less electronegative elmt always comes 1st.

Electronegativity is the ability of an atom in a molecule to attract electrons. Flourine is the most electronegative. Helium doesn't form any molecules and so doesn't win. Francium is the least electronegative.

$\delta+ \rightarrow CO_2 \leftarrow \delta-$

HCl, not ClH b/c Cl is more electronegative.
Cl_2O is not a garden variety molecule. Not stable. It'll find anything to react with.

$H-O^{\delta-}$
$\delta+$ H

Memorize $\boxed{\text{Table 5.1 Solubility / Table 3.3 Names}}$

<u>Writing rxns</u>
1. Find reactants, products
2. know s, l, g, aq
3. Try to balance
easy except for a few redox rxns.

<u>Types of Reactions</u>
1. Precipitation

$Cd(NO_3)_{2\,(aq)} + Na_2S_{(aq)} \rightarrow CdS_{(s)} + 2NaNO_{3(aq)}$
Aqueous + aqueous → solid (precipitate) + aqueous

chlorides are insoluble

$AgNO_{3\,(aq)} + NaCl_{(aq)} \rightarrow AgCl_{(s)} + NaNO_{3\,(aq)}$

$NH_{3\,(aq)} + AgCl_{(s)} \rightarrow Ag(NH_3)^+_{n\,(aq)} + Cl^-_{(aq)}$
Makes precipitate go away

Makes precipitate go away

De precipitation rxn.

2. Acid-Base

$H\_\_ + \_\_OH \rightarrow H_2O + \_\_\_\_\_(aq)$

$HCl_{(g)} + NH_{3(g)} \rightarrow NH_4Cl_{(s)}$ Precipitation rxn in the atmosphere. Also an acid/base rxn.

Acid-base forms a salt + water

Arrhenius said an acid is H^+ + base = OH^-, so when you mix $HBr_{(aq)} + KOH_{(aq)} \rightarrow H_2O_{(l)} + KBr_{(aq)}$

3. Redox LEO says GER

$2\overset{0}{Fe}_{(s)} + \overset{0}{O}_{2(g)} \rightarrow 2\overset{+2}{Fe}\overset{-2}{O}_{(s)}$ iron(II) oxide

↑ oxidation state

reduction is a decrease in oxidation state

Oxidation is an increase in oxidation state

$NaCl_{(aq)}$ Na + Cl are solvates. Aquated. They are surrounded by solvent (water).

$NaCl_{(aq)} = Na^+_{(aq)} + Cl^-_{(aq)}$

<u>Concentration</u>

how much solute is in the solvent

<u>Molarity = mol solute / L solution</u>

(Volume) Molarity = mol

.50 L of 2M HCl. How many mol KOH will react w/ this?

$HCl_{(aq)} + KOH_{(aq)} \rightarrow H_2O + KCl$

mol HCl = mol KOH

1 mol HCl = 1 mol KOH

So 1.0 mol KOH

Concentration Calculations

Wednesday, October 11, 2006
8:00 AM

With mass, volume, & concentration, you can calculate the concentration in every sample. Use Excel.

$\frac{mg}{L} = \frac{parts}{million}$

$=M2*H2/1000 = mg\ Hg$ in 50mL soln

$\left([Hg]\ mg/L\right) * 50\ mL \times \frac{1\ L}{1000\ mL} \times \frac{mg\ Hg}{10\ g\ sample} \times \frac{1000\ g}{1\ kg} =$ = mg Hg in 10g sample

$\frac{mg\ metal}{kg\ sample} = ppm$

$=(M2*H2/1000)/G2*1000$
$=(M2*H2)/G2$

Some levels are incalculable. Below detectable limit.
Show calculations for own sample. How did we figure out amount of metals in our sample?

We should have 2-3 sources. Info. on toxicity in metals, accumulation of whatever fish date we're looking at. Page limit of 5 pages of text

On Arch, there's a drop box where we can turn it in.

In the next lab, we will dissolve Cu and reconstitute it.
We start w/ Cu, we do a # of rxns, & then we go back to Cu. We want to measure how much Cu we get back.

- Weigh it out
- Add nitric acid (HNO_3) Metals become ions. Hydrogen becomes water. $Cu^{2+} + NO_{2(g)}$
- Add OH Forms blue solid of $Cu(OH)_2$
- Heat $Cu(OH)_2$ Forms a black solid. $CuO_{(s)}$
- Add sulfuric acid (H_2SO_4) Forms $CuSO_{4(s)}$
- Add zinc. Zinc becomes oxidized & Cu becomes reduced, so you get $Cu_{(s)}$

You might end up w/ >100%, so it needs to keep reacting until there's no Zn left. If the product is silvery instead of coppery, or if the sample isn't dry at the end, then it might be >100%, and obviously wrong.

Write out all equations. Mass original & final sample, & find % recovery.

Example Probs

Thursday, October 12, 2006
8:00 AM

74. CO_2 gas is produced in combustion of ethane & absorbed in $Ba(OH)_2$ producing .5 g $BaCO_{3(g)}$. g ethane burned

$$C_2H_{6(g)} + \frac{7}{2}O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$$

combustion of ethane.

$$CO_{2(g)} + Ba(OH)_{2(aq)} \rightarrow BaCO_{3(g)} + H_2O_{(l)}$$

absorption of ethane in $Ba(OH)_2$.

$$.5\text{ g } BaCO_{3(g)}\left(\frac{1\text{ mol } BaCO_3}{197.3\text{ g } BaCO_3}\right)\left(\frac{1\text{ mol } CO_2}{1\text{ mol } BaCO_3}\right)\left(\frac{1\text{ mol } C_2H_6}{2\text{ mol } CO_2}\right)\left(\frac{30\text{ g } C_2H_6}{1\text{ mol } C_2H_6}\right)$$

$= .038$ g C_2H_6

104. $C_3N_3(NH_2)_3$ Melamine. Urea $CO(NH_2)_2$ is the sole starting material. Iso something acid HNCO is an intermediate & ammonia & $CO_{2(g)}$ are byproducts. NH_3 & CO_2.

a) Rxn

b) what mass of $C_3H(NH_2)_3$ will be obtained from 100kg urea?

a) $6CO(NH_2)_2 \rightarrow 6HNCO_{(l)} + 6NH_3$ → don't have to balance this as a reactant. Just as a product.

$\rightarrow C_3N_3(NH_2)_{3(l)} + 3CO_{2(g)}$

b) 100.0 kg urea

$$100\text{ kg urea}\left(\frac{1\text{ kmol}}{60.063\text{ kg}}\right)\left(\frac{1\text{ kg}}{1000\text{ g}}\right)\left(\frac{1000\text{ mol}}{1\text{ kmol}}\right)\left(\frac{\quad}{\quad}\right)$$

$$100\text{ kg urea}\left(\frac{1\text{ kmol}}{60.063\text{ kg}}\right)\left(\frac{1\text{ kmol } C_3N_3(NH_2)_3}{6\text{ kmol urea}}\right)\left(\frac{\text{mm kg } C_3N_3(NH_2)_3}{1\text{ kmol } C_3N_3(NH_2)_3}\right)$$

$= \#$

$$Cu^{2+}_{(aq)} + Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$$

redox rxns.

$$2Cu^{+}_{(aq)} + Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2Cu_{(s)}$$

1 ϕ H_2O = 18 g
1 kϕ H_2O = 18 kg

$$3Cu_{(s)} + 8HNO_{3(aq)} \rightarrow 3Cu(NO_3)_2 + 2NO_{(g)} + 4H_3O_{(l)}$$

.696 ϕ Cu Limiting reagent problem
ϕ HNO_3

88. $Pb(NO_3)_2 + 2KI \rightarrow PbI_{2(s)} + 2KNO_3$

Sample Probs

Friday, October 13, 2006
7:55 AM

1. .20 M NaCl, how much is needed to react w/ .04 ϕ of $AgNO_{3(aq)}$?

$AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$

All Chlorides are soluble except mercury, lead, & something else

$$.04\ \phi\ AgNO_3 \left(\frac{1\ \phi NaCl}{1\ \phi AgNO_3}\right)\left(\frac{1\ L NaCl}{.20\ \phi NaCl}\right) = .2\ L\ NaCl$$

$LiNO_3$	Lithium Nitrate. Salt. Soluble. (All Nitrates, acetates, & chlorates are soluble)
$Mg(C_2H_3O_2)_2$	Magnesium Acetate. Soluble b/c Acetate
$(NH_4)_2SO_4$	Ammonium Sulfate. NH_4 is a pseudo alkali. Almost behaves like a sodium. Soluble, colorless, behaves like a salt.
CdS	Cadmium sulfide. Salt Brilliant yellow. Insoluble
$Ca_3(PO_4)_2$	Calcium Phosphate. Colorless. Salt. Insoluble
$CdSO_4$	Salt
$CdSO_3$	Salt

When you dissolve salt in water, the energy drops. Solvation energy, how water is a polar molecule & wants to be in equilibrium. Sulfide & Phosphates won't dissolve b/c more charge = less soluble.

Phosphates ($^{-3}$), Oxides ($^{-2}$), Sulfides ($^{-2}$) are insoluble.

Coulomb's Law tells us that the energy $= \frac{(\text{charge1})(\text{charge2})}{\text{distance}}$

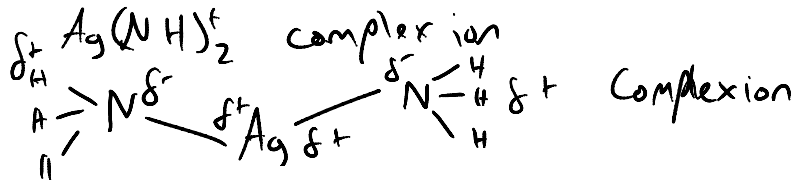
$CdS = q1\,q2 = -4$

$LiBr = -1$

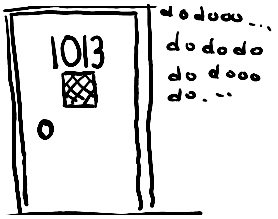
Higher charge = higher cohesive energy = stick together more

Solubility is a competition between solvation energy (energy b/c of $\delta+$ & $\delta-$) vs. cohesive energy that holds the crystal together.

Minus sign means they attract
Lower their energy to come together.



Complexion



Iron in your blood makes it red, & that's because it has been oxidized.

Rule of Thumb for Solns

Monday, October 16, 2006
8:02 AM

$HgNO_{3(aq)} + KCl_{(aq)} \rightarrow HgCl_{(s)} + KNO_{3(aq)}$ Precipitation rxn

Mercury(I) Nitrate, Potassium Chloride, Mercury(I) Chloride – one of the most toxic molecules there is., Potassium Nitrate

$HC_2H_3O_{2(aq)} + KOH_{(aq)} \rightarrow H_2O_{(aq)} + KC_2H_3O_{2(aq)}$ Acid-Base Rxn

Potassium Acetate

$2\overset{0}{Mg}_{(s)} + \overset{0}{O}_{2(g)} \rightarrow 2\overset{2+}{Mg}\overset{2-}{O}_{(s)}$ Redox rxn

$\overset{+}{K}\overset{-}{Cl}_{(aq)} + \overset{+}{H}\overset{-}{Br}_{(aq)} \rightarrow NR$

Soluble, Soluble

So, soluble so no precipitate
balanced oxidation states so no redox
no acid/bases so no acid-base

No Reaction.
Ions are surrounded, and therefore solvated.

$\rightarrow$ means =, and tells you the direction of the rxn.

<u>Rule of Thumb</u> for Solutions

Rxns procede if 1) A precipitate is formed
2) Molecule is formed
or 3) A gas is formed

Rxns out of solns, other stuff happens.

$C_{12}H_{22}O_{11\,(s)} \xrightarrow{H_2SO_4} 12C_{(s)} + 11H_2O_{(s)}$ Redox rxn

Sucrose

100 g sugar react. How many g of C made?

$$100\text{g sugar}\left(\frac{1\ \text{mol sugar}}{342\ \text{g sugar}}\right)\left(\frac{12\ \text{mol C}}{1\ \text{mol sugar}}\right)\left(\frac{12\ \text{g C}}{1\ \text{mol C}}\right) = 42\text{g C}$$

Chemical equation for cooking hot dogs

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ + heat + gray ash carbon & metal oxides

charcoal, smoke

8g C + 8g O_2. How much CO_2 is left?

$$\text{mol C} = 8\text{g C}\left(\frac{1\ \text{mol C}}{12\ \text{g C}}\right) = .67\ \text{mol C}$$

mol O = 8 g O (1 mol O / 16 g O) = .25 mol O

$$\text{mol } O_2 = 8g\ O_2\left(\frac{1 \text{ mol } O_2}{32 g\ O_2}\right) = .25 \text{ mol } O_2$$

$$\frac{\Phi C}{\Phi O_2} = \frac{1}{1} \text{ in an ideal case}$$

$\frac{.67}{.25}$ = actual, so Carbon is in excess because you have more moles C.

