Illustrated Guide to Chemistry

By: Jeff Grant

Matter

Significant Figures

The digits that make up a measurement and show the degree of accuracy.

M. Gandhi

"If we want to reach real peace in this world, we should start educating children."

Counting "Sig Figs"

1. All non zero #s are significant
2. Any # between two sig figs are significant
3. Final zeros only count in the decimal portion

Adding or Subtracting

- Use the smallest # of after decimal sig figs

1.0125

23.24

+ 101.1 ←★

125.3

Multiplying or Dividing

- Use the smallest # of sig figs

18.3 × 1.0245 × 13

★ Answer should have 2 sig figs

240

Ex: If a decimal is absent, start counting from the Atlantic

154100 — 120130

4 sig figs — 5 sig figs

If a decimal is present, start counting from the Pacific

1541.00 — 0.0124

6 sig figs — 3 sig figs

★ Don't start counting zeros as significant until you hit a nonzero #.

Accuracy vs. Precision

• Determined by how close you are to the target	• Determined by how close 2 or more #s are to each other

Goal: Put an X by the Great Lakes

X_2 Group is precise, but far from accurate

X_1 Group is accurate, but needs to work on precision.

THE MAKEUP OF THE UNIVERSE

DARK MATTER & DARK ENERGY

HYPOTHETICAL ENERGY & MATTER THAT MAKES UP ALL OF THE UNIVERSE THAT WE CAN ONLY DETECT THROUGH ITS GRAVITATIONAL EFFECTS.

★ SCIENTISTS BELIEVE IT MAKES UP MOST OF OUR UNIVERSE

MATTER

THE STUFF OF ALL THINGS

- HAS MASS

ENERGY

WHAT THINGS RUN ON

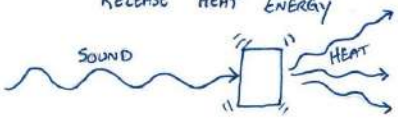
IT COMES IN A WIDE VARIETY

EXAMPLES:

★ GENERAL
- LIGHT - RADIANT ENERGY - VISABLE TO GAMMA
- HEAT - THERMAL ENERGY - RELATED TO TEMPERATURE
- KINETIC - ENERGY OF MOVEMENT

ALL ENERGY CAN BE INTERCHANGED

SOUND ENERGY CAN HIT A MATERIAL CAUSE THE SUBSTANCE TO VIBRATE AND THEN THE SUBSTANCE CAN RELEASE HEAT ENERGY



ATOMS MAKE UP

ELEMENT

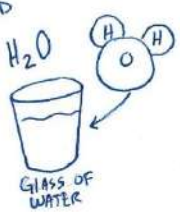
JUST ONE TYPE OF ATOM, BUT LOTS OF THEM TOGETHER

COMPOUNDS

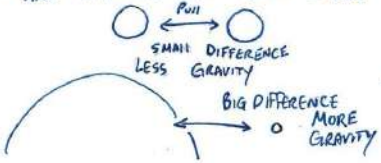
2 OR MORE ATOMS JOINED TOGETHER CHEMICALLY BY A BOND

WATER H_2O

DIHYDROGEN MONOXIDE

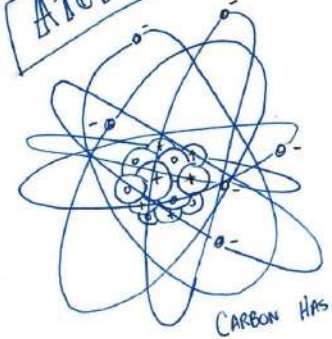


GRAVITY - THINGS WITH MASS ARE ATTRACTED TO EACH OTHER



Organization of Matter

Atom

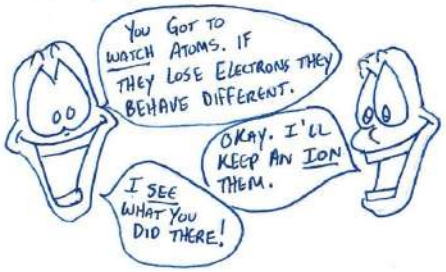


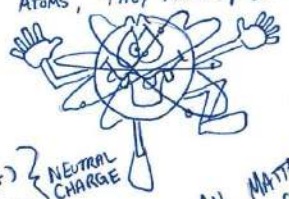
Carbon has 6 Protons (+) } Neutral Charge
6 Electrons (-)
6 Neutrons (0)

Nucleus = Center of Atom
Contains Protons (+) Charge
Neutrons (0) Charge

Electron Cloud = Spins Around outside of the Atom
Contains the Electrons (-) Charge

★ The makeup of an Atom's Protons, Neutrons & Electrons determine its properties





All Matter can be classified as

OR

Pure Substance

Only one type of material in the substance

- Can be a Compound or just an Element

Mixture

Two or more substances together physically, not chemically

Heterogenous

Parts are not uniformly distributed

- Easier to seperate parts

General
- Very Easy to seperate the parts
- Pizza

Suspension
- Will seperate upon standing
- Oil & Vinegar salad dressing

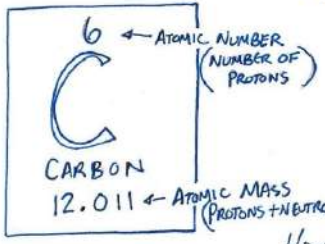
Homogenous

Parts are uniformly distributed

Positive Tyndall Effect - Scatter Light

Colloid
- Won't seperate but parts are visable under a magnifying glass
- Milk, Fog

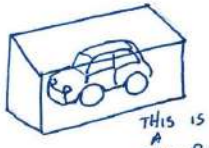
Solution
- Parts are very fine
- Can't see them
- Sugar water



THE ATOM

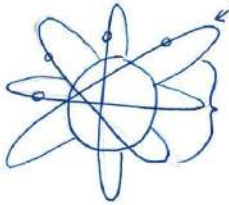
THE BUILDING BLOCK OF MATTER

6
C
CARBON
12.011



THIS IS A CAR BIN

YOU CHANGE THE ELEMENT



ELECTRON CLOUD
ELECTRONS SPINNING AROUND THE NUCLEUS

NUCLEUS
CONTAINS PROTONS & NEUTRONS = MASS OF THE ATOM

CHANGE THE # OF PROTONS

4
Be
9
4 PROTONS
4 ELECTRONS
5 NEUTRONS

4 ← ATOMIC #
TELLS YOU HOW MANY PROTONS THE ATOM HAS

Be
BERYLLIUM
9.0122 ← AVERAGE ATOMIC MASS
HOW HEAVY THE ATOM IS.
PROTONS + NEUTRONS

ISOTOPES = CHANGE THE # OF NEUTRONS

4
Be
10
4 PROTONS
4 ELECTRONS
6 NEUTRONS

MASS BY SUBATOMIC PARTICLE

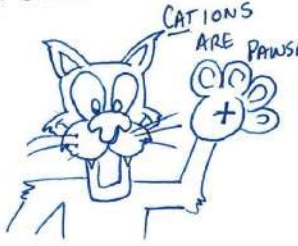
PROTON 1amu
NEUTRON 1amu
ELECTRON 0amu

CHANGE THE # OF ELECTRONS

ION = CHARGED ATOMS

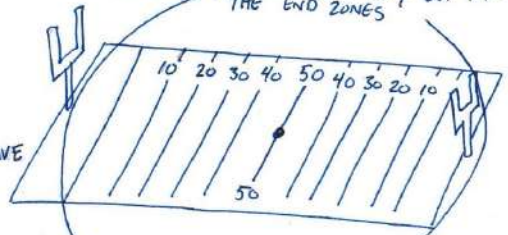
ANION
EXTRA ELECTRONS
NEGATIVE CHARGE
(−)

CATION
LESS ELECTRONS
POSITIVE CHARGE
(+)



CATIONS ARE PAWSATIVE

IF WE ENLARGED AN ATOM AND THE NUCLEUS WAS A SOFTBALL PLACED ON THE 50 YD LINE OF A FOOTBALL FIELD, THE ELECTRONS WOULD SPIN ALL THE WAY OUT AT THE END ZONES



☆ MOST OF AN ATOM IS EMPTY SPACE

PHYSICAL VS. CHEMICAL

PROPERTIES

PHYSICAL PROPERTIES

★ CAN BE OBSERVED WITHOUT CHANGING IT

- COLOR OF THE SUBSTANCE
- MOLECULAR MASS
- VOLUME
- STATE OF MATTER
- MELTING POINT
- BOILING POINT
- DENSITY

CHEMICAL PROPERTIES

★ CAN BE OBSERVED ONLY THROUGH CHANGING ITS COMPOSITION

- CAN IT BURN?
- DOES IT REACT WITH OTHER SUBSTANCES?

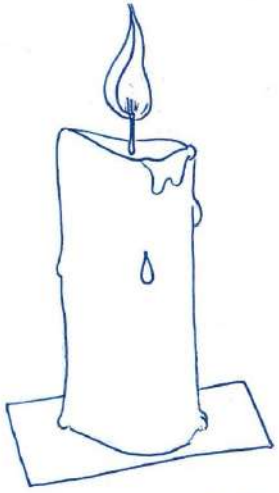
$$\text{DENSITY} = \frac{\text{MASS}}{\text{VOLUME}}$$

THE AMOUNT OF ATOMS CRAMMED INTO A SPACE.

- EVERY SUBSTANCE HAS ITS OWN DENSITY
- BUT A SUBSTANCE'S DENSITY CAN CHANGE WITH TEMPERATURE, PRESSURE, ETC.

@ ROOM TEMP

WATER = $\frac{1g}{cm^3}$ SILICON = $\frac{2.3g}{cm^3}$



A CANDLE BURNING HAS EVIDENCE OF CHEMICAL & PHYSICAL CHANGE

- THE ACTUAL BURNING OF THE WAX IS CHEMICAL

$C_{25}H_{52}$ + $38O_2$ → $25CO_2$ + $26H_2O$
WAX + OXYGEN → CARBON DIOXIDE + WATER

- THE MELTING OF THE WAX FROM SOLID TO DRIPPY LIQUID IS PHYSICAL

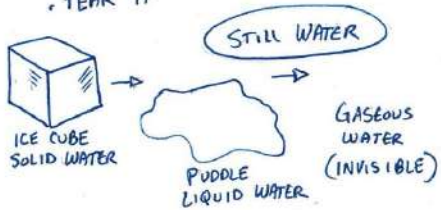
→ AND THIS IS A Silly CON →

CHANGE

PHYSICAL CHANGE

★ A CHANGE OF THE PHYSICAL STATE OF MATTER BUT NOT THE MAKEUP.

- CHANGE THE SHAPE
- MELT IT
- TEAR IT



CHEMICAL CHANGE

★ SUBSTANCES COMBINE TOGETHER & A NEW SUBSTANCE IS FORMED

HYDROGEN GAS + OXYGEN GAS → WATER H_2O

FACTOR LABEL CONVERSIONS

PURPOSE: WE MUST HAVE MATERIALS IN PROPER UNITS IN ORDER TO MAKE COMPARISONS.