Now this is why someone would suffocate if you shut them in a room with a grill turned on, & all the windows shut. It would use up all the O_2.

$$.25\ \Phi O_2\left(\frac{1\ \Phi CO_2}{1\ \Phi O_2}\right)\left(\frac{44 g CO_2}{1\ \Phi CO_2}\right) = 11 g\ CO_2$$

Remaining Carbon

$.67\Phi - .25\Phi = .42\Phi$

$$.42\Phi C\left(\frac{12 gC}{1\ \Phi C}\right) = 5.04 gC$$

Limiting Reagent Problem

$$\overset{+1}{H_2}\overset{-1}{O_{2(aq)}} \xrightarrow{MgO_2} \overset{+1}{H_2}\overset{-2}{O_{(l)}} + \frac{1}{2}\overset{0}{O_{2(g)}}$$ Redox Rxn

oxygen doesn't like to be -1, it would rather be -2. MgO_2 was a catalyst, but this rxn proceeds because of that uncomfortable state.

Molarity of water in water (pure water)

Volume · Molarity = mol

$$\text{Molarity} = \frac{\text{mol}}{V}$$

in 1 L:

$$1L\left(\frac{1000 mL}{1 L}\right)\left(\frac{1 g}{1 mL}\right)\left(\frac{1\ \Phi H_2O}{18\ g H_2O}\right) = 55\ \Phi H_2O$$

$\frac{55\Phi}{1 L}$ = 55 M. Pure water is $55\Phi/L = 55M$

electrolyte = soln of ions in solvent

nonelectrolyte = [illegible]

nonelectrolyte is a soln w/out ions. A weak electrolyte has a few ions. A strong electrolyte has a lot of ions.

Molecules don't break apart - nonelectrolyte

Acids, Bases, + Salts are kinds of electrolytes.
Insoluble salt is a weak electrolyte.
strong acid is an acid that mostly dissociates. Strong electrolyte.

Limiting Rxns, Electolytes

Tuesday, October 17, 2006
8:02 AM

$M = \frac{\text{mol solute}}{\text{L solution}}$

Water is 55M. The concentration of water is higher than anything else.

20g NaOH in a 250mL beaker, M?

$20g\ NaOH\left(\frac{1\ mol\ NaOH}{40\ g\ NaOH}\right) = \frac{1}{2}\ mol\ NaOH$

$250\ mL\left(\frac{1\ L}{1000\ mL}\right) = .25\ L$

$M = \frac{\phi}{L} = \frac{.5}{.25} = 2M$

200 mL of 1M $AgNO_3$ react w/ 100mL of HBr of unknown concentration. 1) Moles of precipitate 2) Molarity of HBr?

$AgNO_{3(aq)} + HBr_{(aq)} \rightarrow AgBr_{(s)} + HNO_{3(aq)}$

You don't actually need the aq b/c NO_3, nitrates, are always soluble.

Silver bromide - you know this is not soluble b/c of silver.

1) $\phi\ AgBr = \phi\ Ag^+ = \left(\frac{.2\ L}{}\right)\left(\frac{1\ \phi}{1\ L}\right) = .2\ \phi\ AgBr_{(s)}$
B/c of mole ratio.

2) $\phi\ HBr = \phi(AgBr) = .2\ \phi$
$.20\ \phi = (V)(M) = (.100\ L)(M)$, $M = 2\ \phi/L = 2M$ of HBr

Not a limiting rxn b/c nothing is in excess.

1 mL of 2.0 M $Hg_2(NO_3)_2$ is added to a 1000 gallon marine aquarium. What precipitate is formed, + how much (g)?

just indicates we have extra. empirical = $HgNO_3$

$Hg_2(NO_3)_{2(aq)} + 2NaCl_{(aq)} \rightarrow Hg_2Cl_{2(s)} + 2NaNO_{3(aq)}$

all Cl are soluble except 3. Hg, Ag, + Pb.

We have enough info - they don't tell us how much salt is in there, so

So . . .

1000 gallons = ____ L

Limiting reagent is Hg^{2+}.

$\Phi Hg_2Cl_2 = \Phi Hg^{2+}$ = blah blah stoichiometry.

Electrolytes - ions in soln

Strong electrolyte = many ions in soln

Weak electrolyte = few ions in soln

Non electrolyte = no ions in soln

Strong base = many OH^- in soln. (only 2 (common) KOH, NaOH)

Strong acid = many H^+ in soln (HCl (stomach acid), HNO_3 (nitric), H_2SO_4, $HClO_4$ (per chloric))

Most OH's are insoluble. So it can't be a strong base if it doesn't dissolve

Limelight = making light by heating CaOH (by Hydrogen flame)
used to use it on ships to light water. & Oxygen

Time	Acid	Base	Person	
1870	H^+	OH^-	Arrhenius	then ppl thought about diff rxns. HCl

Acid, Base, Soluble, Insoluble

Wednesday, October 18, 2006
7:58 AM

Acid	Base	Person	Time
H^+	OH^-	Arrhenius	1880
proton donor	proton accepter	Bronsted/Lowry	1900

$2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)}\ H_{2(g)}$ Proceeds b/c it makes a gas

$Hg(NO_3)_{2(aq)} + H_2S_{(aq)} \rightarrow HgS_{(s)} + HNO_{3(aq)}$

soluble — insoluble — black gunk — Proceeds b/c it makes a solid

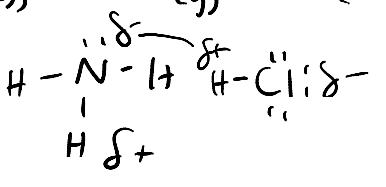
$HClO_{4(aq)} + KOH_{(aq)} \rightarrow H_2O_{(aq)} + KClO_{4(aq)}$ Proceeds b/c it makes a molecule

Acid-Base

$(N\overset{+}{H}_4)_2\overset{2-}{S} + \overset{+}{Rb}\overset{-}{Cl}_{(aq)} \rightarrow NR$

Rubidium is soluble. Ammonium is soluble. So no precipitation.
No redox (nothing to redox) ~~No~~

$NH_{3(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(g)}$



Ammonium chloride is soluble so it can't be precipitation rxn
Not redox. Proton donor/acceptor reaction, so acid-base rxn.

$H^+ + OH^- \rightarrow H_2O$

Ammonia is acting as a base b/c it accepts a proton. The HCl (hydrochloric acid) is a proton donor, so it's an acid.

EBERHARD

Other kinds of rxns

$CaCO_{3(s)} \xrightarrow{\Delta\ \text{lots of heat}} CO_{2(g)} + CaO$

Limelight. It didn't burn, it gave off light.

No redox.
Not acid-base.

Lime (lots of stuff is lime)

Not acid-base.

Decomposition!

Lime (lots of stuff is lime)

$$\overset{0}{S}_{(s)} + \overset{0}{O}_{2(g)} \xrightarrow{\Delta heat} \overset{4+\ 2-}{SO}_{2(g)}$$

Redox rxn.

It's balanced already.

$$\overset{+4}{U}\overset{-2}{O}^{+2} + \overset{+6}{C}r_2\overset{-2}{O}_7^{-2} \longrightarrow \overset{+5}{U}\overset{-2}{O}_2^{+} + \overset{+3}{C}r^{+3}$$

In acid, so aqueous rxn.

1) Write half rxns.

$$Cr_2O_7^{-2} \rightarrow Cr^{+3}$$
$$UO^{+2} \rightarrow UO_2^{+}$$

2) Balance non-O & H.

$$Cr_2O_7^{-2} \rightarrow 2Cr^{+3}$$

3) Balance O, H_2O

$$14H^+ + Cr_2O_7 \rightarrow 2Cr^{+3} + 7H_2O$$

4) Balance H_2 using H^+

$$H_2O + UO^{++} \rightarrow UO_2^{+} + 2H^+$$

5) e^-

$$(H_2O + UO^{++} \rightarrow UO_2^{+} + 2H^+ + e^-)\ 6$$

Multiply to cancel e^- then add

$$6e^- + 14H^+ + Cr_2O_7^{-2} \rightarrow 2Cr^{3+} + 7H_2O$$

$$\cancel{6H_2O} + 6UO^{2+} + 14H^+ + Cr_2O_7^{2-} \rightarrow 6UO_2^{+} + \cancel{12H^+} + 2Cr^{3+} + 7H_2O$$

$$6UO^{2+} + 2H^+ + Cr_2O_7^{2-} \rightarrow 6UO_2^{+} + 2Cr^{3+} + H_2O$$

Add, simplify, & check. Are they balanced?

Add phases

$$6UO^{2+}_{(aq)} + 2H^+_{(aq)} + Cr_2O_7^{2-}{}_{(aq)} \rightarrow 6UO_2^{+}{}_{(aq)} + 2Cr^{3+}_{(aq)} + H_2O_{(l)}$$

Weak/Strong Electrolytes Sample Probs

Thursday, October 19, 2006
8:03 AM

1. a) HC_6H_5O Weak electrolyte
   Acid. (Not on list of strong acids, is organic + therefore probably weak)
   b) Li_2SO_4
   ionic compound. Soluble b/c of Lithium. So strong electrolyte
   c) MgI_2
   Strong electrolyte b/c compounds w/ single charged ions Mg^+ I^- are usually soluble.
   d) $(CH_3CH_2)_2O$
   Organic compound. Diethyl ether. Nonelectrolyte. No H to dissociate.
   e) $Sr(OH)_2$ A strong base
   Strong electrolyte. Ionic compound. Hydroxides insoluble, but Sr is slightly soluble. It seems like it'd be a weak electrolyte. The "strong electrolyte" solution is probably wrong.

22. Predict whether a rxn is likely to occur. If so, write net ionic equation.
   a) $AgNO_{3(aq)} + CuCl_{2(aq)}$
   Silver is insoluble. $\rightarrow Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)} \rightarrow AgCl_{(s)}$
   nitrates are soluble $Cu^{2+}_{(aq)} + NO_3^-{}_{(aq)} \rightarrow Cu(NO_3)_2 + Cu(NO_3)_2$
   b) $Na_2S_{(aq)} + FeCl_{2(aq)}$
   Salt is soluble Sulfides are insoluble.
   $\rightarrow FeS_{(s)} + NaCl$
   c) $Na_2CO_{3(aq)} + AgNO_{3(aq)}$
   Most sodium compounds are soluble
   Silver is almost always insoluble $\rightarrow NaNO_3 + Ag_2CO_3$

   I wonder if $NaNO_3$ is Prof. Rather's fav. compound .. Nano!

27. a) $Ba^{2+} + 2OH^- + HC_2H_3O_2 \rightarrow$
   OH is strong base acid
   neutralization acid/base rxn
   $\rightarrow H_2O + C_2H_3O_2^- + Ba^{2+}$
   Ba^{2+} is a spectator ion.
   b) $H^+ + Cl^- + HC_3H_5O_2 \rightarrow$ NR
   Dissolved ions of HCl acid. Similar to acetic acid, so weak acid
   Acid + Acid = NR
   c) $FeS + H^+ + I^-$
   solid. Insoluble b/c of which is like adding HI
   HI is solid but a strong
   $\rightarrow H_2S_{...} + Fe^{2+} + I^-$

KERRY
CONNOR
KELLY
KARA
KIRBY
CHRIS

5. acid. $_{(g)}$

if it's not neutralization, & there's no precipitate, then it's got to be a gas. H_2S is a gas. It smells really bad. It's always a gas, & smells like rotten eggs.

d) $K^+ + HCO_3^- + H^+ + NO_3^-$

carbonates (nitric acid)

→ H_2CO_3 is not stable — Memorize

break down to H_2O & CO_2

e) $Mg_{(s)} + H^+$

redox rxn, b/c Mg^{2+} & H^+ neither are likes their electrons. → $Mg^{2+} + H_{2(g)}$

None of these are balanced.

Test is based on everything we've learned so far.