SOLVE IS A CAR DRIVING FAST IF IT IS GOING 12,152 mm PER MINUTE? → GET IT INTO mph AND YOU CAN ANSWER MILES/HOUR

1 Km = 0.621 MILE

1000 mm = 1 Km

$$\left\{\frac{12{,}152\text{mm}}{1\text{ min}} \;\middle|\; \frac{1\text{ Km}}{1{,}000\text{mm}} \;\middle|\; \frac{0.621\text{ MILE}}{1\text{ Km}} \;\middle|\; \frac{60\text{ min}}{1\text{ hour}}\right\} = \frac{452{,}783.52}{1{,}000} = \frac{452.78\text{ miles}}{1\text{ Hour}}$$

- WHAT THE PROBLEM GAVE US
- CONVERTS mm INTO Km
- CONVERTS Km INTO MILES
- CONVERTS MIN INTO HOURS

★ ANSWER HAS 5 SIG FIGS. BECAUSE THE STARTING # HAD 5 (12,152 mm)

CONSIDERING THE SPEED OF SOUND IS 767 mph, YEAH THAT IS FAST

RAILROAD TRACKS

1. FIRST SPOT RESERVED FOR WHAT THE PROBLEM GIVES YOU
2. KEEP UNITS IN EACH BLOCK
3. UNITS MUST CANCEL OUT DIAGONALLY

   EX: 1 (BOX) | 1 CARTON / 3 (BOX)
4. MULTIPLY ALL NUMBERS ACROSS THE TOP
5. MULTIPLY ALL NUMBERS ACROSS THE BOTTOM
6. DIVIDE TOP BY BOTTOM

EX: IF IT TAKES 6 EGGS (b) TO MAKE A CAKE. HOW MANY DOZEN DOES IT TAKE TO MAKE 63 CAKES? (a)

63 CAKES (a)	6 EGGS	1 DOZEN → 378
	(b)	→ 12
	1 CAKE	12 EGGS

32 DOZEN

★ 2 SIG FIGS

JUST MAKE SURE UNITS CANCEL OUT DIAGONALLY!

EGGSACTLY! GET IT?! NICE YOLK! DID IT CRACK YOU UP? SHELL I CONTINUE?

Naming and Forming

Chemical Formula

The composition of a compound noting the amount of atoms per element

% Composition of sugar in your gum

$$\frac{(\text{Gum mass before} - \text{After})}{\text{Gum mass before}} \times 100$$

*Sugar dissolves & you swallow it

$C_6H_{12}O_6$

Six atoms of carbon	$6 \times 12.0107 = 72.0642$	180.156 g/1 mole
Twelve atoms of hydrogen	$12 \times 1.00794 = 12.09528$	
Six atoms of oxygen	$6 \times 15.9994 = 95.9964$	

Mole mass

% Composition

The amount of mass taken up by an element in a compound.

Ex: What is the % comp of carbon in glucose $C_6H_{12}O_6$?

$$\% \text{ Composition} = \frac{\text{Part}}{\text{Whole}} \times 100$$

$$\frac{\text{Mass of Carbon } 72.0642\text{g}}{\text{Mass of the whole Compound } 180.156\text{g}} \times 100 = 40\% \text{ Carbon}$$

Change the # of just one element & you change the compound

H_2O = 🙂

H_2O_2 = 😵

Empirical Formula

is the simplist ratio of atoms per element in a compound

$C_6H_{12}O_6 = CH_2O$

Ex: If you know a compound has 48.38% C 8.12% H and 53.5% O, what is the Empirical Formula?

* Turn the % into grams, so 48.38% = 48.38g
* Turn it into moles

$$\frac{48.38\text{g C}}{12.0107\text{g}} = 4.03 \quad \frac{8.12\text{g H}}{1.00794} = 8.06 \quad \frac{53.5\text{g O}}{15.994} = 3.35$$

* Use the smallest to determine ratio

$C\ 4.03/3.35\ H\ 8.06/3.35\ O\ 3.35/3.35 = C_{1.2}H_{2.4}O_1$

* Use a multiplier to get rid of decimals

$5 \times (C_{1.2}H_{2.4}O_1) = \boxed{C_6H_{12}O_5}$

Naming & Forming Compounds

BASIC

Ionic Compounds (Metals with Nonmetals)

- Cation Goes First, Anion Second

NaCl

Sodium — Chlor(ine) → Sodium Chloride

*ine turns to ide

Magnesium Chloride

You should be able to figure out based on the column on the periodic table

Mg → Mg^{+2}

Cl → Cl^{-1}

$Mg^{+2}Cl^{-1}_2$

$MgCl_2$

Ionic Compounds

- You must use the ionic charge the element tends to form

★ Criss Cross ★

- Criss cross the number associated with the charge (don't move the + or -)
- If you can reduce, reduce

$Ca^{+2}O^{-2}$ → Ca_2O_2 → CaO

Molecular Compounds (Nonmetals with Nonmetals)

- The # of each element matters when you name the compound

CF_4

One carbon — 4 Flourine

Carbon tetraflouride

*If the first element only has one atom you don't need to put mono

Use the following

1 = Mono
2 = Di
3 = Tri
4 = Tetra
5 = Penta
6 = Hexa
7 = Hepta
8 = Octa
9 = Nona
10 = Deca

Dihydrogen Monoxide

H_2O

Caution

Product is known to contain Dihydrogen Monoxide. Over consumption can lead to frequent bathroom visits & the possibility of drowning.

Naming & Forming Compounds Continued

Poly Atomic Ions

2 or more atoms that have one overall charge

Hydroxide = OH^{-1}

Phosphate = PO_4^{-3}

Ammonium = NH_4^{+1}

* When naming & forming using polyatomics it follows the same idea as ionic compounds but you must keep the polyatomic together

Ex.

Calcium Hydroxide

Ca^{+2} OH^{-1}

Brackets keep the polyatomic together

$Ca(OH)_2$

Combo

Tin (IV) phosphate

Sn^{+4} PO_4^{-3}

$Sn_3(PO_4)_4$

Transition Metals

These metals tend to have more than one type of ion

Iron (II) Fe^{+2}

Iron (III) Fe^{+3}

* Roman numerals tell you the charge of the ion

Iron (II) oxide

Fe^{+2} O^{-2}

FeO

When naming reverse your criss cross

$CuCl_2$ → You know chloride is -1 so two Cl^{-1} balance the one copper therefore it must be +2

Copper (II) chloride

PolyAtomic
Charges & Formation
- Oxygen Focus -

- If the ion has an **ide** ending it is just that element

Cl^{-1} = Chloride

- **ate** suffix used for the most common oxy anion
- **ite** suffix used for one less oxygen than the ate.
- **Hypo** prefix with **ite** suffix is one less than ite

Gang of 4
All 4 touch in a block on the periodic table

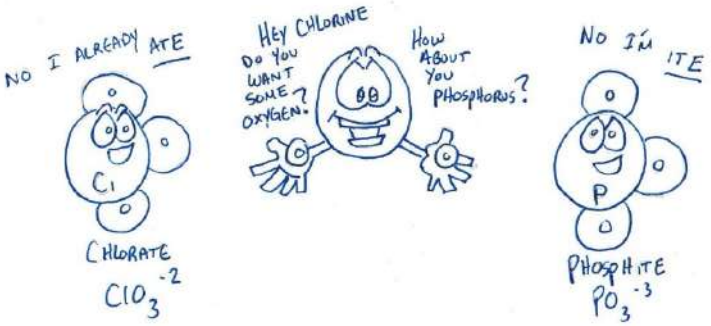
P	S
As	Se

Sulfur, Phosphorus, Arsenic, Selenium
use 4 oxygens as common

Sulfate	Phosphate	Arsenate	Selenate
SO_4^{-2}	PO_4^{-3}	AsO_4^{-3}	SeO_4^{-2}

Chlorine Carbon Nitrogen Silicon Bromine Iodine
use 3 oxygens as common

Chlorate	Carbonate	Nitrate	Silicate	Bromate	Iodate
ClO_3^{-1}	CO_3^{-2}	NO_3^{-1}	SiO_3^{-2}	BrO_3^{-1}	IO_3^{-1}



Chlorate ClO_3^{-2}

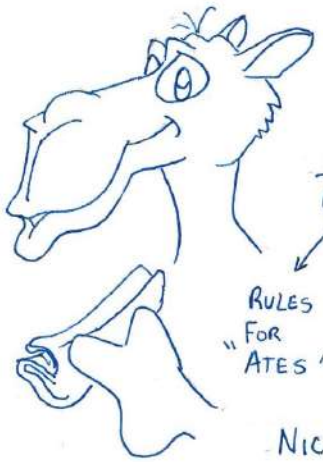
Phosphite PO_3^{-3}

- Charges don't change for the poly atomic ion as you add or subtract oxygen

NO_3^{-1}	NO_2^{-1}	NO^{-1}
Nitrate	Nitrite	Hyponitrite

POLYATOMIC

NAMING & FORMING



NICK THE CAMEL AND ED THE CLAM (ATE) A SUPPER OF CREPES IN PHOENIX.

RULES "FOR "ATES"

a. CONSONANTS = ATOMS OF OXYGEN
b. VOWELS = CHARGE
C. WORD GIVES A HINT TO THE NAME OF THE POLYATOMIC

	a.	b.	C.	
NICK =	3 OXYGEN	-1	NITRATE =	NO_3^{-1}
CAMEL =	3 OXYGEN	-2	CARBONATE =	CO_3^{-2}
CLAM =	3 OXYGEN	-1	CHLORATE =	ClO_3^{-1}
SUPPER =	4 OXYGEN	-2	SULFATE	SO_4^{-2}
CREPES =	4 OXYGEN	-2	CROMATE	CrO_4^{-2}
PHOENIX =	4 OXYGEN	-3	PHOSPHATE	PO_4^{-3}

ALL HALOGEN "ATES" WILL HAVE THE SAME PATTERN AS CHLORATE

EX: BROMATE BrO_3^{-1}

IODATE IO_3^{-1}

☆ REMEMBER "ITES" JUST HAVE ONE LESS OXYGEN BUT HOLD THE SAME CHARGE

☆ "HYPO" "ITES" HAVE ONE LESS THAN THE "ITES", BUT STILL HAVE THE SAME CHARGE

The Mole

THE MOLE

IS A WAY TO COUNT THINGS.

THINK OF IT LIKE COUNTING USING DOZENS. 36 DONUTS = 3 DOZEN

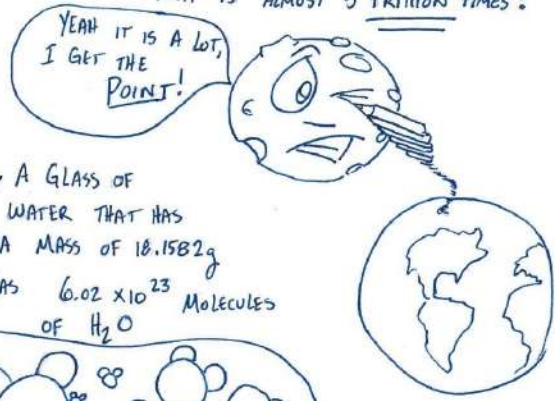
THE MOLE (mol) IS 6.022×10^{23} THINGS. THIS IS A HUGE NUMBER THAT IS USED TO COUNT SMALL THINGS.

AVOGADRO'S NUMBER

1 MILE IS 63,360 INCHES
OR
253,440 PENCILS

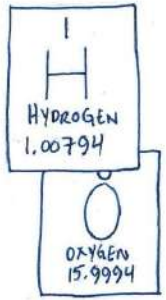
IT IS 238,900 MILES TO THE MOON

BASED ON THIS, 1 MOLE OF PENCILS STACKED ON TOP OF EACH OTHER WOULD GO TO THE MOON AND BACK 4,970,000,000,000 THAT IS ALMOST 5 TRILLION TIMES!



HERE IS THE BEAUTY OF THE MOLE

- YOU CAN ASSUME THE AMU OF AN ELEMENT IS ITS GENERAL MASS (grams) PER MOLE OF IT.



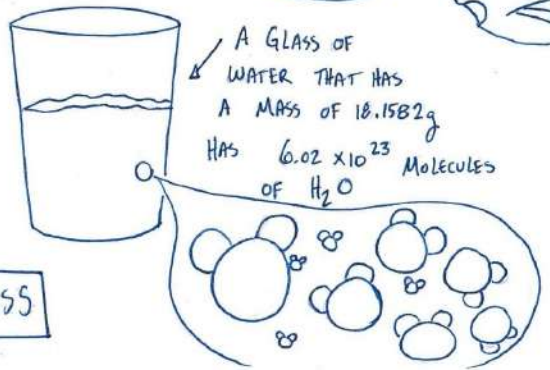
H_2O
WATER

$1.00794 \times 2 = 2.1588$
$15.9994 \times 1 = 15.9994$

18.1582

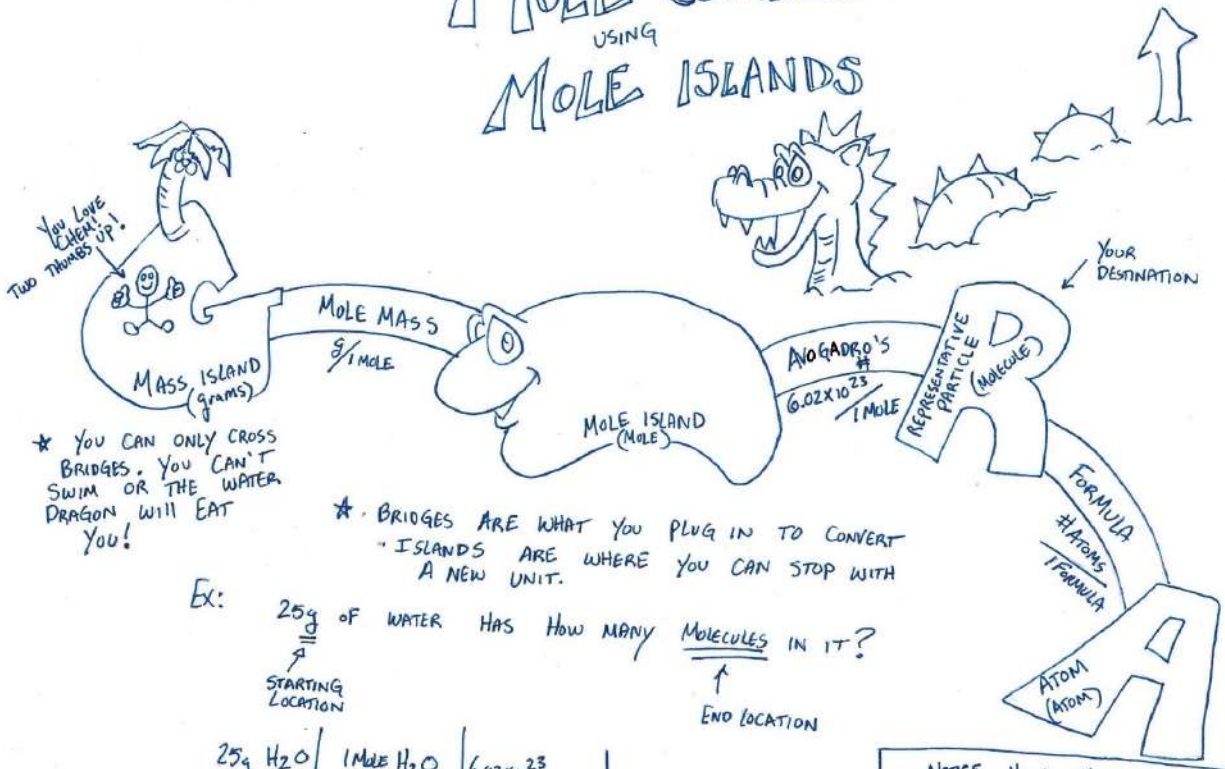
SO ONE MOLE OF WATER HAS A MASS OF 18.1582 g

WE CALL THIS THE **MOLE MASS**



A GLASS OF WATER THAT HAS A MASS OF 18.1582g HAS 6.02×10^{23} MOLECULES OF H_2O

MOLE CONVERSIONS USING MOLE ISLANDS



* YOU CAN ONLY CROSS BRIDGES. YOU CAN'T SWIM OR THE WATER DRAGON WILL EAT YOU!

* BRIDGES ARE WHAT YOU PLUG IN TO CONVERT
* ISLANDS ARE WHERE YOU CAN STOP WITH A NEW UNIT.

Ex: 25g of WATER HAS How MANY MOLECULES IN IT?

25g = STARTING LOCATION

MOLECULES = END LOCATION

$$\frac{25\text{ g } H_2O}{} \times \frac{1\text{ Mole } H_2O}{18.01528\text{ g}} \times \frac{6.02\times10^{23}\text{ Molecules}}{1\text{ Mole } H_2O} = 8.4\times10^{23}\text{ Molecules}$$

ENTER BRIDGE INFO SO UNITS CANCEL OUT →

BRIDGE 1: MOLE MASS BRIDGE

BRIDGE 2: AVAGADRO'S BRIDGE

NOTICE HOW THE UNITS ARE ALWAYS DIAGONAL FROM EACH OTHER

Ex: $\frac{1\text{ APPLE}}{2\text{ APPLES}} \times \frac{10\text{ ORANGE}}{1\text{ ORANGE}} \times \frac{22\text{ CENTS}}{}$ ← CANCEL OUT SINCE CENTS CAN'T BE YOUR FINAL UNIT

1 APPLE = 11 CENTS

STOICHIOMETRY

IS THE CALCULATIONS OF REACTANTS & PRODUCTS IN A CHEMICAL REACTION – BASED ON THE LAW OF CONSERVATION OF MATTER

CONSERVATION OF MATTER
YOU CANNOT CREATE OR DESTROY MATTER, ONLY REARRANGE IT.

LETS SAY YOU RUN A BURGER JOINT. IN ORDER TO OPTIMIZE PROFITS YOU MUST MAKE SURE YOU KNOW STOICH.

SCRABBY BURGER FORMULA

2 BREAD + 1 CHEESE + 3 PICKLES + 1 BURGER SLICE
2 TOMATO + 4 LETTUCE → 1 SCRABBY BURGER

MR. SHRIMP

LOOKS IN THE STOCK ROOM TO SEE HOW MANY BURGERS HE CAN MAKE

STOCK ROOM

- 505 PICKLES
- 350 CHEESE SLICES
- 200 PIECES OF LETTUCE
- 200 BREAD SLICES
- 300 TOMATOES
- 200 BURGER SLICES

OUR BALANCED EQUATION TELLS US WE CAN ONLY MAKE 50 SCRABBY BURGERS

BECAUSE 4 LETTUCE ARE REQUIRED FOR EACH ONE!

$$H_2 + O_2 \longrightarrow H_2O$$

HYDROGEN GAS + OXYGEN GAS → WATER

2 ATOMS OF HYDROGEN REACT WITH 2 ATOMS OF OXYGEN TO YIELD 2 ATOMS OF HYDROGEN COMBINED WITH 1 ATOM OF OXYGEN?!

VIOLATION!

AN ATOM OF OXYGEN WAS DESTROYED?!

HOW DO WE FIX IT?

- WITH COEFFICIENTS
- DO AN INVENTORY

$$H_2 + O_2 \longrightarrow H_2O$$

H = 2 | O = 2 → H = 2 | O = 1

* ADDING COEFFICIENTS MULTIPLIES THE WHOLE MOLECULE

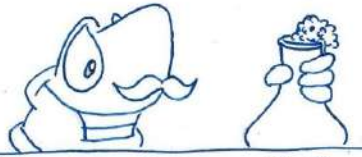
$$2H_2 + O_2 \longrightarrow 2H_2O$$

H = 4 | O = 2 → H = 4 | O = 2

CORRECT!

BALANCED EQUATION

2 HYDROGEN MOLECULES + 1 OXYGEN MOLECULE → 2 WATER MOLECULES



MOLE PRACTICE

IF YOU ARE GIVEN 31.2g OF GLUCOSE & 16.0g OF OXYGEN CALCULATE HOW MUCH CARBON DIOXIDE WOULD BE PRODUCED?

① WRITE OUT THE REACTION & BALANCE IT.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

② USING MOLE RATIO SEE HOW MUCH CO_2 YOU WOULD MAKE WITH THE GLUCOSE.

31.2g Glucose	1 Mole Glucose	6 Moles CO_2	44.01g CO_2	45.7g CO_2
	180.16g Glucose	1 Mole Glucose	1 Mole CO_2	
	Mole Mass	Mole Ratio	Mole Mass	

③ USING MOLE RATIO SEE HOW MUCH CO_2 YOU WOULD MAKE WITH THE OXYGEN.

16.0g O_2	1 Mole O_2	6 Mole O_2	44.01g CO_2	22.0g CO_2
	32.00g O_2	6 Mole O_2	1 Mole CO_2	
	Mole Mass	Mole Ratio	Mole Mass	

SMALLEST IS THE ANSWER

★ O_2 IS THE LIMITING REACTANT

IF YOU ARE GIVEN 16.2g OF ZINC METAL & IT WAS DROPPED INTO 135mL OF A 3M $CuCl_2$ SOLUTION, HOW MANY GRAMS OF COPPER WILL PRECIPITATE?