75. What volume of a .248 M $CaCl_2$ (Ca^{2+} Cl^-) must be added to .186 M KCl (.335 mL) to produce a concentration of .250 M Cl^-

$CaCl_2 + KCl \rightarrow$

$$[Cl^-] = (.335L)\left(\frac{.186 \text{ mol KCl}}{1 \text{ L soln}}\right)\left(\frac{1 \text{ mol } Cl^-}{1 \text{ mol KCl}}\right) + V\left(\frac{.248 \text{ mol } CaCl_2}{1 \text{ L soln}}\right)\left(\frac{2 \text{ mol } Cl^-}{1 \text{ mol } CaCl_2}\right)$$

$[Cl^-] = .25$ M

$$\frac{.25 - (.335L)\left(\frac{.186}{1}\right)}{\left(\frac{.248 \text{ mol}}{1L}\right)\left(\frac{2 \text{ mol}}{1 \text{ mol}}\right)} = V + .335$$

38. c) $\overset{+1\ 2-}{HS^-} + \overset{+1\ +4\ 2-}{HSO_3^-} \rightarrow \overset{2-\ 2-}{S_2O_3^{-2}}$

Oxidation: $2HS^-_{(aq)} + H_2O_{(l)} \rightarrow S_2O_3^{2-}$ + electrons & stuff

Reduction: $2HSO_3^-$ + electrons & stuff → stuff

$2HS^-_{(aq)} + 4HSO_3^- \rightarrow 3S_2O_3^{2-} + 3H_2O$

Boyle's Law
Friday, October 20, 2006
7:54 AM

Boyle's Law
Part 1: Determine relationship between Pressure & Volume
Part 2: Determine the identity of an unknown metal by calculating the molar mass

Even if you get a molar mass that says the metal is X, don't write down X b/c it could be a gas. Like if you get 14, don't write N b/c N is a gas, not a metal.
Also use the balanced = then. If the balanced equation has $2e^-$ then it won't be K, for instance.
And duh, nothing's radioactive.

Part 1: Derive the P-V relationship

Part II: React metal to produce hydrogen gas
Use ideal gas law $PV = nRT$
Pressure · Volume = moles · Temp (K) · R (Ideal gas constant)

Demonstration of procedure
0.0128 g M #1
5 mL is more than enough to react w/ all of the metal. All of the metal will react.
You don't need exactly 5 mL b/c it's in excess but you do need all the metal to be exact.

Calculation pt. 1?
All comp. instructions are in the lab manual. Don't copy comp instructions into lab notebook. Bring the &@! **! lab manual.

20 mL open to atmosphere then close. Pressure is now 1 atm.

pull out plunger to 40 mL & at that pt, pressure will be .5 atm
open it & close it, then it'll be 1 atm again.
press in & pull out plunger until you have a graph. valve must be closed.

Start pt. 2, do pt. 1 & come back to pt. 2.
6 mL H_2 (g) remain
Solve for n.

$n = \frac{PV}{RT}$ ← guess. Actually measure in the lab)

$$n = \left(\frac{\frac{(.082)\,L\,atm}{K\,Mol}(294\,K)}{(.97\,atm)(.006\,L)} \right)^{-1}$$

depends on temp. There's a list of them.

$n = 2.4E-4$ mol

$\frac{.0128\,g}{2.4E-4\,mol} = 53.02$ MM but wasn't a 1-1 ratio
divide by 2. $\frac{53.02}{2} = 26.5$

$(2.4E-4)$ mol · 2 mol metal / 3 mol hydrogen
mol metal = $1.6E-4$ mol met.

$\frac{.0128\,g}{1.6E-4\,mol} = 80$ MM has to be something that can form at +3 charge.

Aluminum? No, it's +3. Mg is more likely b/c it's +2

We love to make you smile!!

Be the boss not the one being bossed at!!

Bob Evans
Down on the farm!

Gases

Monday, October 23, 2006
8:03 AM

Gases

Equal volumes of gas contains same # of particles. Avogadro's Hypothesis

Gases are mostly empty space. There's nothing to them. Solids have molecules touching, which is why you can't get past them.

$\boxed{STP = 273.15\,K,\ 1.00\ldots atm}$

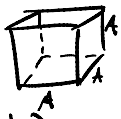
1 mol gas at STP occupies $\boxed{22.4\ L}$

1 mol H_2O at STP occupies $\boxed{18\ cm^3}$

$$\left(\frac{22\,400\,cm^3}{1\ mol}\right)\left(\frac{1\ mol}{6.02E23\ molecules}\right) = \frac{22.4}{6.02E20}\ cm^3$$

$$\approx 4E{-}20\ cm^3$$

If you had a box like this, one molecule occupies a tiny little space, $\frac{1}{1000}$ of the total area ($\frac{1}{10}w, \frac{1}{10}l, \frac{1}{10}h$).



$A^3 = 4E{-}20\,cm^3$

$A = \sqrt[3]{4E{-}20\,cm^3}$

$A \approx 3E{-}7\,cm$

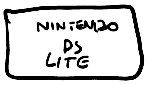
The space of this room is 99.9% empty.

Avogadro's hypothesis is not <u>exactly</u> correct. Stay tuned.

T, V, n, ρ

thermometer, beaker, $g\left(\frac{mol}{g}\right)$, $\frac{m}{V}$

$P = \frac{force}{area}$ | $N/m^2 = pascal, Pa$



101.3 kPa = 1 atm pressure of a Standard atmosphere (Earth)

760ish Torr = 1 atm

14.7 PSI = 1 atm

R. Boyle (Skiptical Chemist 1661)

Measurments obtained w/ a vacuum pump.

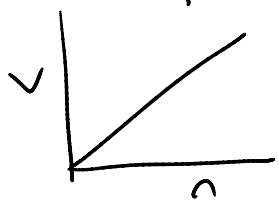
PV = constant Boyle's Law

Gases are easy to squeeze. This is why Boyle's Law works. This doesn't hold for liquids & solids.

Charles' Law ($V \propto Temp$)

Avogadro's Law ($V \propto n$)

If you you move the temp to absolute 0, the volume does <u>not</u> get to 0.
Charles' Law



If you have 0 mols, you have 0V.
Avogadro's Law

Hyperbola
R. Boyle's Law
The harder you squeeze it, Volume goes down.

$PV = \text{const.}$ fixed T
$V \propto n$ fixed P, T
$V \propto T$ fixed P
$\boxed{PV = nRT \text{ ideal gas law}}$ Predicts behavior of gases over types of ranges. Universal ideal gas law.

1.5 L of air measured at 2.25 atm. What is P in Volume of 8.10L?

$$P_1V_1 = P_2V_2$$
$$(2.25\text{atm})(1.5\text{ L}) = P_2(8.10\text{L})$$
$$.417\text{atm} = P_2$$ Pressure goes down a lot.
$$P_2 \text{ in Torr} = .417\text{atm}\left(\frac{760\text{Torr}}{1\text{ atm}}\right) = 317\text{ Torr} = \text{mmHg}$$

As particles push into one another, they push each other away but not in gas, b/c they're too far apart to really interact.

Maxwell-Boltzman

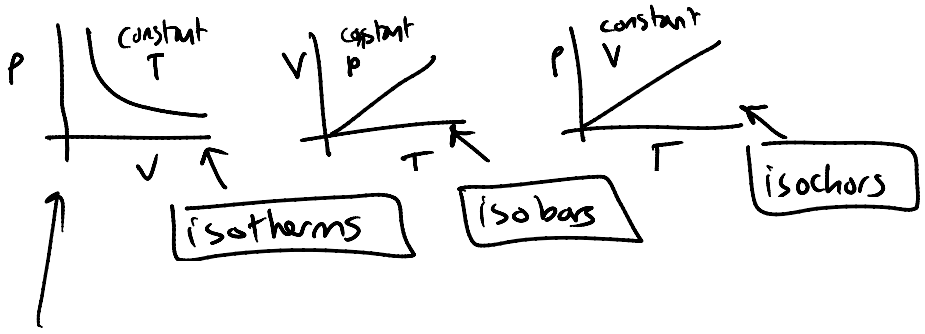
Tuesday, October 24, 2006
8:06 AM

$$R = \begin{cases} .082 \ \frac{L \cdot atm}{mol \cdot K} \\ 8.31 \ J/mol \cdot K \end{cases}$$

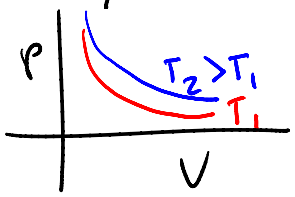
1 mol Ne at STP occupies what V ?

$$V = \frac{nRT}{P} = \frac{(1\ mol)(.082 \frac{L \cdot atm}{mol \cdot K})(273 K)}{1\ atm} = 22.4\ L$$

That's how we get our 22.4 L



diff temps have diff curves



The assumption about the ideal gas law is that molecules have no volume, so the most ideal gas has less molecules.
More dilute the gas more ideal the Volume.

Model

Models are used to represent the almost-correct version of things.
Model for ideal gas - Kinetic Molecular Model

Maxwell, Boltsman, + others developed this

Assumptions

1. Gas is made of noninteracting point particles that have mass
2. They move according to Newton's Laws
3. Elastic collisions with walls

* No Potential energy. That's why it's called Kinetic Molecular Model

$$P = \frac{F}{A} = \frac{m(\Delta p)}{\Delta t \cdot \text{area}}$$ momentum

$$= \frac{(m\vec{v} - m\vec{v})}{\frac{2\ell}{\vec{v}} \quad \text{area}}$$

$$v_x = \frac{2\Delta \ell}{t_c}$$ time between collisions

$$t_c = \frac{2\ell}{\vec{v}}$$

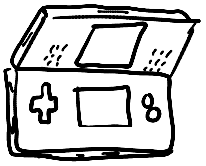
$$= \frac{2m\vec{v}_x}{\frac{2\ell}{\vec{v}_x} \cdot \text{area}}$$ (diff by sign, so $m\vec{v} - (-m\vec{v})$)

area → (ℓ^2)

$$= \frac{m\vec{v}_x^2}{\ell^3}$$ ℓ^3 is volume

$$P(V) = \frac{m\vec{v}_x^2}{\ell^3}(V)$$

$$PV = m\vec{v}_x^2$$



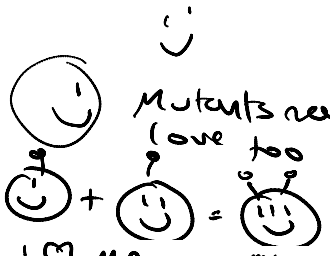
My Nintendo DS Lite

Total velocity^2, $\overline{\vec{v}^2} = \overline{\vec{v}_x^2} + \overline{\vec{v}_y^2} + \overline{\vec{v}_z^2}$

average b/c there are a lot of molecules in that little space

$$PV = \frac{1}{3} m \overline{\vec{v}^2}$$

$$PV = n\left(\frac{1}{3} m \overline{\vec{v}^2}\right)$$ many particles



Mutants need love too

I ♡ MR WISWELL & ALL HIS CRAZY JOKES

$$E_k = \left(\frac{1}{2} m \vec{v}^2\right) n$$

$$PV = \frac{2}{3} E_k$$

$E_k \propto (n, T)$ $\quad PV \propto nT$

$$PV = nT(C)$$ where C is a constant

$$PV = nRT \quad C = R$$

has to be K b/c as it's 0, it needs to have 0

Keebler Elves in the tree...

Pillsbury Doughboy

Crazy German made-up phrases & ppl start moving & doing things to make you happy.

Eisenveiger Shnell! Nütenberg! Die! Die!

Back to our assumptions

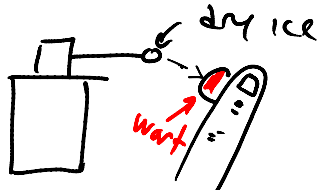
- It is totally reasonable to assume that Newton's Laws apply
- It is reasonable to think collisions are relatively elastic
- It is unreasonable to think of molecules as points that don't interact w/ each other.

The ideal gas law doesn't hold completely for all things b/c of that assumption that ~~the~~ molecules are points that don't interact. And they can't be infinitely small

$$PV = \frac{2}{3} E_k = \frac{2}{3} n \frac{1}{2} m \overline{\vec{v}^2} = nRT$$

$$\overline{\vec{v}^2} = \frac{nRT}{nm}(3)$$

$$\overline{\vec{v}^2} = \frac{3RT}{Nm}$$



$\sqrt{\overline{\vec{v}^2}}$ = root mean square velocity

$$v_{RMS} = \sqrt{\frac{3RT}{m N_{avogadro}}}$$


no wart

describes trajectory of particles in air.

$\propto \sqrt{T}$, & $\frac{1}{\propto} \sqrt{m}$

Maxwell-Boltzman, Effusion

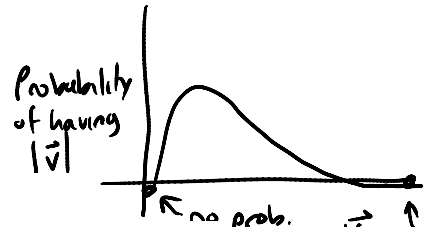
Wednesday, October 25, 2006
8:02 AM

$$\vec{v}_{rms} = \sqrt{\frac{3RT}{N_{avogadro} \cdot \text{mass}}}$$

mass ↑ amu's

10^{ϕ} amu's = 1 g

Root mean square
mean ↓ avg.



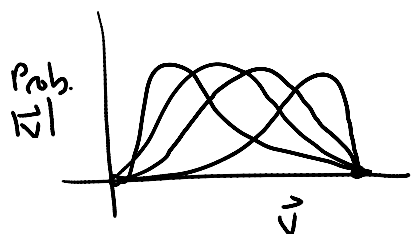
no prob. at 0, either.

no probability for infinite $\vec{v}$, speed of light, b/c nothing does that.

The average particle goes at the speed of sound.

Probabilities are always positive

This is for some temp.



As you heat it, peak moves to the right

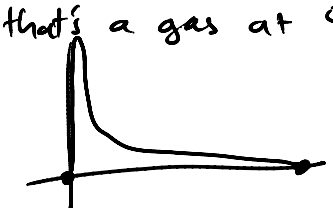
Area under curve = 1, always.

same area at all times

Maxwell-Boltzman distribution.

$$\text{prob}|\vec{v}| = (\text{const})\, v^2 e^{-\frac{1}{2}mv^2/RT}$$

Helium is the only thing that's a gas at 5K. At 5K, graph would be really steep.

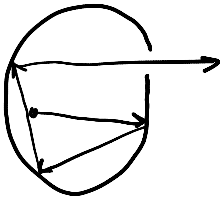


Heavier, it is the slower it goes. Lighter it is faster it goes.

Speeds (velocity)

$$|\vec{v}| \propto \sqrt{\frac{T}{m}}$$

$$\frac{|\vec{v}_1|}{|\vec{v}_2|} = \sqrt{\frac{m_2}{m_1}}$$



Process of effusion. Depends on size of the whole & how fast molecule moves.

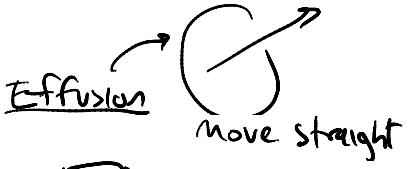
$\propto |\vec{v}|$

$rate_1 \propto |\vec{v}_1|$

$rate_2 \propto |\vec{v}_2|$ if you had a 2nd molecule

$$\frac{rate_1}{rate_2} = \frac{|\vec{v}_1|}{|\vec{v}_2|}$$

$$\frac{rate_1}{rate_2} = \sqrt{\frac{m_2}{m_1}}$$ Law. Graham's Law of effusion.



Measure rate at which they effuse & find the rate of effusion of tar

pollen particle in glass of water, constantly getting hit by other stuff (water).

Diffusion

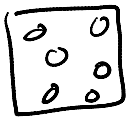
Separate uranium by making a gas out of it, and spin it around in a centrifuge. – but that didn't work. Effusion worked (heavier & lighter are effused in effusion cell). $\frac{rate\ 232U}{rate\ 235U}$ $\frac{faster}{slower}$

Do this again & again.

Tennessee Valley Authority allowed for lots of dams & energy, used this to separate 235U.

Speed of sound depends on density.

Prof. Ratner's voice got higher when he breathed the helium b/c the density was less.



$P_{ideal}V_{ideal} = nRT$

$V_{real} = V_{ideal} + nb$

b: sort of a molar volume; molecular

Volume

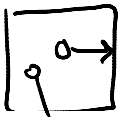
$V_{ideal} = V_{real} - nb$

$V_{ideal} = V - nb$

size of the box, what you measure.

$P(V - nb) = nRT$

2 constants. Differ per item.



If this molecule attracts the other one, then it could slow down that other one. Molecules do interact. Every time they hit they decrease speed, so it decreases pressure

$P_{real} = P_{ideal} - a\left(\frac{n}{V}\right)^2$ $\quad \frac{n}{V}$ = density.

Reduces # of collisions & intensity of collisions. 2 factors, so it's squared

$P_{id} V_{id} = \boxed{\left(P + a\frac{n^2}{V^2}\right)(V - nb) = nRT}$

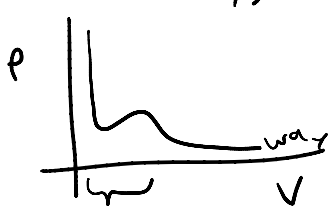
a tells you about how much one particle interacts w/ another particle

a describes how much molecules stick to each other. Molecular stickiness.

Van Der Waals

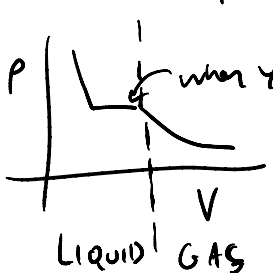
Dutch 1881, he came up w/

This is not a trivial equation b/c mathematically, it's a cubic equation



way out here, very large volume, low pressure. Gas is pretty much ideal.

why does it have this bump? V↑, P↑ ← WRONG. Nothing gets bigger when you squeeze it.



when you push it in enough, you end up with a liquid.

Phase changes!

2 things make the gas become a liquid. Particles stick together. Particles occupy space.

Molecule Species	Stickiness a	Volume b
He	.034	.024
Xe	4.2	.051
H_2O	5.5	.031

the larger, more attract

H_2O	5.5	.031	Hydrogen bonds attract
H_2	.24	.027	

Specific Heat

Thursday, October 26, 2006
8:02 AM

All chem rxns are accompanied by a heat change

Temperature change w/ no change in substances & no change in state.

Hot object heat flows to cool object until equilibrium is reached.

Calorie is the energy it requires to raise 1 g H_2O (or 1 mL H_2O) 1 °C.

Specific heat of H_2O = 1 Calorie by definition.

Joules = 4.18 Calories.

Specific heat - the amount of energy it takes to raise a substance 1°C.

$$C_s = \frac{\#\text{g substance}}{\Delta T}$$

$$q = mC_s\Delta T$$

grams, not moles

$$q = nC_s\Delta T\left(\frac{\text{mol}}{\text{g}}\right) = q = nC_m\Delta T$$

C_m = molar heat capacity.

At constant pressure, $q = \Delta H$, where ΔH = enthalpy (amount of heat gained or lost during a rxn)

When ΔH is negative, it's exothermic, meaning heat is given off in the reaction.

Specific heat * Molar mass = C_s

Take ice, melt it, look at heat change accompanying this rxn. calculate heat of fusion

Enthalpy of fusion

Enthalpy of vaporization.

$Ca_{(s)} + HCl_{(aq)} \rightarrow$

Calculate heat change for rxn that we do not do.

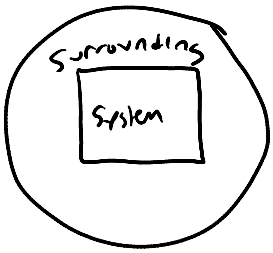
Hess's Law, Enthalpy of fusion, etc

Coffee cup calorimeter

48 hrs after lab to finish.

Energy, Work

Monday, October 30, 2006
9:05 AM



$\Delta E = E_f - E_i$

when you drop keys,

$\Delta E_{sys} < 0$

$\Delta E_{surr} > 0$

$\Delta E_{total} = \Delta E_{sys} + \Delta E_{surr} = 0$

Keys & floor together conserve energy.

Before you drop keys, PE. After KE.

<u>Newton</u>

Mechanical system

$E_f - E_i = \boxed{\Delta E_{sys} = W}$, work done on a system

work-energy theorem

$W = \text{Force} \cdot \text{distance} = mg(h_f - h_i)$

This only works with mechanical systems, though.

<u>R. Mayer</u>

Realized there was a correlation between caloric value of what you eat & how much work you can do.

<u>B. Thompson</u>

was a spy for the U.S., Spent time in France. Wanted to be quantitative about how much heat you could generate doing work w/ mechanical cannon boring.

<u>J. P. Joule</u>

Mechanical equivalent of heat. Able to make an equivalence between heat & work.

<u>Lord Kelvin</u>

Put everything together on an equation basis.

Even though Newton was the most important scientist who ever lived, he wasn't very good at work because he only looked at mechanics.

$\boxed{\Delta E_{sys} = W + q}$ 1st Law of Thermodynamics

W = work done <u>on</u> system

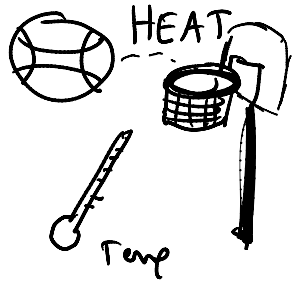
q = heat made <u>by</u> system

$\boxed{W_{gas} = -P_{ext}\Delta V}$ Work done on gas = (neg. external pressure)(ΔV)

State functions
E, T, V, P, n || W, q
$\int dq$ or $\int dW$ are not path independent

	q	W	ΔE
heat up T	+	0	+
lift up barbell	0	+	+
drop a penny into cold hot water, penny is system	−	−	−

b/c if you lift penny, you do work on penny. drop penny, penny does work



7 L ideal gas
$\Delta V = 1.0L$ $P_{ext} = 1.0$ atm

heat will make this rxn happen
heat it isothermally so at any point, the temperature is the same as temp outside.

$W = -P_{ext}\Delta V = -(1atm)(1L) = -1$ L·atm
$\Delta E = \Delta PE + \Delta KE$ 0 PE in ideal gas b/c "noninteracting particles"
KE is constant b/c $KE \propto nT$, & we aren't changing n or T.

$\Delta E = \Delta PE + \Delta KE$
$\Delta E = \Delta KE$
$W + q = \Delta KE$

13. $NaOH_{(aq)} + KCl_{(aq)} \rightarrow NR$

25°C, P = 1atm CO_2, H_2
CO_2 molecules are moving more slowly than the H_2 molecules.
Faster = lighter, & CO_2 is heavier.
Equal volumes of gas contain equal # of particles, but H_2 & CO_2 weigh completely diff weights, so equal volumes of CO_2 & H_2 do not produce equal weights.

17. b) 45 g sample of $CaCO_3$ is added to

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow H_2O_{(l)} + CaCl_{2(aq)} + CO_{2(g)}$$

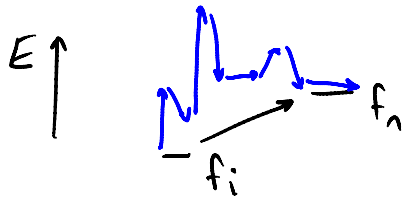
All chlorides are soluble.

soluble.

State Functions, Enthalpy

Tuesday, October 31, 2006
9:07 AM

Function of state



different processes
total change in energy
$\Delta F = F_n - F_i$

Functions that are path independent like this one are called functions of state.

$H \equiv E + PV$ Enthalpy, function of state

$\Delta H = \Delta E + \Delta PV$ by definition

P = constant

then ΔPV becomes $P\Delta V$

$\Delta E = q + W$

$\Delta H = q + W + P\Delta V$

$W = -P\Delta V$

$\Delta H = -P\Delta V + q + P\Delta V$

$\Delta H = q_P$ ← subscript p means pressure is constant

Measurements of heat flow into or out of system, & you can measure ΔH.

Calorimeters measure heat. 2 kinds cheap & expensive. Cheap operates at constant pressure.

$Mg_{(s)} + H_2O_{2(g)} \rightarrow MgO$

$\Delta H_{sys} < 0$ b/c enthalpy outside goes up, so enthalpy in sys goes down.

$\Delta H_{sys} < 0 \equiv H_{prod} - H_{reactant}$

$CO_{(g)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{2(g)}$ Heat released into environment, so $\Delta H_{sys} < 0$.

$\Delta H = -283$ kJ/mol

Burn 2.8 g CO, what heat is released? Heat or enthalpy? Both
B/c you're at constant pressure. So $q = \Delta H$

$$\Delta H = (-283 \text{ kJ/mol})\left(\frac{1 \text{ mol}}{28 \text{ g}}\right)(2.8 \text{ g}) = -28.3 \text{ kJ} = q_p$$

Constant pressure calorimetry allows you to measure ΔH

The other kind of calorimetry is constant volume calorimetry.

$\Delta E = q + W$ $\quad W = -P\Delta V$

if ΔV is 0, W is 0.

$W = 0$

$\Delta E = q + 0$ $\quad$ no change in volume means no work.

<u>Bomb Calorimeter</u> Almost always used.