① WRITE A BALANCED EQUATION

$$Zn_{(s)} + CuCl_{2(aq)} \longrightarrow Cu_{(s)} + ZnCl_{2(aq)}$$

② SEE HOW MUCH COPPER YOU MAKE WITH THE $CuCl_2$

★ REMEMBER $3M = \frac{3 \text{ MOLES}}{1 \text{ LITER}}$

.135 L $CuCl_2$	3 Moles $CuCl_2$	1 Mole Cu	63.55g Cu	25.7g Cu
	1L	1 Mole $CuCl_2$	1 Mole Cu	
	Concentration	Mole Ratio	Mole Mass	

③ SEE HOW MUCH COPPER YOU MAKE WITH THE ZINC.

16.2g Zn	1 Mole Zn	1 Mole Cu	63.55g Cu	15.75g Cu
	65.38g Zn	1 Mole Zn	1 Mole Cu	

★ 15.75g Cu — Zn IS THE LIMITING REACTANT

Periodic Table

Atomic History

How did we figure out what atoms look like?

John Dalton

The Atomic Theory

1. Elements are made of small pieces called atoms
2. Atoms of an element are all the same. (size, mass, behavior, etc.)
3. Different elements have atoms that are different in those properties
4. Atoms cannot be subdivided or destroyed

Be like a nucleus
Stay positive

Lord Kelvin

0°K

Proposed that absolute zero is a temperature where all atoms would stop moving. -273.15°C

2nd Law of Thermo Dynamics
The total entropy of a system will always increase over time.
Entropy = disorder
*You can add energy to a system and decrease the entropy

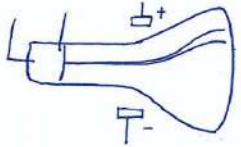
Ernest Rutherford

Atoms have a positive nucleus and electrons outside of that nucleus

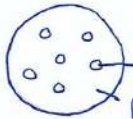
Shooting particles at a sheet of gold he observed deflection
- Atoms must have a lot of empty space with a dense (+) center

JJ Thompson

Nobel laureate who is credited with the discovery of the electron



Cathode tube
The ray was bent towards + side
Thus



Atoms are like plum pudding
Negative plums
Positive pudding

Niels Bohr

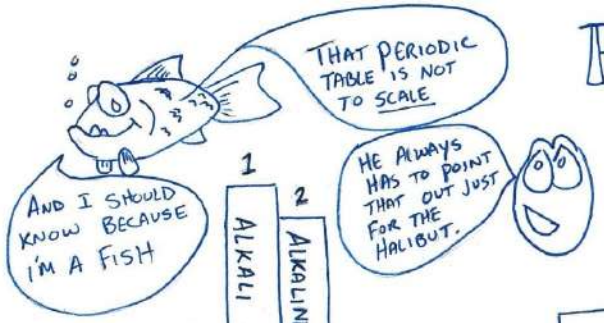
Described the atom as a small (+) nucleus with (-) electrons orbiting that nucleus

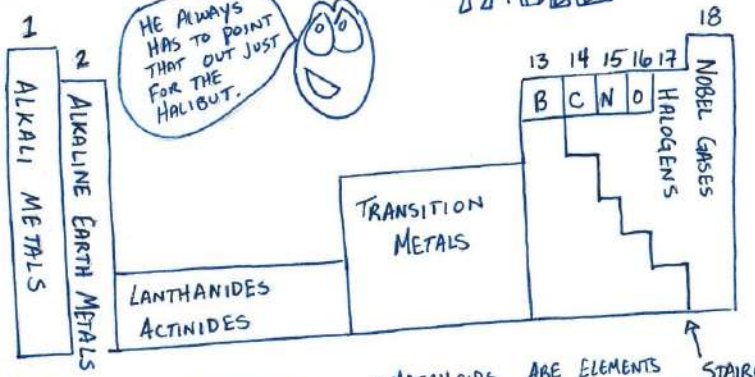
- Prescribed orbits
- If an electron falls to a lower orbit it releases energy = light

Heisenberg Uncertainty Principle

You cannot know both the momentum & the position of electrons at the same time

PERIODIC TABLE





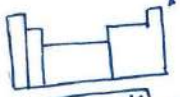
DMITRI MENDELEEV

FORMULATED PERIODIC LAW & WAS ABLE TO BEGIN TO PUT ELEMENTS IN COLUMNS AND ROWS THAT PREDICTS ELEMENTS THAT WEREN'T EVEN DISCOVERED YET

• METALLOIDS ARE ELEMENTS THAT TOUCH THE STAIRCASE

STAIRCASE SEPARATE METALS (LEFT) FROM NONMETALS (RIGHT)

THE PERIODIC TABLE OFTEN IS SHOWN LIKE THIS



* MAIN REASON IS TO FIT IT ON PAPER

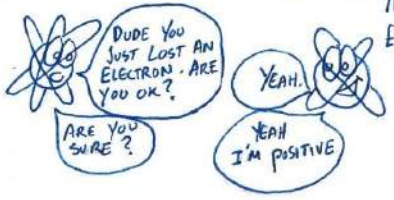
LANTHANIDES ACTINIDES ← RARE EARTH METALS = OFTEN RADIOACTIVE

COLUMNS = UP & DOWN → ELEMENTS IN A COLUMN ARE CONSIDERED TO BE IN THE SAME FAMILY.

ROWS = LEFT & RIGHT → ELEMENTS IN THE SAME ROW HAVE SAME # OF ENERGY LEVELS.

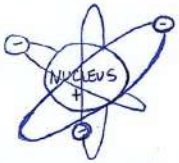
SAME # OF VALENCE ELECTRONS = BEHAVE IN SIMILAR WAYS WHEN THEY REACT WITH OTHER ELEMENTS

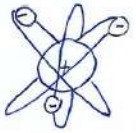
ELEMENTS IN COLUMN 1 HAVE 1 VALENCE ELECTRON. ELEMENTS IN COLUMN 2 HAVE 2 VALENCE ELECTRONS COLUMN 13 = 3 COLUMN 14 = 4 ETC. IGNORE THE TRANSITION METALS FOR NOW.



Periodic Table

Trends



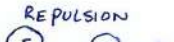


Objects: + Nucleus & - Electron Cloud
or
- Electron Cloud & - Electron Cloud

The charge can be considered electrostatic

Like when hair attracts to a balloon

Coulomb's Law - The strength of the force of attraction or repulsion between two objects with a charge is proportional to the magnitude of the charge & inversely proportional to the square of distance between them



Repulsion

Works on the same level as attraction

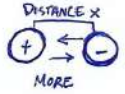
This force helps to explain the major trends of the periodic table

- Atomic radii
  - Neutral & Ions
- Electronegativity
- Electron Affinity
- Ionization Energy

Less attraction

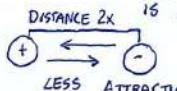
vs.

More attraction because the difference is more



More

vs.



Less attraction because they are farther away from each other

Ionization Energy

The minimum energy required to remove one electron from each atom in a mole of atoms in the gaseous state

Increases L to R on periodic table

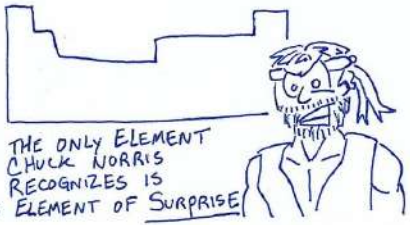
Increases bottom to top

Helps you figure out the valence e⁻

You can continually remove electrons & note the energy differences

Ex: Li 1st Ionization Energy much lower than its 2nd

- Wants to get rid of 1e⁻ not 2.



The only element Chuck Norris recognizes is the element of surprise

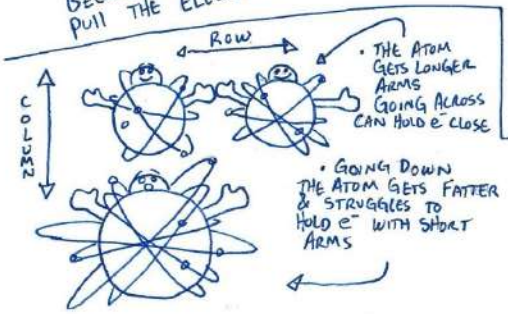
Periodic Table Trends

Atomic Radius

The measure of the size of the atom measured from the middle of the nucleus to the outer electron cloud

Increases going ⇩ on the periodic table

Why? As you go down a column you are adding another orbital & electrons are further out. It shrinks going across a row because you add protons which pull the electrons closer.



Remember all atoms want to be like the noble gases

Ionization Energy

Amount of energy required to remove the most loosely attached electron

Increases going ⇨ ⇧ on the periodic table

Why? The smaller the atom nucleus the closer the valence electrons are. To the positive protons and the attraction distance shorter = stronger

★ It is all about the e⁻

being attracted to the positive nucleus

Like a magnet

Electron Affinity

The amount of energy used or released when an electron is added to a neutral atom

Increases going ⇨ ⇧ on the periodic table

Why? Electrons that have an easier time getting closer to the nucleus release more energy when added

So the trends are determined by the ability of the protons to hold the electrons close. If they hold them close

a) the size of the atom is smaller

b) less likely to lose the farthest out electrons

Valence

PERIODIC TABLE

PRACTICE PROBLEMS

Q: PUT THE ATOMS IN ORDER FROM SMALLEST TO LARGEST. ATOMIC RADII

ANS: Li, Pb, Fe, F
1, 4, 3, 2

EXPLANATION: LITHIUM HAS VERY FEW PROTONS/ELECTRONS

Q: COMPARE THE FOLLOWING ELEMENTS & THEIR IONS. ID WHICH IS BIGGER IN THE PAIR

Fe vs. Fe^{+2}

ANS: Fe IS BIGGER

O vs. O^{-2}

ANS: O^{-2} IS BIGGER

EXPLANATION:

METALS TEND TO LOSE e^- WHEN THEY LOSE e^- THEY SHRINK

. NONMETALS TEND TO GAIN e^- & THESE ADD TO THE ELECTRON CLOUD

BASED ON THE FOLLOWING IONIZATION ENERGIES, FIGURE OUT HOW MANY VALENCE e^- THE ELEMENT WOULD HAVE

ELEMENT	1ST IE	2ND IE	3RD IE	4TH IE
X	737.7	1450.6	7732.6	10,540
Y	495.8	4562.4	6912	9543
Z	577.6	1816.6	2744.7	11,577

ANS:
ELEMENT X = 2 VALENCE e^-
ELEMENT Y = 1 VALENCE e^-
ELEMENT Z = 3 VALENCE e^-

EXPLANATION:

LOOK FOR THE LARGEST JUMP BETWEEN IONIZATION ENERGIES

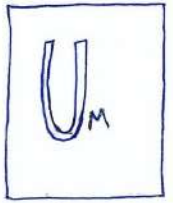
IT IS EASIER TO TAKE e^- FROM THE OUTER SHELL OF AN ATOM. AFTER THE LAST e^- IN THE OUTER SHELL IS TAKEN. THE IE SPIKES

Q: WHICH ELEMENT WOULD HAVE THE HIGHEST ELECTRONEGATIVITY

B, O, Cu, Mg ?