Heat capacity $C_p = \left.\frac{\Delta H}{\Delta T}\right|_p$

Constant pressure heat capacity. $\left(\frac{\text{kJ}}{°\text{K}}\right)$

When you look up a C_p you have to keep units in mind b/c Specific heat measured in grams $\frac{\text{kJ}}{\text{g K}}$

MULDER

$C_p(H_2O)(25°C) = \frac{15}{\text{g K}}$ Calorie.

The calories we eat are in kCalories.

2.43 g Mg burns in air. 60.2 kJ heat is released. Find ΔH.
Constant pressure experiment.

$q = \Delta H$ $\quad$ what we really want is ΔH/mol

$\Delta H = q_p = 60.2$ kJ per 2.43 g.

Mg = 24.3 g/mol

-6.02 kJ/mol

$$Mg_{(s)} + \tfrac{1}{2}O_{2(g)} \rightarrow MgO_{(s)}$$

$CO_{2(s)} \rightarrow C_{(s)} + O_{2(g)}$

Fire extinguisher works by spouting off $CO_{2(s)}$ & they turn into $C_{(s)} + O_{2(g)}$.

$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$

$2Mg_{(s)} + O_{2(g)} + CO_{2(s)} \rightarrow C_{(s)} + O_{2(g)} + 2MgO_{(s)}$

$2Mg_{(s)} + CO_{2(s)} \rightarrow C_{(s)} + 2MgO_{(s)}$ ΔH for this rxn is $\Delta H_1 + \Delta H_2$ b/c it's a function of state.

So if you have tables that tell you ΔH_1 & ΔH_2, you can find ΔH_{sys}.

Newton predicted ΔH values for rxns you don't want to run. Like explosions & stuff.

Hess's Law (ΔH_1 & ΔH_2 & ΔH_n... added together produce ΔH_{sys})

$A \rightarrow B$	ΔH_1
$B \rightarrow C + D$	ΔH_2
$A \rightarrow C + D$	$\Delta H = \Delta H_1 + \Delta H_2$

This works for ΔE as well.

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ Formation rxn. Make a compound from elements.

If you wanted $CO_{2(s)}$, ΔH would be diff

ΔH_f° means ΔH of formation for all species in standard state.

What's a standard state? Define for any material, the enthalpy = 0.

$H^\circ = 0$ in standard state.

Standard state is usually the stable state under STP.

Graphite ($C_{(s)}$) is standard state of Carbon.

Hess's Law, Heat Capacity

Wednesday, November 01, 2006
9:04 AM

<u>Hess's Law</u>

$Sn_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow SnO_{(s)}$
$\Delta H_f^\circ = -285$ kJ/b

$SnO_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow SnO_2$

ΔH not formation b/c the SnO is not an element.

$\Delta H = -296$ kJ/b

$Sn_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow SnO_{2(s)}$ $\Delta H = -581$ kJ/b

$H_2O_{2(aq)} \rightarrow H_2O_{(l)} + \frac{1}{2}O_{2(g)}$ ΔH°?

$H_{2(g)} + O_{2(g)} \rightarrow H_2O_{2(aq)}$ $\Delta H_f^\circ = -188$ kJ/b

reverse [[illegible] $\Delta H^\circ = -196$ kJ/b]

reverse this one $\left[H_{2(g)} + \frac{1}{2} O_{2(g)} \rightarrow H_2O_{(l)} \quad \Delta H_f^\circ = -286\ kJ/\phi \right]$

$\frac{1}{2} O_{2(g)} + H_2O_{(l)} \rightarrow H_2O_{2(aq)} \quad \Delta H = 98\ kJ/\phi$

[MOOSEJAW]

$\overset{0}{Na}_{(s)} + \overset{+}{H}_2\overset{2-}{O}_{(l)} \rightarrow \overset{+}{Na}\overset{-}{OH} + \overset{0}{H}_2$ Exoergic b/c it sends out heat (hydrogen explodes).
Redox rxn.

CAMPMOR

$Na_{(s)} + \frac{1}{2} H_{2(g)} + \frac{1}{2} O_{2(g)} \rightarrow NaOH(1M)$ REI

$\Delta H_0^f = -470\ kJ/\phi$ SIERRA TRADING POST

$H_{2(g)} + \frac{1}{2} O_{2(g)} \rightarrow H_2O_{(l)} \quad \Delta H_0^f = 286$ pos. b/c it's reversed.

$Na_{(s)} + \frac{1}{2} H_{2(g)} + H_2O_{(l)} \rightarrow NaOH(1M) + H_2$

$Na_{(s)} + H_2O_{(l)} \rightarrow NaOH(1M) + \frac{1}{2} H_{2(g)} \quad +286 - 470 = -\_\_\ kJ/\phi$

How much energy is derived from oxidation of 1 Tbspn of glucose

Glucose $= C_6H_{12}O_6$ Tbspn = 25g

$CaO_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_2$

Egg demo (cooked the egg)

Heat Capacity $C_p = \frac{\Delta H}{\Delta t}$ at fixed pressure.

For $H_2O_{(l)}$, $C_p = \boxed{\frac{1\ \text{calorie}}{g \cdot K}}$

What is C_p for $1\ \phi\ H_2O_{(l)}$? $\left(1\ \text{calorie}/g \cdot K\right)\left(\frac{1\ \phi\ H_2O}{18\ g\ H_2O}\right)$

$= \boxed{\frac{18\ \text{calories}}{mol \cdot K}}$

C_p for 85 H_2O?

$\frac{18\ \text{calories}}{mol \cdot K}\left(\frac{4.8\ J}{1\ \text{calorie}}\right) = \boxed{75.2\ J/mol \cdot K}$

Heat of rxn measured by how much H_2O there is + how much it changes in temp.

Many things have heat capacity.

An atom can move in the x direction, y direction, & z direction. It can't rotate or stretch.
A water molecule can rotate, stretch, & move in 3 D. So there are more ways to take in energy.
Water has a larger heat capacity than Aluminum because water can take in a whole

$YBaCrO_{7-x}$

7-x does not obey laws of whole #s. But it's a solid, & solids don't have to.

This is a superconductor.

The little magnetic thing is hanging in the air.
This is the same thing as a maglift train (that never touches the ground)
When made cold enough, it couldn't touch the magnet.
The magnetic field is repelled by Meissner effect in the superconductor.

$CH_4 + O_2 \rightarrow CO_2 + 2H_2O$

Using Hess's Law, figure out ΔH

20 quadrillion $\frac{kCalories}{mol}$ World uses this

dU=q+W, Sample Prob

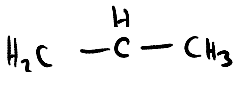
Thursday, November 02, 2006
9:04 AM

$\Delta U = q + W$

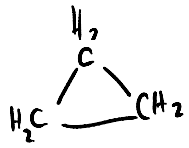
$H = U + PV$
$\Delta H = \Delta U + \Delta PV$
$\Delta H = q + W + \Delta(PV)$

<u>Condensed phase</u> $\Delta H = q$ Not the same when talking about systems that are pushed / pulled / expanded / contracted

52. ΔH is >, <, or = ΔU for the following reasons
$\Delta H = \Delta U + \Delta PV$
so figure out if there's a substantial PV
Complete combustion of 1 ⊕ Butanol.
Burning Butanol gives you CO_2 & H_2O b/c combustion.
Same # of mols at the end as beginning? No, because you have more mols (little molecules)
$\Delta U \neq \Delta H$



C_3H_6 Propene



but not the same molecule.

C_3H_6 Cyclopropane

Isomerization. No diff between ΔV & ΔH

Combustion of Glucose.
2 products, 2 gases (CO_2 + H_2O)
Diff # of gases in product & reactants (glucose is not a gas).
So $\Delta H \neq \Delta U$.

ΔU = change of internal energy.

$NH_4NO_{3(s)} \xrightarrow{\Delta} 2H_2O_{(l)} + N_2O_{(g)}$
This is World Trade Center 1993 explosion, & Oklahoma City Center explosion as well.

$CH_{4(g)}$ Standard state of methane.

$\Delta H_f^\circ = -50$ kJ/mol Forming Methane from <u>Carbon</u> + <u>Hydrogen</u>

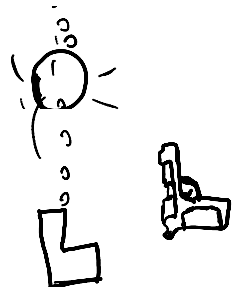
The rxn that this corresponds to is everything in its standard state.
$C_{(s)} + 2H_{(g)} \rightarrow CH_{4(g)}$

$C_{(s)}$ $H_{2(g)}$ $CH_{4(g)}$

[s] T = 298K graphite.

[g] P = 1atm T = 298K

[g] P = 1atm T = 298K



Now for Hess's Law,

$$2CH_4 \rightarrow C_2H_6 + H_2$$

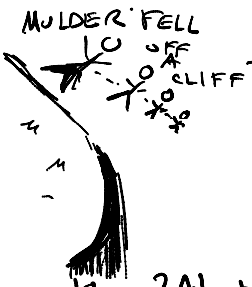
$H_2 \rightarrow H_2$ $\Delta H_f^\circ = 0$

X don't need this

$2C_{(s)} + 3H_{2(g)} \rightarrow C_2H_{6(g)}$ $\Delta H_f^\circ = -84.68$

$2[CH_4 \rightarrow C + 2H_2$ $\Delta H_f^\circ = 50.7]$

add them & get ΔH for system.



18. $2Al_{(s)} + Fe_2O_3 \rightarrow 2Fe + Al_2(O_2)_3$

852 kJ is liberated.

$q = \Delta H = -852$ kJ

$C_p = .85 J/g \cdot K$

$q = mC\Delta T$

$-852{,}000J = m(.85 J/g \cdot K)(\Delta T)$ ← finding this

$\frac{q}{m(.85 J/g \cdot K)} = \Delta T$

$\frac{852{,}000J}{(18kg)(.85 J/g \cdot K)} = \Delta T$

_____ $= \Delta T$

2 Mol Al

$2 \text{ Almol}\left(\frac{26.98g}{1 \text{ mol}}\right) =$ _____

M_T = Mass of Iron oxide + $M_{Aluminum}$

= 213 g + _____

They used to weld railroad tracks w/ this rxn

Almost all common explosives have Nitro groups

The weapon of choice is no longer nitrate

Acetateperoxide is now the weapon of choice.

This is why you aren't allowed to have liquids

$C_4H_{10(g)} \rightarrow 4CO_2 + 5H_2O + \frac{13}{2}O_2$ ΔH°

$\Delta PV = \Delta nRT$

Lab Prep

Friday, November 03, 2006
9:02 AM

This week, we write a design proposal for our lab. We work together w/ our lab partner to create a single proposal

1. Chem equations
2. Materials list
3. Construction plan (What will tell you that there's iron in your sample? How much?)
4. Testing procedures
5. Predicted results

We are not penalized for getting things wrong.

be able to go from undetectable up to where the color doesn't get any more intense, at which pt. you say it's at least X concentration, maybe more.

All of this is in the lab manual.
We will find the information from elsewhere, or it needs to be <u>cited</u>.

Test for iron in whatever you want. Fish. Tuna. Unknown sample.

<u>Supply List</u> Changes

You can ask for things if it's not on the list.

~~Digested soil samples, undigested soil samples~~

~~1,10 phenanthrolly~~

0.002 M $FeCl_3$

We're given iron III as a chemical.

Ferrozine does not react w/ iron III, and so we have to change the oxidation state of iron III in a redox rxn. Reduce iron III to iron II.

- Ascorbic acid
- UV light
- Hydrogen peroxide
- hydroxylamine

All else capable of reducing Iron III to iron II.

You cannot reduce iron III with hydrogen peroxide

It becomes water, and so it's reduced, not the iron III. $\overset{2+}{H}_2\overset{2-}{O}_2 \rightarrow \overset{\uparrow}{H}_2\overset{2-}{O}$

We will detect iron by eye, judging the color

During the lab, we will write the procedure we end up doing

; a little touch-CRAZY!

as bad as being super happy

Oh wahoo! wahoo!

She is
t
Not as
trigg

Particles/Waves

Monday, November 06, 2006
9:01 AM

Particles

$\vec{F} = m\vec{a}$

Trajectories

Waves

$$\frac{\partial^2 f}{\partial t^2} = c^2 \frac{\partial^2 f}{\partial x^2}$$

speed

partial derivatives gives you wavelike disturbances

propogating waves

$$\underbrace{f(x,t)}_{\text{amplitude}} = \cos\left(\frac{x}{a} - \omega t\right)$$

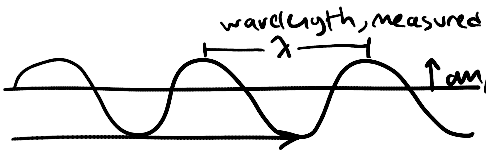
frequency / pitch

The less dense your medium is, the higher speed is.