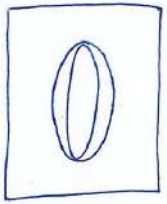
ANS: OXYGEN

EXPLANATION: OXYGEN HAS THE HIGHEST # OF PROTONS COMPARED TO ITS ATOMIC RADIUS, SO IT HAS THE HIGHEST DRAW OF e^-



THE ELEMENT OF CONFUSION

INCREASING KNOWLEDGE

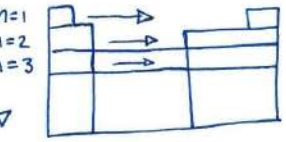


THE ELEMENT OF LEARNING

Electrical Orbitals

ELECTRON ORBITALS

DESCRIBES THE SPECIFIC DISTRIBUTION OF AN ELECTRON IN SPACE



HEISENBERG UNCERTAINTY PRINCIPLE

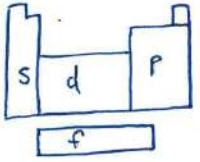
IT IS IMPOSSIBLE FOR US TO SIMULTANEOUSLY KNOW BOTH THE EXACT MOMENTUM & THE EXACT LOCATION OF AN ELECTRON

WHERE I AM YOU DON'T KNOW HOW FAST I'M GOING

SHELL & SUBSHELLS

(n) = SHELL # THE ELECTRONS ARE IN
CORRESPONDS TO THE ROW ON PERIODIC TABLE

(ℓ) = SUBSHELL WITHIN THE SHELL
GIVEN LETTERS s, p, d, f → CORRESPONDS TO DIFFERENT SECTIONS ON THE PERIODIC TABLE



(m) = MAGNETIC QUANTUM #

s = 0 (1)
p = 1, 0, -1 (3)
d = 2, 1, 0, -1, -2 (5)
f = 3, 2, 1, 0, -1, -2, -3 (7)

★ NOTICE THAT EACH SUBSHELL HAS A MAX THAT IS THE NEXT ODD # (1, 3, 5, 7)

(SPIN) = ELECTRONS SPIN OPPOSITE OF EACH OTHER SO ONE ↑ AND THE OTHER ↓

★ WHEN SPIN IS ADDED TO MAGNETIC QUANTUM YOU CAN FIND THE MAX OF 2 x m

So YOUR s CAN HOLD 2
p CAN HOLD 6
d CAN HOLD 10
f CAN HOLD 14

LETS TRY TO LOOK AT HOW AN ELEMENT'S PLACEMENT ON THE PERIODIC TABLE CAN HELP US FIND n, ℓ, m

BORON = ELEMENT #5
SECOND ROW SO IT GETS 1n AND 2n
IN THE p BLOCK SO 1s, 2s, 2p

WORK CHECK

LOOK AT HOW MANY VALENCE ELECTRONS THE ELEMENT SHOULD HAVE. COLUMN 1 = 1V.E.
COLUMN 2 = 2V.E.
COLUMN 14 = 4 V.E.
COLUMN 15 = 5 V.E.

NOW LOOK AT YOUR FINAL ANSWER $1s^2, (2s^2, 2p^2)$

LOOK AT ALL THE HIGHEST SHELL # = 2 ↓
IT SHOWS (4) TOTAL ELECTRONS
THOSE ARE THE VALENCE ELECTRONS.

Ex:

★ WILL NOT WORK WELL WITH TRANSITION METALS

ELECTRON ORBITALS

CONTINUED

USING THE n, ℓ, m INFORMATION WE CAN FIGURE OUT AN ELEMENTS ELECTRON CONFIGURATION

ELECTRON CONFIGURATION OF IRON

$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^6$

REARRANGE IT SO THE BIGGEST # IS LAST.

$1s^2, 2s^2, 3s^2, 3p^6, 3d^6, 4s^2$

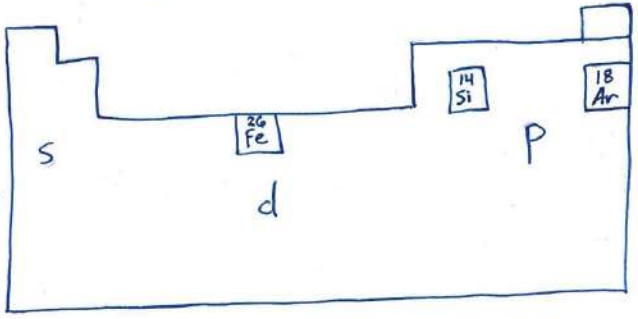
NOBLE GAS CONFIGURATION

SHORTHAND

- LOOK BACK TO THE LAST NOBLE GAS - PUT IT IN BRACKETS AND THEN CONTINUE YOUR CONFIGURATION

Fe NOBLE GAS

$[Ar]\ 3d^6, 4s^2$



REMEMBER MAX ELECTRONS PER SUBSHELL

s = 2
p = 6
d = 10
f = 14

★READ THE PERIODIC TABLE LIKE A BOOK FROM LEFT → RIGHT & TOP → BOTTOM

EX: WRITE THE ELECTRON CONFIGURATION FOR SILICON.

SILICON HAS 14 ELECTRONS, IS IN THE THIRD ROW AND THE p BLOCK.

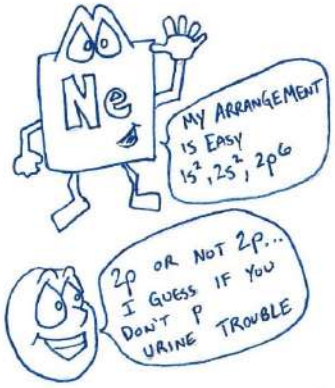
- START 1s (WHICH MUST BE FULL B/C WE ARE IN THE n=3) SO $(1s^2)$
- THEN WE MOVE TO n=2 SO $(2s^2), (2p^6)$ } WHICH IS FULL B/C WE ARE IN THE n=3
- THEN WE MOVE TO n=3 SO $(3s^2)$ $3p^2$ ← IT IS NOT 6 BECAUSE Si IS THE SECOND ELEMENT IN THE 3p

FINAL ANSWER $1s^2, 2s^2, 2p^6, 3s^2, 3p^2$

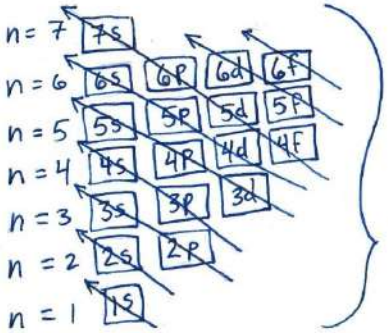
NOTE

- S CAN START WITH 1
- P HAS TO START WITH 2
- d HAS TO START WITH 3
- F HAS TO START WITH 4

ELECTRON ORBITALS



ANOTHER WAY TO VISUALIZE HOW ORBITALS ARE FILLED



THEY FILL IN DIAGONAL ARRANGEMENT FROM BOTTOM UP

LETS TRY COPPER

IT HAS 29 ELECTRONS. REMEMBER S HOLDS 2 p HOLDS 6 d HOLDS 10 & f HOLDS 14.

SO $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^9$

ALMOST DONE.

* REMEMBER THE BIGGEST # GOES LAST SO THE 4s SWITCHES WITH THE 3d
* ALSO SINCE THE 3d IS SO CLOSE TO FULL IT WILL PULL DOWN ONE OF 4s e^- TO BE MORE STABLE

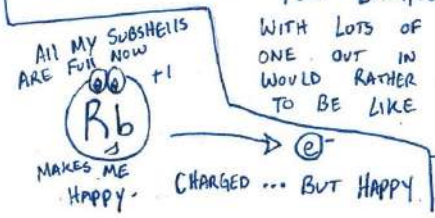
THUS THE ANSWER IS

$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^1$

REMEMBER

THE REASON THAT IT IS IMPORTANT TO UNDERSTAND THE ELECTRON ORBITALS IS BECAUSE IT HELPS US TO UNDERSTAND THE VALENCE e^-. VALENCE e^- DETERMINE HOW AN ELEMENT WILL REACT WITH OTHER ELEMENTS.

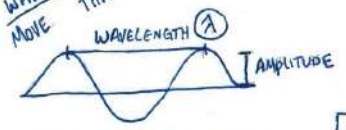
FOR EXAMPLE: A BIG ATOM WITH LOTS OF ELECTRONS BUT ONLY ONE OUT IN THE S SUBSHELL WOULD RATHER GIVE THAT e^- AWAY TO BE LIKE KRYPTON.



LIGHT

AND THE ELECTROMAGNETIC SPECTRUM (EMS)

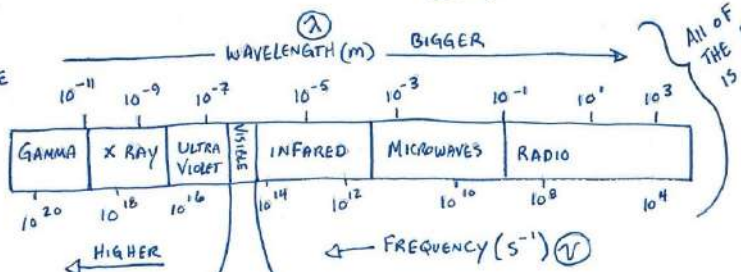
ELECTROMAGNETIC RADIATION — WAVES OF ENERGY THAT MOVE THROUGH SPACE

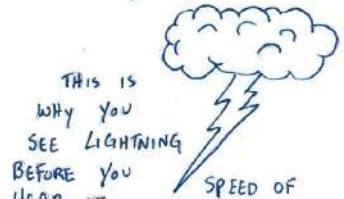


FREQUENCY (ν) = HOW OFTEN A WAVE OCCURS DURING A TIME

LIGHT ALL TRAVELS AT 3.00×10^8 m/s "SPEED OF LIGHT" (C)

THAT IS 670,600,000 mph!