Propogating waves vs. standing waves.

Changing the length of the pipe on an instrument changes the frequency.

I LIKE PI 3.14159265358979...



amplitude, A, depends on distance.

If the wave is moving, it has speed, c.

frequency, ν ← weird thingie. $(1/s)$

$$\boxed{c = \lambda \nu}$$

Sound travels faster in water than in air.

Light travels faster in air than in water.

WFMT 98.7 stands for 98.7 MHz. $1\,Hz = \frac{1}{sec}$

$\frac{(98.7E6)\text{ waves}}{sec}$ $\lambda = ?$

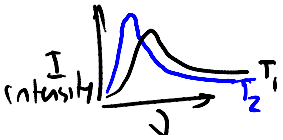
c in air = 3E8 m/s

$\lambda = \frac{c}{\nu} = \frac{3E8\ m/s}{(98.7E6)/sec} = 3.04\ m$ Pretty long wavelength (about 10 feet)

1900

Black Body Radiation

SCILLY



MULDER

PICARD

At a lower temp, it gives a larger maximum.

← Rayleigh & Jeans Law, but it's wrong. It doesn't go to infinity.

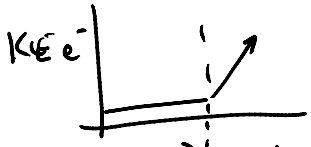
Ultraviolet catastrophe

is the curve that said you get infinite intensity.

Photoelectric effect

Start w/ metal, shine light on metal, & electrons come boiling off metal.

If you graph KE e^- vs ν of light:



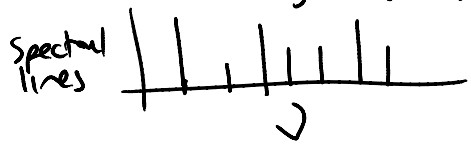
threshhold value, Φ where something starts happening

Above the threshold frequency, it just goes upward.

If you double the intensity of the light, you get the same KE, which was puzzling. KE e^- vs. ν is independent of Intensity.

Spectral lines

If you shine light on a material, or examine light coming off material, get function of light vs. ν.



only comes off at certain ν's.

What ppl observed was that you could fit ν's

$$\boxed{\nu = R\left(\frac{1}{m^2} - \frac{1}{n^2}\right)}$$ where m & n are integers.

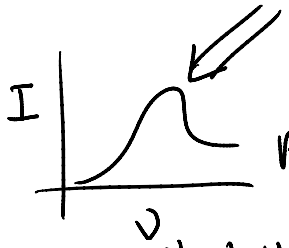
Balmer Rule

They could not figure out why some materials emmitted also some colors.

M. Planck

Relationship between frequency & energy. $E = h\nu$. h is a constant & it's 6.6E-24 J/s

h is really small.



Plot exactly explains blackbody radiation.

However, it introduced a new constant that no one knew about, & now energy is quantified. At certain frequencies, energy comes in chunks. There is no in-between.

<u>1905</u> Einstein

$E = h\nu$

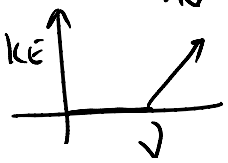
$E_{initial} = h\nu$

E_{final} of e^- = KE − Φ ← threshold

Energy is always conserved.

$h\nu = KE + \Phi$

$h\nu - \Phi = KE$



This was the 1st paper Einstein wrote.

Bohr Model for H

Tuesday, November 07, 2006
8:55 AM

$E = h\nu$

1911 - 1913
Rutherford
N. Bohr

$\frac{E}{h} = \nu = R\left\{\frac{1}{m^2} - \frac{1}{n^2}\right\}$
So there's still a puzzle

Bohr had to invent a new model.

Model for H (Bohr)

1. e^- is in stationary state
2. e^- move among these stationary states if perturbed
3. In these states, energy is quantized. Quantized means the states have an energy, & the energies are fixed.
4. $E_n = \frac{R_h}{n^2}$ where n is an integer & is a whol #. n is a quantum #. Describes orbits.

Bohr invented the idea of a quantum #.

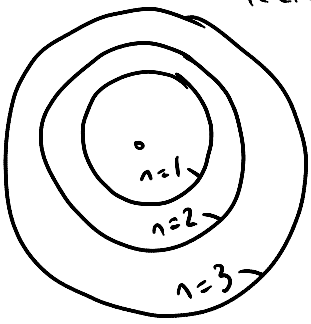
R_H Rydberg constant for H

$R_H = 1312$ kJ/mol

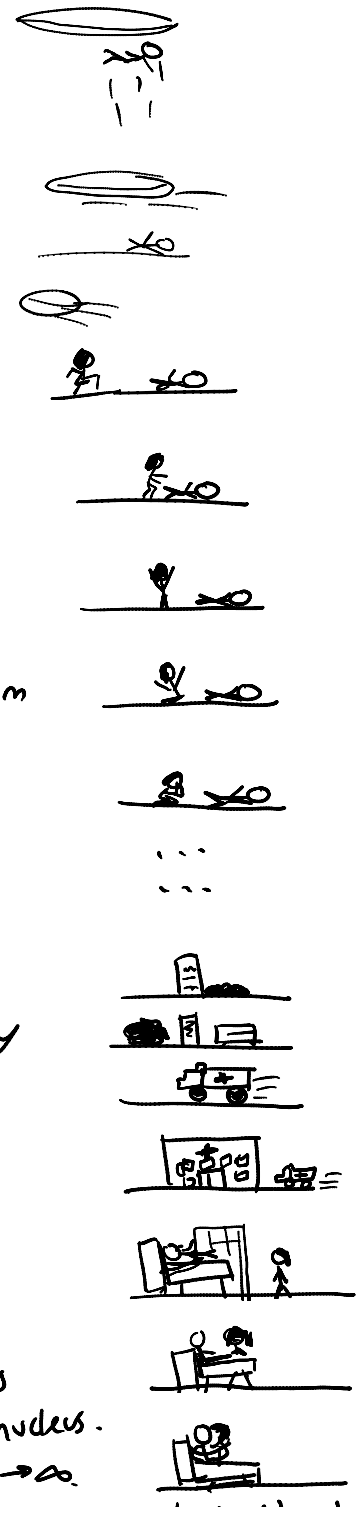
$= 2\pi^2 m e^4/h^2$

m: mass of e^-; e: charge

The electron is held onto nucleus by electrostatic forces, so charge matters

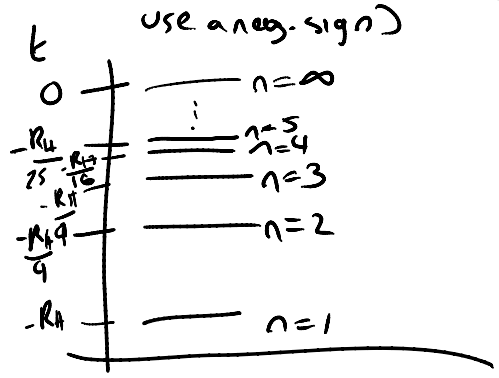


The electron in a H atom could be in any of these rungs.
Zero is when n^2 becomes infinity, so the electron is infinitely far away from nucleus.
$E_h = 0$ at $n \to \infty$, so $r \to \infty$.



The closer together the nucleus & electron is, it's more stable, energy goes down (that's why we use a neg. sign)

He's Alive!

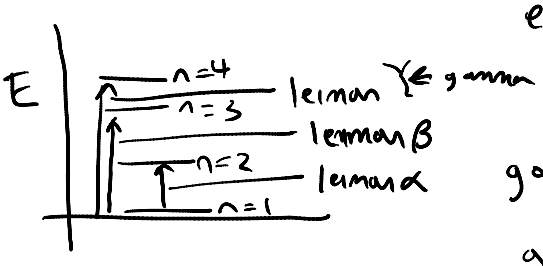


As you go further from nucleus, energies are smaller & smaller & smaller.

$$\Delta E = -R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$h\nu = -R_H\left(\frac{1}{m^2} - \frac{1}{n^2}\right)$$

Now it's reproduced as Balmer equation.



going from n=2 to n=3 is Balmer α

going from n=2 to n=4 is Balmer β

You can keep going until you run out of Greek letters. You can really go to infinity. It gets hard to measure then past 5 or 6.

Bohr explained one atom – Hydrogen.
No one could explain He b/c it has 2e⁻. Those e⁻ are negatively charged & they stay away from each other.

He^+ $1e^-$ $R = R_H \cdot Z^2$, Z being atomic #.
Li^{2+} $1e^-$ $R = R_H \cdot Z^2$
U^{+91} $1e^-$ $R = R_H \cdot Z^2$

<u>de Broglie</u> 1920

$E = h\nu$ $E = mc^2 = \underbrace{(mc)}_{\text{momentum}}c$

$h\nu = pc$

$\nu = \frac{c}{\lambda}$

$$\boxed{\begin{aligned} p &= \frac{h}{\lambda} \\ \lambda &= \frac{h}{p} \end{aligned}}$$

de Broglie relationships

particles & waves have properties of each other. If something has a it has a momentum.

wave, it has a momentum.

WAVE-PARTICLE DUALITY

Davisson / Germer

showed that electrons had waves.

This shows us that light is both a particle & a wave.

1925 E. Shrödinger $\frac{ih}{2\pi}\frac{\partial\psi}{\partial t} = \left[\frac{p^2}{2m} + V\right]\psi$

Shrödinger wave equation ↗ size & amplitude & how big something is. V is a potential energy $\frac{p^2}{2m} = \frac{1}{2}mv^2 = KE$

$$\frac{ih}{2\pi}\frac{\partial\psi}{\partial t} = [E]\psi$$

H Atom, energy is $-\frac{R_H}{n^2}$ where n is 1, 2, 3.

This is really important b/c it proves this model is useful.

In Bohr's case, we need 3 variables (latitude, longitude, & distance)

The only one that matters is distance.

When Shrödinger solved this equation, he deduced the energies & agreed w/ Bohr.

Another thing he did is say that Amplitude must depend on 3 #s (distance, latitude (θ), longitude (ϕ)).

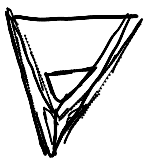
Bohr Model

Wednesday, November 08, 2006
8:56 AM

In the middle, all the weight of the atom is concentrated. It's the nucleus.

N. Bohr came up w/ spherical shell orbits for atomic model. Closest to the nucleus is $n=1$. Electrons sit in orbits, orbits have energies. Energy for Bohr model is $E = R\left(\frac{1}{m^2} - \frac{1}{n^2}\right)$
The problem was that it only works for the hydrogen atom, or atoms w/ 1 e^-.

E. Shrödinger wrote down the equation (see yesterday's notes) & solved it.



Ψ represents the Amplitude of a wave.

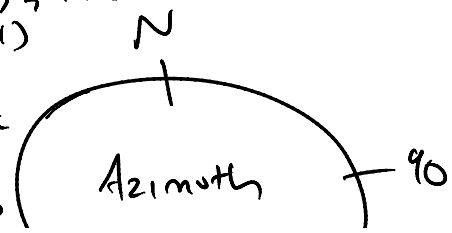
$\Psi(r, \theta, \phi)$ Polar Coordinates

In Bohr's theory, R matters. It is the only thing that really matters. They don't vary much w/ θ or ϕ. If motion is going to be quantized w/ 3 coordinates, there will be only 1 quantum #. Principle Quantum # for Bohr's model (only 1). Now 3 Principle Quantum #s, that index shapes.

$\Psi_{nlm}(r, \theta, \phi)$ tells you the address. E (energy) should depend on all 3 coordinates, but it doesn't b/c only force is Coulomb force, and so it only depends on the distance $E = -\frac{R_H}{n^2}$

<u>1926</u> Max Born
The intensity is $\propto$ to wave amplitude^2. Ψ^2
Probability of finding the electron in (r, θ, ϕ) is $\propto \Psi^2$.