LIGHT IS ENERGY AND IT IS RELEASED OR ABSORBED IN CHUNKS & MAX PLANCK DEVELOPED THIS CONSTANT (h) = 6.63×10^{-34} J-s

SO THE HIGHER THE FREQUENCY THE LIGHT WAVE HAS THE HIGHER THE ENERGY

$E = h\nu$

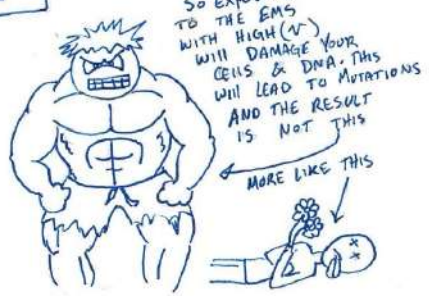
VIBGYOR

400nm 750nm

$C = \lambda\nu$

WAVELENGTH × FREQUENCY = SPEED OF LIGHT

★ SINCE ALL LIGHT TRAVELS AT THE SAME SPEED, WHEN WAVELENGTH ↑ FREQUENCY ↓



$E = mc^2$

MASS ENERGY EQUIVALENCE

EINSTEIN IN 1905

SO MASS OF AN OBJECT HAS A RELATIONSHIP TO ITS ENERGY

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

LIGHT PROBLEMS

IF WE SENT A RADIO WAVE FROM EARTH TO MARS (54.6 Million Km) How Long would it take to get there?

① All Light travels at the same speed. $C = 3.0 \times 10^8$ m/s
Radio waves are part of the EMS so it is included

② Convert your Distance to Metes & then apply the speed of Light

54.6×10^6 Km	1,000m	1 SECOND
	1Km	3.0×10^8 m

182 SECONDS

$C = \lambda \nu$

$E = h\nu$

$E = mc^2$

$E = \frac{hc}{\lambda}$

$C = 3.0 \times 10^8$ m/s

$h = 6.626 \times 10^{-34}$ J·s

REMEMBER

WHEN WAVELENGTH ↓
FREQUENCY ↑
ENERGY ↑
BUT ITS SPEED IS ALWAYS THE SAME

MR WATNEY
JUST WANTED TO LET YOU KNOW, BY THE TIME YOU HEAR THIS WE HAVE BEEN ON LUNCH BREAK FOR 3 MINUTES.

NASA

CALCULATE THE WAVELENGTH OF LIGHT THAT HAS AN ENERGY VALUE OF 3.54×10^{-19} J. WHAT COLOR WOULD IT APPEAR?

① USE THE EQUATION $E = h\nu$

BECAUSE IT IS THE ONLY EQUATION WHERE ONE VARIABLE IS MISSING.

PLUG & CHUG

$3.54 \times 10^{-19} J = (6.626 \times 10^{-34} J \cdot s)(x)$

$\nu = 562 nm$

TAKE THIS WAVE LENGTH & LOOK IT UP ON THE E.M.S. TO FIND IT IS GREEN

ITS NOT EASY BEING REFLECTIVE OF WAVELENGTH 562nm

PHOTONS USUALLY DON'T PACK MUCH WHEN THEY GO ON VACATION.

THEY ALWAYS TRAVEL LIGHT!

Lewis Dots

LEWIS DOT DIAGRAMS

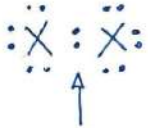
THESE ARE DIAGRAMS THAT SHOW THE VALENCE ELECTRONS OF AN ELEMENT & HELP US PREDICT HOW THE ELEMENT WILL BOND WITH OTHER ELEMENTS

IONIC BONDS

METAL GIVES
NONMETAL TAKES

COVALENT BONDS

NONMETAL & NONMETAL SHARING



SHARED ELECTRONS

1. PUT THE ELEMENT SYMBOL IN THE MIDDLE OF AN IMAGINARY SQUARE

CARBON HAS 4 VALENCE ELECTRONS

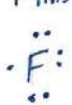
2. EACH SIDE OF THE SQUARE CAN HOLD 2 DOTS. DOTS = ELECTRONS

3. PUT ONE ELECTRON ON EACH SIDE BEFORE YOU START TO DOUBLE UP

P HAS 5 V.E.

MORE EXAMPLES:

F HAS 7 V.E.



Cl HAS 7 V.E.

N HAS 5 V.E.

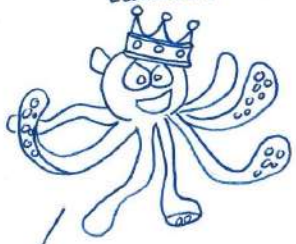
Kr HAS 8 V.E. & IS A NOBLE GAS

NOTICE HOW P & N HAVE THE SAME LEWIS DOT
- ELEMENTS IN THE SAME COLUMN BEHAVE SIMILAR BECAUSE THEY HAVE THE SAME AMOUNT OF VALENCE e^-

8 OCTET RULE

ELEMENTS TEND TO GAIN, LOSE, OR SHARE ELECTRONS IN ORDER TO BE LIKE THE NOBLE GAS CLOSEST TO THEM.

THOSE NOBLE GASES HAVE 8 VALENCE ELECTRONS



Lewis Dot Diagrams For Compound

Gilbert Lewis

Guess you can call me 007 because I developed the diagram of bonds

What?... was that dot what you expected for a joke?!

Ionic

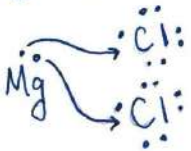
Easy

Just show how the electrons move from the metal to the non metal

$MgCl_2$

Mg = 2 V.E.

Cl = 7 V.E. each



$MgCl_2 \rightarrow Mg^{+2} + 2Cl^{-1}$

Covalent

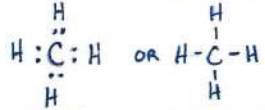
Ex: Methane CH_4

Steps

1. Count up all of the valence electrons

C = 4
H = 1 x 4 = 4
8 V.E.

2. Pick a central atom
   - usually surrounded by the others
   - * can never be H

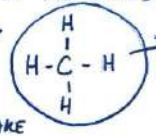


Each bond contains 2 electrons

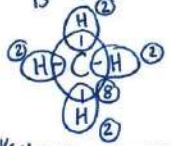
3. Subtract the # of electrons used in the bonds

4 bonds = 8 electrons
- none left -

Done



Check to see if each element's octet is full



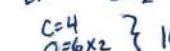
* H & He only want 2

4. If you have extra we need to make more bonds or put in lone pairs

Ex: CO_2

C = 4
O = 6 x 2 } 16 V.E.

(a.)



4 used in bonds
12 left

(b.) Start adding extra e⁻

All electrons used but this oxygen is unhappy

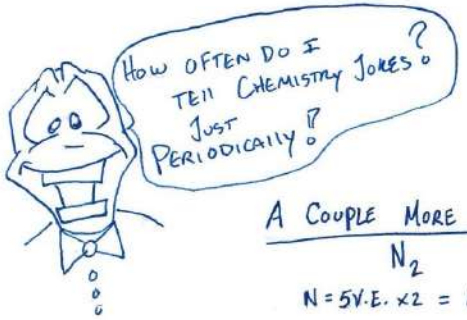
(c.) Try a double bond

3 bonds = 6 V.E.
10 left over
oxygen not happy

(d.) Try 2 doubles

4 bonds = 8 V.E.
8 left over

Everyone is happy



Lewis Dots

Covalent Bonds Continued

A Couple More Examples

N_2

N = 5 V.E. × 2 = 10 V.E.

N – N

2 V.E. in bond 8 left over

:N̈ – N̈: ← Not Happy

* Try more bonds

:N̈ = N: ← Still Not Happy

* Try a triple bond

N̈ ≡ N̈ Happiness!

Final Answer

Each Nitrogen has a lone pair

NH_3

N = 5 V.E.
H = 1 V.E. × 3 } 8 V.E.

H – N – H
|
H

6 used in the bonds
2 left over

H – N̈ – H
|
H

Polyatomic Ions

Phosphate

PO_4^{-3}

The -3 means we add 3 V.E. to the total

P = 5 O = 6 × 4 + 3 Bonus

32 V.E.

O
|
O – P – O
|
O

8 in the bonds
24 left

$$\left[:\ddot{O}: \;\; :\ddot{O}=P-\ddot{O}: \;\; :\ddot{O}: \right]^{-3}$$

Yes P is not happy but this is the most reasonable structure

* Had to add a double bond

☆ If you have a positive polyatomic just subtract electrons from the total

Determining if the Covalent Bond is Polar.

Yes a covalent bond is shared but a <u>Polar</u> covalent is shared unequally.

☆ Look up the Electron Affinity of the two elements the difference = Bond Type

Δ Electron Affinity	Type of Bond
> 1.7	Ionic
0.4 – 1.7	Polar Covalent
< 0.4	Non Polar

Ex:

Bond between Carbon & Hydrogen
2.5 – 2.1 = (0.4)
<u>Nonpolar</u>

Bond between Oxygen & Hydrogen
3.5 – 2.1
(1.4)
<u>Polar Covalent</u>

Bond between Na & F
0.9 – 4.0
(3.1)
Ionic

Bond Geometry

VSEPR

VALENCE SHELL ELECTRON PAIR REPULSION

BOND GEOMETRY PART 1

ALTHOUGH WE MAY DRAW A MOLECULE IN TWO DIMENSIONS WE NEED TO REALIZE THEY ARE IN THREE DIMENSIONAL SPACE

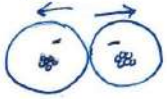
1. DRAW OUT THE LEWIS STRUCTURE OF THE MOLECULE OR ION
2. COUNT THE TOTAL NUMBER OF ELECTRON DOMAINS AROUND YOUR CENTRAL ELEMENT. THEN ARRANGE THEM SO THEY HAVE MAXIMUM SPACE BETWEEN THEM.
3. DOUBLE AND TRIPLE BONDS ARE COUNTED AS ONE DOMAIN.

ELECTRON DOMAINS	BONDED	NOT BONDED	SHAPE
2	2	0	LINEAR
3	3	0	TRIGONAL PLANAR
	2	1	BENT
4	4	0	TETRAHEDRAL
	3	1	TRIGONAL PLANAR
	2	2	BENT

UNPAIRED TAKE UP SPACE

LIKES REPEL EACH OTHER IN MAGNETS.