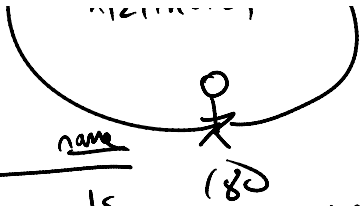
There are an infinite # of names that you can have, pretty much. But (r, θ, ϕ) have limited values.
n is Principle quantum #. 1, 2, 3, 4 . . .
L is 0, 1, 2 . . . $< n \ldots (n-1)$
Azimuth 0–360°
$m = [-l, -l+1, \ldots 0 \ldots l-1, l]$ magnetic



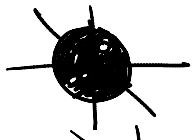
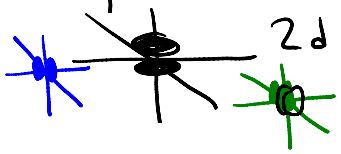
when $n \to \infty$, smaller than

when $n \to \infty$,
$E = 0$.
energy as $n \downarrow$ must be smaller n.
$m = \ell$

270



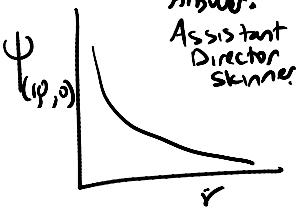
(80)

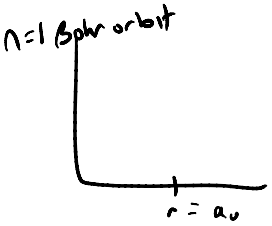
n	ℓ	m	energy (R_H)	sketch	name
1	0	0	-1		1s
2	0	0	$-\frac{1}{4}$		2s
2	1	$(-1,0,+1)$	$-\frac{1}{4}$		2d
3	0	0	$-\frac{1}{9}$		

WORD PROBLEM

If Mulder and Scully have 3 government conspiracies, and Cigarette Smoking Man has ∞ gov't conspiracies, and the Alien Bounty Hunter is after Scully, how many times will Mulder be shot?

Answer: Assistant Director Skinner





Sample Probs

Friday, November 10, 2006
9:03 AM

17. The combustion of hydrogen-oxygen mixtures is used to produce very high temps (approx. 2500°C) needed for welding.

$$H_{2(g)} + \frac{1}{2} O_{2(g)} \rightarrow H_2O_{(g)} \quad \Delta H^\circ = -241.8\ kJ.$$

What is the quantity of heat evolved in kJ when a 180g mixture containing equal parts of H_2 & O_2 by mass is burned?

$$q = \Delta H_f^\circ$$

Find limiting reagent

180g ($H_{2(g)}$ & $O_{2(g)}$) equal parts mean 90g H_2 & 90g O_2

$$90g\ O_2 \left(\frac{1\ mol\ O_2}{32\ g\ O_2}\right) = 2.81\ mol\ O_2 \leftarrow \text{limiting reagent}$$

$$90g\ H_2 \left(\frac{1\ mol\ O_2}{2\ g\ H_2}\right) = 45\ mol\ H_2$$

$$90g\ O_2 \left(\frac{1\ mol\ O_2}{32g\ O_2}\right)\left(\frac{-241.8\ kJ}{\frac{1}{2}\ mol\ O_2}\right) = 1.36E3\ kJ$$

69. $2Cl_{2(g)} + 2H_2O_{(l)} \rightarrow 4HCl_{(g)} + O_{2(g)} \quad \Delta H^\circ = ?$

$$\Delta H^\circ = \Sigma H^\circ_{products} - \Sigma H^\circ_{reactants}$$

$$\Delta H^\circ = 4H^\circ_{HCl} + H^\circ_{O_2} - (2H^\circ_{Cl_2} + 2H^\circ_{H_2O})$$

lookup H°

$$\Delta H^\circ = 4(-92.31\ kJ/mol) + \underset{\text{standard state}}{0} - (2(0) + 2(-285.8))$$

$$\Delta H^\circ = 202.4\ kJ$$

Pure elements $\Delta H_f^\circ = 0$.

53. Combustion of 2 propanol at 298.15 K, determined in bomb calorimeter is −33.41 kJ/g. For the combustion of 1 mol 2-propanol, determine ΔU & ΔH

2-propanol - $CH_3CH\,OH\,CH_3 + \frac{9}{2}O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$

~~$\Delta U = -33.41\ kJ/g$~~ $\Delta n = 3 - 4.5 = -1.5$ mol gas

$\Delta U = (-33.41\ kJ/g)\left(\frac{60.096\ g}{1\ mol\ propanol}\right)$

$= -2008\ kJ/mol$

$\Delta H = \Delta U - W = \Delta U - (P\Delta V) = \Delta U - (-nRT)$

$= \Delta U + \Delta nRT$

Plug & Chug

$= -2012\ kJ/mol$

Orbital Names

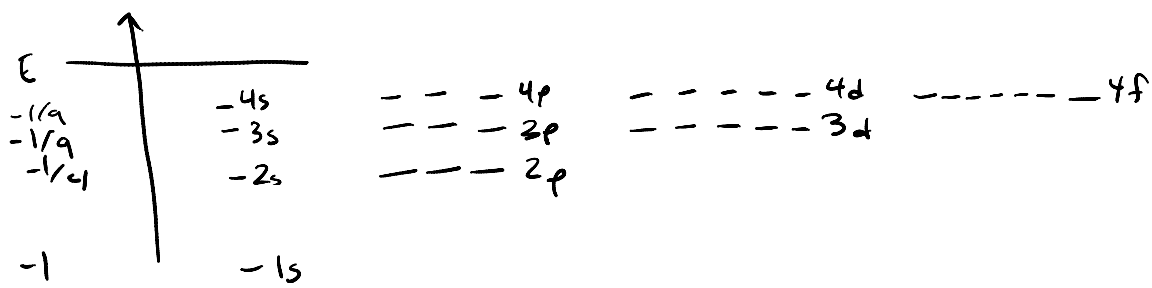
Monday, November 13, 2006
9:02 AM

ψ^2 is a probability

n	l	m	#	name	E/R_H
1	0	0	1	1s	-1
2	0	0		2s	$-1/4$
2	1	$-1,0,1$	3	2p	$-1/4$
3	0	0	1	3s	$-1/9$
3	1	$-1,0,1$	3	3p	$-1/9$
3	2	$-2,-1,0,1,2$	5	3d	$-1/9$

Orbital names

l	name
0	s
1	p
2	d
3	f



Graduate students in the Netherlands, 1921-22

e^- Spin has 2 values, m_s, $+\frac{1}{2}$ or $-\frac{1}{2}$

Upspin ↑ Downspin ↓

1925 Heisenberg

Uncertainty Principle

When you make a measurment of something, you slightly disturb the thing you're observing.

When you bounce light off of something, you change it.

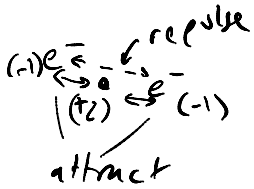
Heisenberg showed that $(\Delta x)(\Delta p) > \frac{h}{4\pi}$ uncertainty in position times uncertainty in momentum is greater than $\frac{h}{4\pi}$

$\Delta f = \sqrt{\overline{f} - \overline{f}^2}$ $\sqrt{\text{avg.}f - (\text{avg.}f)^2}$

Avg. velocity of a gas particle is 0, but avg. of square is never 0.

Heisenberg says, if you measure a particle, you can't get a correct measurement. $h = E^{-34}$, so it's really small. If you measure uncertainty in a hockey puck, it doesn't matter. But for an e^-, it matters.

<u>He</u>



MULDER!

Many-Body Problem

In order to solve for what e^- 1 is doing, you have to know what e^- 2 is doing.

We can't get an exact answer → just an avg.

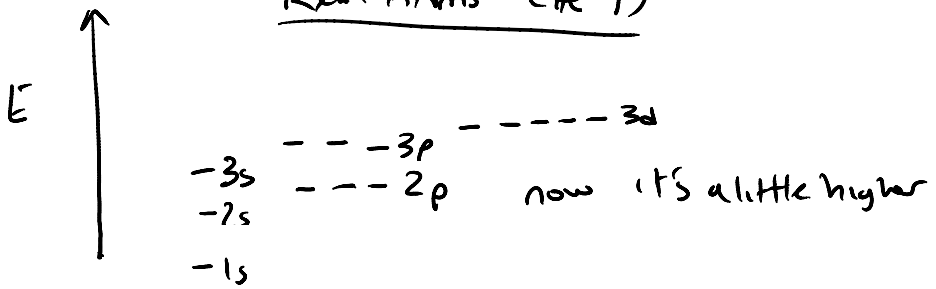
<u>Mean Field</u>

Each particle moves in avg. field of the other.

First you solve for 1, solve for the other, solve for the 1st, until it's done.

called <u>Central Field</u> sometimes

<u>Real Atoms (He ↑)</u>

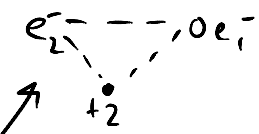


Energies are diff from atom to atom.

Electron Config

Tuesday, November 14, 2006
9:00 AM

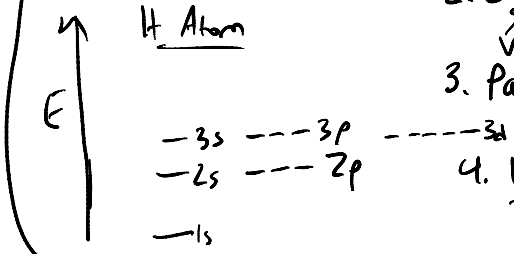
He



D. Hartree — Central field. 1931.

(his father's name was W. Hartree)

H Atom

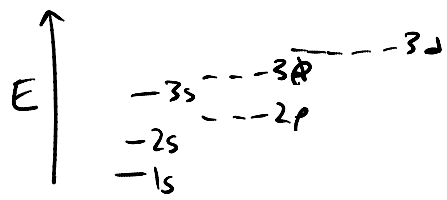


But when you go here this isn't true anymore

Tools

1. ψ^2_{nlm} → Probability of finding e^- at r.
2. Every system in nature wants to lower energy.
   ↗ Variation principle
3. Pauli Exclusion principle → no 2 e^- can have same 4 quantum #s
4. Hund's Rule - only pair if you must or maximize total spin up.

H	He
↑ e^-	↑↓
1s	1s

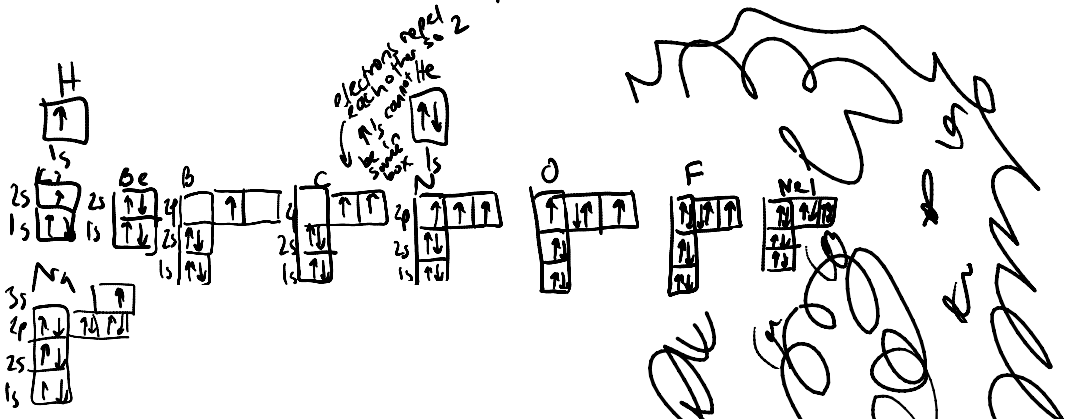


Configuration

H(1s) He($1s^2$)

Li($1s^2 2s$) $n=1, l=0, m=0, m_s=\uparrow$ $n=1, l=0, m=0, m_s=\downarrow$

To minimize the energy, it makes sense that it would go in 1s, but 1s only holds 2 e^-, so the other one is bumped up.



Configurations

Kenisha is random

The more nodes, the higher the energy. The nodes are the points at which shapes change.

H(1s) He($1s^2$)

Li($1s^2 2s$) Be($1s^2 2s^2$) B($1s^2 2s^2 2p$) C($1s^2 2s^2 2p^2$) I WANT X-FILES

N($1s^2 2s^2 2p^3$) O($1s^2 2s^2 2p^4$) F($1s^2 2s^2 2p^5$) Ne($1s^2 2s^2 2p^6$)

Both He & Ne have filled up a shell. $n=1$ & $n=2$.

Full shells & subshells are more stable.

Make the energy as low as you can.

Aufbau means "building up" the Periodic Table. You put the e^- in the boxes by these rules, & it tells you where the e^- are in the ground state atom.

The periodic table is built the way it is b/c of quantum mechanics

Na($1s^2 2s^2 2p^6 3s$) = Ne($3s$)

Li & Na are both alkali metals. They both make compounds w/ Cl. They both have 1s e^- outside a closed shell. These properties come from quantum mechanics.

DO NOT JUDGE MYSELF

Main Group Atoms

Wednesday, November 15, 2006
8:58 AM

$\lambda = 300\ E{-9}\ m$ $\qquad$ $c = \lambda \nu$

$E = h\nu$ $\qquad$ $\lambda = \frac{c}{\nu}$

$E = h\frac{c}{\lambda}$

$E =$ ____

# of nodes is related to principle quantum # & ℓ quantum #.

	nodes
2s	1
2p	1
3s	2
3p	2

Configurations of neutral atoms

<u>Main group atoms</u>

Yellow + orange (transition & rare earth elmts not included)

E ↑
- 4s - 4p - 4d
- 3s - 3p - 3d
- 2s - 2p
- 1s

1s
2s 2p
3s 3p 3d
4s 4p 4d 4f

Pneumonic thingie

This is the structure of the chart

1s (2)
2s (2)
2p (6)
3s (2)
3p (6)
4s (2)
3d (10)
4p (2)
4d (10)
4f (14)

Ne

Ar

Kr

Stable positions in the periodic table mean full shells & full subshells.

<u>Stable configurations</u> (valence e^-) → beyond the last rare gas.

H (1s) always we an e^- becomes H^+

gains an e^-, becomes H^-. $(1s^2)$ — only slightly stable, b/c of repulsion. only stable in solids.

He $(1s^2)$ totally stable.

Li $(1s^2 2s) = [He]2s$ — gains an e^-, Li^- $(1s^2 2s^2)$ more common.
gives up an e^-, Li^+ $(1s^2)$
Alkalides, not particularly stable. Kind of stable b/c of repulsion. Solide more stable than lithide. Solide have more protons, bigger orbital, so e^- farther apart. Less repulsion.

Be $(1s^2 2s^2)$ — Be^{++} or $1s^2 2s^2$ but no other states.

B $(1s^2 2s^2 2p)$ — Lose 1 e^-, B^+ $2s^2$
lose 3 e^-'s, B^{3+} $3s^2$

C $(1s^2 2s^2 2p^2)$ — Lose 4 e^-, C^{4+} $(1s^2)$
Lose 2 e^-, C^{2+} $(2s^2)$
Gain 4 e^-, C^{4-} $(2p^6)$ Normally doesn't do this unless solid state.

Stable oxidation states
Zero
Group #
(Group # − 2)
(Group # − 8)
For any given atom, stable states are 0
don't always exist

Element Lithium — Expect $\underbrace{\text{Lithium O}}_{\text{elmt}}$ & Li^+ Group 1
ex. Li_2O

Sr — $\underbrace{Sr}_{\text{elmt}}$ & Sr^{++} group 2
ex. SrO

Al — $\underbrace{Al}_{\text{elmt}}$ & Al^{+3} Group 3
ex. Al_2O_3

Si — $\underbrace{Si}_{\text{elmt}}$ & Si^{4+} Group 4
ex. SiO_2
Si^{2+} Group 4 − 2
Al — Al — Al^{3-} Group #

N	N (elmt)	N^{3-} Group # − 2 ? ex. HNO_3
Ga	Ga (elmt)	Ga^{+3}
O	O_2 (elmt)	O^{-2} Group # − 8
Se	Se (elmt)	Se^{-2} Group # − 8 ex. SeO_3 ex. H_2Se
Br	Br (elmt)	Br^{+7} ex. $HBrO_4$ ex. $HBrO_3$ ex. HBr

Group # −2 → Br^{+5}

Br^{-} ← Group # − 8

Using the rules, we can explain the stability of the atoms, oxidation states, & structure of periodic table.

Transition elmts

Ti	$Ti_{(s)}$ (elmt)	Ti^{+4} ex. TiO_2

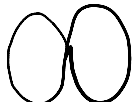
$\Delta E = h\nu$

starting/excited state goes to ground state. As we change atoms, diff ΔE's, diff colors.

Potassium = purple
Copper = green
Lithium = red
Calcium = orange
Sodium = yellow
Strontium = red

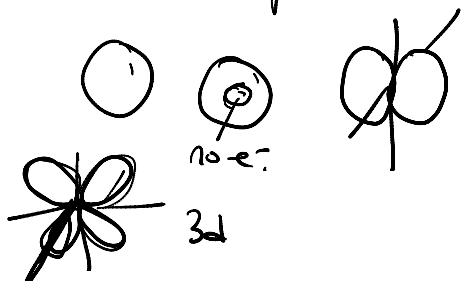
Mostly Random Doodles

Thursday, November 16, 2006
9:02 AM



2p

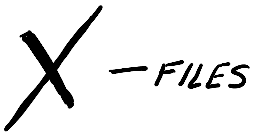
1s 2s 2p



208.4 kJ to remove 1 mol e⁻

$$\frac{208.4\,kJ}{1\ mol\ e^-}\left(\frac{1\ mole^-}{6.022E23\ e^-}\right) = \_\_\_\_$$

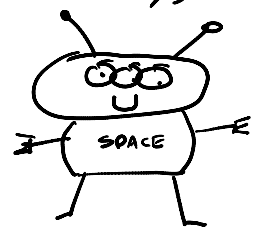
$$\lambda = \frac{h}{p}$$



Ionization Energy

Friday, November 17, 2006
9:01 AM

Funny Configurations, Sizes, Ionization energies, electron affinity & electronegativity.



high energy $V^*[Ar\ 4s^2 3d^3]$ V_2O_3, V_2O_5 V^{+5}

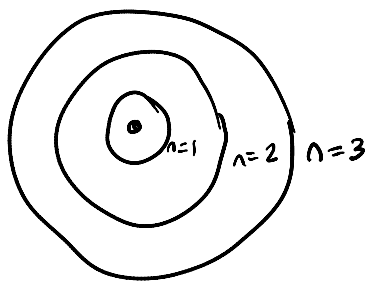
$Cr^*[Ar\ 4s^2 3d^4]$

Ground state $Cr[Ar\ 4s^1 3d^5]$ Lower energy b/c 3d is really close to 4s

$C[1s^2 2s^2 2p^2]$ CrO_3, Cr^{+6} toxic stuff

$C^*[1s^2 2s^1 2p^3]$ Bigger diff between 2s & 2p.

Sizes of atoms



The excited state is larger (n=3) than the ground state.

General rule about size is that as you go down periodic table, the sizes increase. This is b/c n gets bigger.

Atoms get bigger.
As you go across, → the sizes decrease.

Fr is the biggest atom, & He is the smallest.

To measure how big an atom is, you make a diatomic molecule w/ covalent bonding & you measure that distance & then half it.
To measure distance from nucleus to nucleus, fire x-rays & they scatter off

Na (+11) (10e⁻) + (1e⁻)

<u>Screening</u> – The outermost electron sees only part of the nuclear charge. Z effective = Z − screening
As Z, charge, goes up, effective Z goes up faster than screening.
As Z effective goes up, the atom scrunches in b/c the charge is greater.

nucleus, fire x-rays & they scatter off the nucleus.

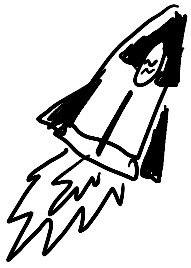
Cr Cr^+ Cr^{+2} Cr^{+3}

largest — smallest b/c it lost its electrons

K^- K K^+

biggest — smalest

Cations are smaller.
Anions are bigger.



<u>Ionization energy</u>

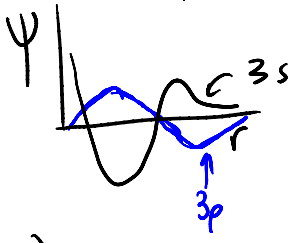
$A \rightarrow A^+ + e^-$ Ionization energy $= \Delta H^\circ$.
Measure how many e^- come off of A.

Valence electron is further from nucleus when it comes off, so IE ↓ as you move down the table, and this is b/c of bigger orbits

→ <u>increase</u> because it's harder to pull the e^- off as you go across (the size is getting smaller b/c the effective nuclear charge will go up)

<u>decrease</u> ↓

These are estimations, not rules b/c in Al for example, $1s^2 2s^2 2p^6 3s^2 3p$ & in Na, $1s^2 2s^2 2p^6 3s$



The closer to the nucleus the orbital is, the more attracted to the nucleus it is. $3s > 3p > 3d$ in penetrating the orbital. Penetrating effect is larger in 3s. So it's easier to pull an e^- off of a p than an s, & it's easier to pull it off Al or A than an Na.

	IE (kJ/mol)	
Na	495	↑
Mg	735	↓
Al	580	↑
Si	780	↑
P	1060	↑
S	1005	↓ this is a full shell
Cl	1255	↑
Ar	1527	

$A^+ \rightarrow A^{++} + e^-$ is the 2nd IE
It's bigger than the 1st

Ar 1527 It's bigger than the 1st

When you add an e^- instead of subtract an e^-, the IE will be much smaller. When you add one, you add it to a neutral.

Electron Affinity, Electronegativity

Monday, November 20, 2006
9:02 AM

Electron affinity

$A \rightarrow e^- + A^+$ Ionization energy
$A + e^- \rightarrow A^-$ electron affinity

It will be bigger for ionization energy than for electron affinity b/c of coulomb's Law. Here, it's attracted to a neutral center, so much smaller value.
Smaller ea's than ie's.

2nd ionization energies: $A^- + e^- \rightarrow A^{2-}$
<u>does not happen</u>

ΔH for $A + e^- \rightarrow A^-$ is ea. If ΔH is neg, it's exothermic & goes downhill. Energetically it would rather be A^- than A.

EA (kJ/mol)

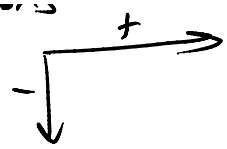
Na	Mg	Al	Si	P	S	Cl	Ar
-53	>0	-47	-134	-72	-200	-349	>0

goes to a fil shell which is why it's so big.

EA's should get bigger as you go across →.
EA's get smaller as you go down. ↓
The reason for the exceptions is b/c they have full shells or empty shells, etc.
Small #s are susceptible to fluctuations more than big #s are

<u>Electronegativity</u>
Electron affinity can be precisely measured. For IE's you shine light on them until an electron comes off & $h\nu$ is EA.

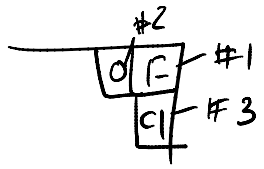
Electronegativity is ability of an atom in a molecule to attract electrons



They get more electronegative as they go across, & they get smaller as they go down b/c their shells are further out.

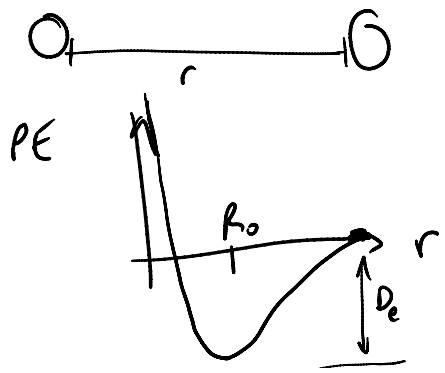
Most electronegative elmt is F. Least electronegative elmt is Fr.

L. Pauli invented electronegativity & came up w/ a scale.
Mulligan came up w/ another scale.
And yet another scale was invented later, which is most accurate



Most electronegative elmts.
ClF ← Chlorine Fluoride
FCl ← Doesn't exist.
Cl_2O ← Chlorine Oxide

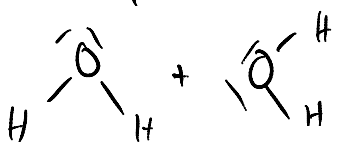
<u>bonding</u>



R_0 is equilib distance
D_e is dissociation energy
$D_e = \Delta U$

AB at $r = R_0$ → A + B
then $\Delta U = D_e$

Covalent bond
this happens b/c 2 electrons pair, & it's very hard to break apart.



→ $(H_2O)_2$

hydrogen bonding

If the hydrogen bond is weaker, De is smaller.

Small R_0 implies big De

If you brought 2 Ar together, one being a liquid & one being another state (gas) you get van der Waals forces. Molecular

stickiness. Very, very small strength.
Hydrophobic interactions is a fancy way of saying that like dissolves like. Things are afraid of water

As $n \uparrow$, # of nodes $\uparrow$ Only the s's are finite at the nucleus. p's, d's, & f's are not.

catalyst = vanadiums & irons V, Fe

$N_2 + 3H_2 \rightarrow 2NH_3$ This is what we breathe & this is what's in our protein.

The Germans ran out of gunpowder in 1916. F. Haber became a war hero in Germany b/c he found a catalyst. Same process added to oxygen makes gunpowder.
Society could use NH_3 literally for guns or butter.