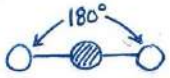
ELECTRON CLOUDS OF ATOMS (NEGATIVE CHARGE) DO THE SAME THING



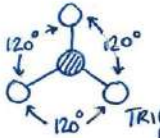
OF ELECTRON DOMAINS = (# OF ATOMS BONDED TO THE CENTRAL ATOM) + (# OF NONBONDING PAIRS ON THE CENTRAL ATOM)

Bond Geometry Part 2

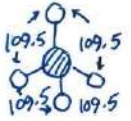
Predicting Angles of the Bonds



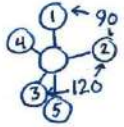
Linear 180°



Trigonal Planar 120°



Tetrahedral 109.5



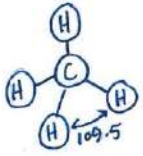
Trigonal Bipyramidal

1-2 = 90°

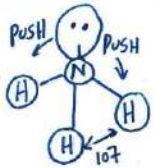
2-3 = 120°

Octahedral 90°

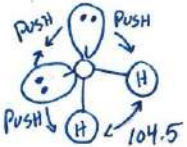
- Non Bonding Electrons push other Atoms in your Molecule decreasing the Angles



CH_4

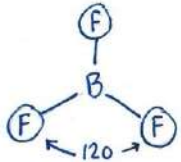


NH_3

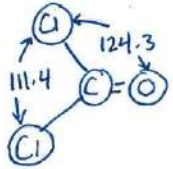


H_2O

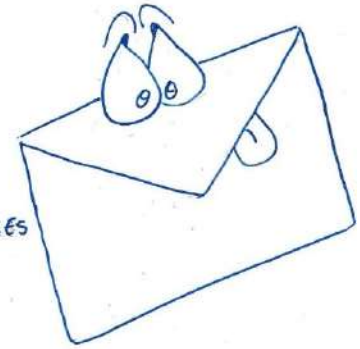
- Electron Bonds for Multiple Bonds push more than single Bonds



BF_3



Cl_2CO



No Matter How Much you Push the Envelope it is still Stationary

Bond Geometry

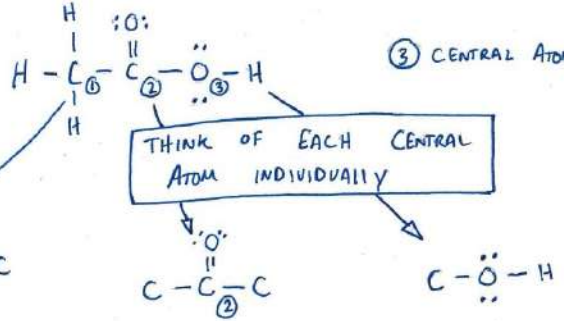
Part 3

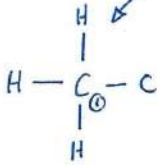
Bond... Molecular Bond

Molecules with More than One Central Atom

- Analyze molecules that have more than one central atom by looking at each main atom individually

Ex: Acetic Acid CH_3COOH





4 bonds to central

Tetrahedral

109.5°

3 bonds to central, no unpaired

Trigonal planar

120°

2 bonds to central, 2 non bonded pairs

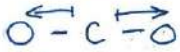
Tetrahedral

109.5°

Polarity of Polyatomics

Bond Dipole – Dipole Moment due only to the two atoms in the bond.

– Does one atom pull electrons more than another?

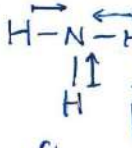


Linear

Equal pull on each dipole = **Nonpolar**

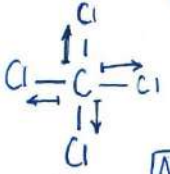
Bent

Equal pull on each dipole but molecule is bent, so more at oxygen side = **Polar**



More pull towards N

Polar



Equal pull but balanced

Nonpolar

BONDING

THE JOINING TOGETHER OF TWO OR MORE ATOMS FORMING A COMPOUND

INTRA MOLECULAR FORCE INSIDE MOLECULE

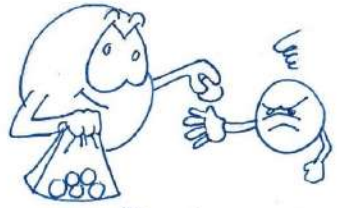
NON METALS WITH NONMETALS

COVALENT

WHEN THE ELECTRONS ARE SHARED EQUALLY (KIND OF)

LIKE FRIENDS SHARE

NONPOLAR COVALENT
EACH ATOM SHARES ELECTRONS WITH EACH OTHER



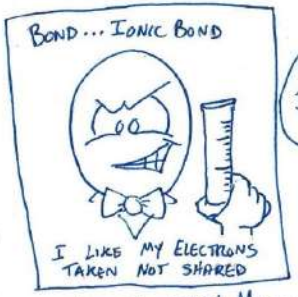
LIKE SIBLINGS SHARE

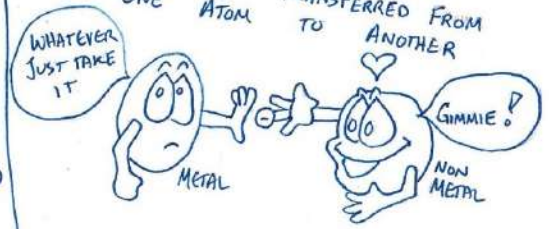
POLAR COVALENT
ONE ATOM HOLDS MOST OF THE ELECTRONS BUT THERE IS STILL SOME SHARED

METALS WITH NONMETALS

IONIC

WHEN ELECTRONS ARE COMPLETELY TRANSFERRED FROM ONE ATOM TO ANOTHER

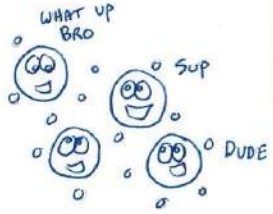




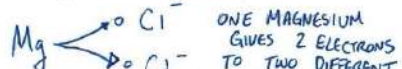
METALS WITH METALS

METALLIC

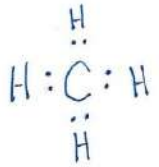
METAL ATOMS SITTING TOGETHER IN A SEA OF SHARED MOVING ELECTRONS



ATOMS CAN SHARE, TAKE OR GIVE MORE THAN ONE ELECTRON



ONE MAGNESIUM GIVES 2 ELECTRONS TO TWO DIFFERENT CHLORINE ATOMS



CARBON SHARES 4 ELECTRONS WITH 4 HYDROGEN ATOMS

Types of Reactions

Types of Reactions (RXNS)

I told a joke about noble gases but it got no reaction.

1) Synthesis – Bringing together ← Reverse —

$A + B \longrightarrow AB$

Ex: $2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$

2) Decomposition – Breaking apart

$AB \longrightarrow A + B$

Ex: $H_2CO_{3(aq)} \longrightarrow H_2O_{(l)} + CO_{2(g)}$

Predicting Products

- Carbonates: turn into metal oxide + CO_2
- Chlorates: turn into metal chloride + O_2
- Acids + bases containing oxygen: turn into nonmetal oxide + H_2O
- Others: break into their two parts
  Ex: $2H_2O \rightarrow 2H_2 + O_2$

3) Single Replacement – The chemistry student gets chosen by the girl & the non science student is left alone :(

$A + BC \longrightarrow AC + B$

Ex: $Zn_{(s)} + 2AgNO_{3(aq)} \longrightarrow Cu(NO_3)_{2(aq)} + 2Ag_{(s)}$

4) Double Replacement – A double date switcheroo

$AB + CD \longrightarrow AD + CB$

Ex: $NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl$

Note: on replacement reactions a cation will switch with a cation & anion with anion

5) Combustion – Burn baby burn

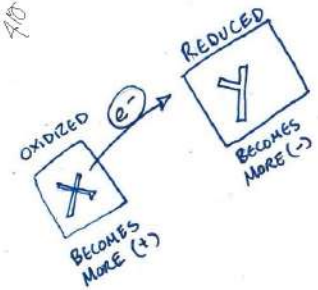
Fuel + oxygen → Carbon dioxide + water

Ex: $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

REDOX REACTIONS

REDUCTION / OXIDATION REACTIONS

ONE ATOM LOSES AN ELECTRON AND ANOTHER ATOM GAINS IT.



L.E.O. GOES G.E.R.

LOSS ELECTRONS OXIDATION

GAIN ELECTRONS REDUCTION

MOLECULAR EQUATION

$$Fe_{(s)} + Ni(NO_3)_{2(aq)} \rightarrow Fe(NO_3)_{2(aq)} + Ni_{(s)}$$

NET IONIC EQUATION

$$Fe_{(s)} + Ni^{+2}_{(aq)} \longrightarrow Fe^{+2}_{(aq)} + Ni_{(s)}$$

NOTICE WHEN WE REMOVE THE SPECTATOR IONS THE CHARGE ON THE LEFT (+2) IS THE SAME AS THE RIGHT (+2).

THE CHEMICAL REACTION HAS CONSERVATION DOWN TO THE ION LEVEL.

EXAMPLE:

$$Mg_{(s)} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$$

0 CHARGE | +1 CHARGE | +2 CHARGE | 0 CHARGE

OXIDIZED → MAGNESIUM LOST 2 ELECTRONS = BECAME +2

REDUCED → 2 HYDROGEN IONS GAINED 1 ELECTRON EACH = BECAME NEUTRAL

OXIDATION #'S

1. AN ATOM IN ELEMENT FORM IS ALWAYS 0. EX: $H_2 = 0$, $Cu = 0$
2. MONOATOMIC IONS HAVE OXIDATION #S EQUAL TO THE CHARGE OF THE ION
   EX: ALL GROUP 1A = +1; $Li = +1$ $Na = +1$
   ALL GROUP 3A = +3; $B = +3$ $Al = +3$
3. NONMETALS USUALLY HAVE NEGATIVE OXIDATION #'S
   OXYGEN = -2
   * HYDROGEN = +1 WITH NONMETALS
   = -1 WITH METALS
4. SUM OF OXIDATION NUMBERS OF A NEUTRAL COMPOUND IS ZERO
   POLYATOMIC IONS TOTAL CHARGE MUST BE THE CHARGE OF THE ION

FIND OXIDATION #S FOR ALL ATOMS.

EX: Na_2SO_3

START WITH ATOMS YOU KNOW THE CHARGE

Na = +1 ⇒ SO Na_2 = +2 TOTAL MEANS SO_3 = -2

O = -2 ⇒ WE HAVE 3 × -2 = -6 BUT SO_3 = -2

$-SO-$

S = +4

Na_2SO_3 (+2, +4, -6) = 0

REACTIONS

ACTIVITY SERIES

ACTIVITY SERIES OF METALS IN AQUEOUS SOLUTION

METAL	OXIDATION REACTION
LITHIUM	$Li_{(s)} \rightarrow Li^{+}_{(aq)} + e^{-}$
POTASSIUM	$K_{(s)} \rightarrow K^{+}_{(aq)} + e^{-}$
BARIUM	$Ba_{(s)} \rightarrow Ba^{2+}_{(aq)} + 2e^{-}$
CALCIUM	$Ca_{(s)} \rightarrow Ca^{2+}_{(aq)} + 2e^{-}$
SODIUM	$Na_{(s)} \rightarrow Na^{+}_{(aq)} + 1e^{-}$
MAGNESIUM	$Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + 2e^{-}$
ALUMINUM	$Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e^{-}$
ZINC	$Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^{-}$
IRON	$Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^{-}$
COPPER	$Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^{-}$
SILVER	$Ag_{(s)} \rightarrow Ag^{+} + 1e^{-}$
MERCURY	$Hg_{(l)} \rightarrow Hg^{2+} + 2e^{-}$
PLATINUM	$Pt_{(s)} \rightarrow Pt^{2+} + 2e^{-}$
GOLD	$Au_{(s)} \rightarrow Au^{3+} + 3e^{-}$

OXIDATION #'S ANOTHER GREAT MICHAEL FARADAY NOTATION

PREDICTING IF A REDOX REACTION WILL OCCUR

LONE METAL + METAL COMPOUND ⟶ ?

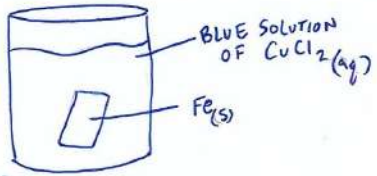
① IDENTIFY WHERE THE LONE METAL IS LOCATED ON THE ACTIVITY SERIES COMPARED TO THE METAL COMPOUND

② IF THE LONE METAL IS HIGHER, A REPLACEMENT (REDOX) REACTION WILL OCCUR.

EX: $Iron_{(s)}$ STRIP IS PUT INTO A SOLUTION OF COPPER (II) CHLORIDE. WRITE THE BALANCED REACTION IF THE REACTION WOULD PROCEED.

★ IRON IS HIGHER THAN COPPER = PROCEED

$$2Fe_{(s)} + 3CuCl_{2(aq)} \rightarrow 2FeCl_{3(aq)} + 3Cu_{(s)}$$



AS THE REACTION PROCEEDED YOU WOULD SEE Cu FORMING ON THE SURFACE OF THE Fe STRIP

NOTICE THAT THERE ARE e^{-} RELEASED. THESE ARE "GRABBED" BY ANOTHER SUBSTANCE.

THAT EXCHANGE OF e^{-} IS ELECTRICITY = FLOW OF ELECTRONS

12

PREDICTING

PRODUCTS & REACTION TYPE

1. COPPER (II) CHLORIDE REACTS WITH ZINC METAL

$Cu^{+2}Cl^{-1}_{2\,(aq)}$ $Zn^{0}_{(s)}$

$$CuCl_{2(aq)} + Zn \longrightarrow \overset{+2\ -1}{Zn\,Cl_{2(aq)}} + \overset{0}{Cu_{(s)}}$$

① WRITE OUT THE SUBSTANCES THAT ARE REACTING - BALANCE THEM

② COMPOUND + SINGLE METAL
2 PARTS
★ SINGLE REPLACEMENT

③ BALANCE THE REACTION

2. BUTANE BURNS IN THE PRESENCE OF OXYGEN

C_4H_{10} O_2

$$C_4H_{10} + 6.5O_2 \longrightarrow 4CO_2 + 5H_2O$$

$\times 2$

$$2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$$

① REMEMBER OXYGEN IS DIATOMIC

② BURN = COMBUSTION ★
SO CO_2 + H_2O ARE PRODUCTS

③ BALANCE THE REACTION
C = 1ST
H = 2ND
O = 3RD

3. HYDROGEN GAS REACTS WITH OXYGEN GAS

H_2 O_2

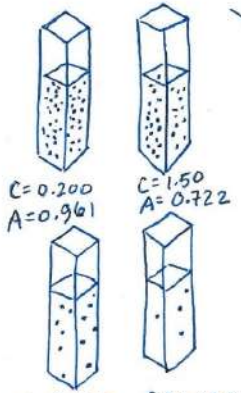
$$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(l)}$$

① REMEMBER OXYGEN + HYDROGEN ARE DIATOMIC

② TWO SINGLE MOLECULES PROBABLY JOIN TOGETHER
★ SYNTHESIS

③ PREDICT A PRODUCT THAT SEEMS LIKELY

BEER-LAMBERT LAW



WE CAN DETERMINE THE CONCENTRATION OF A SOLUTION BY UNDERSTANDING HOW MUCH LIGHT CAN PASS THROUGH THE SOLUTION.

BEER'S LAW SHOWS A MATHMATICAL RELATIONSHIP BETWEEN THE CONCENTRATION & ABSORBANCE

$$A = \varepsilon b c$$

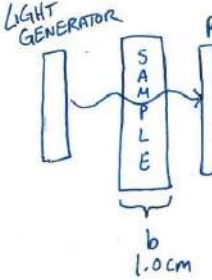
A = ABSORBANCE

ε = MOLAR ABSORPTIVITY (CONSTANT FOR A GIVEN SOLUTE @ GIVEN WAVELENGTH)

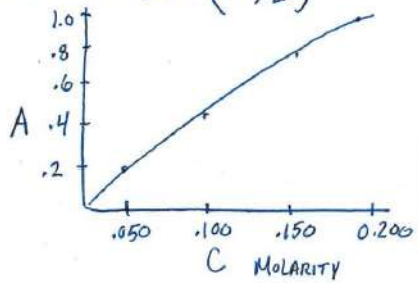
b = DISTANCE BETWEEN LIGHT SOURCE ENTERING THE SOLUTION & WHERE IT EXITS (cm)

C = MOLAR CONCENTRATION (MOL/L)

SPECTROPHOTO METER

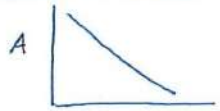


THE HIGHER THE CONCENTRATION THE MORE LIGHT HITS THE MOLECULES & DOESN'T MAKE IT TO THE RECEIVER = HIGH ABSORBANCE

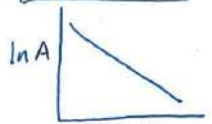


APPLY THIS TO DETERMINE THE RATE LAW

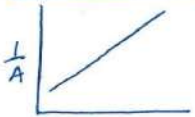
ZERO ORDER



FIRST ORDER



SECOND ORDER



SINCE CONCENTRATION IS RELATED TO ABSORBANCE WE CAN FIGURE THE RATE LAW

Gases

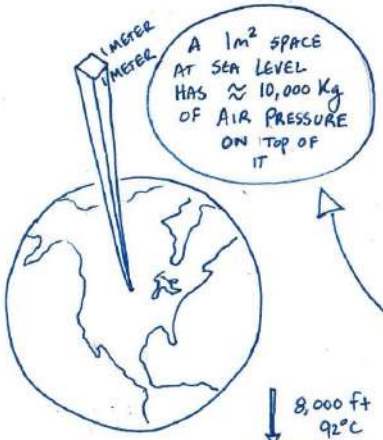
Pressure = Force / Area

Gas Laws

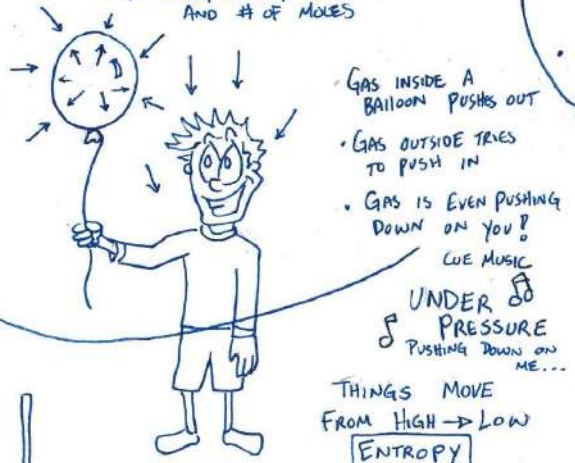
Most common properties measured when looking at gases are temperature, volume, pressure and # of moles

Just because you can't see a gas doesn't mean it isn't there.

- Gases allow you to drink from a straw
- They allow you to fly in a plane
- They give a balloon its shape



A $1m^2$ space at sea level has ≈ 10,000 Kg of air pressure on top of it

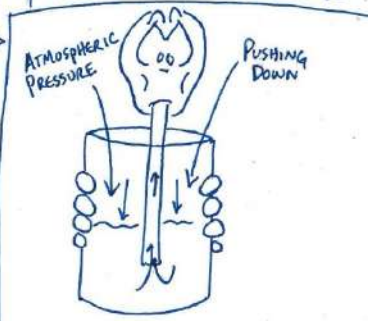


- Gas inside a balloon pushes out
- Gas outside tries to push in
- Gas is even pushing down on you!

Cue music

Under Pressure

Pushing down on me...



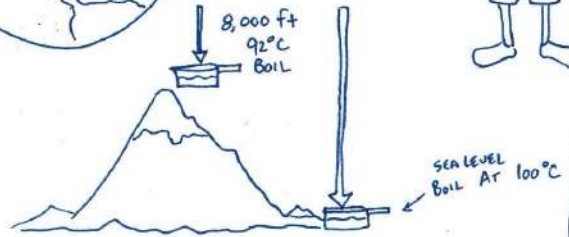
Inhaling = ↑ the volume of your lungs. Higher pressure outside forces the liquid up to the lower pressure area

Things move from high → low

Entropy

From order to disorder

No energy required



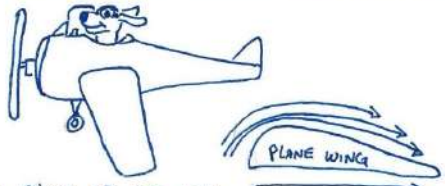
Water boils faster at higher altitudes because there is less gas holding it in liquid state

Lower vapour pressure.

This is why it takes longer to cook delicious Mac n' cheese at high altitudes ↴

Boil = put in noodles 92°C Lower temp = Longer cook time

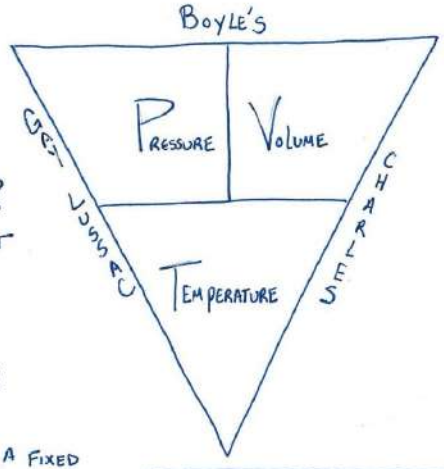
Bernouli's Principle →



Due to the shape of the wing air rushes over the top faster = lower pressure the higher pressure on the bottom yeilds lift.

Gas Laws

The Pressure Triangle will help you with a variety of problems. Just cover the letter the problem doesn't use.



Ex: A balloon has a volume of 355 ml at 1.0 atm what will its volume be at 0.4 atm?

We use P & V so cover T

$P_1 \times V_1 = P_2 \times V_2$

$(1.0\ atm)(355\ ml) = (0.4\ atm)(x)$

890 ml — Boyle's Law

Ex: If a container that has a fixed volume was warmed to 101 °C & its starting pressure was 120.1 kPa and its final pressure was 3.31 atm, what was its starting temp?

Volume is fixed = cover it

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{120.1\ kPa}{101.325\ kPa} \quad \frac{1.0\ atm}{}$

$\frac{1.2\ atm}{x} = \frac{3.31\ atm}{374\ °K}$

140 °K — Gay-Lussac

* Problem, gas pressure units need to be the same
* Change temp to °K

Pressure Conversions
1.0 atm = 101.325 kPa = 760.0 Torr = 760 mmHg = 14.7 psi
Temperature Conversion
0 °C = 273 °K

Boyle's Law

$P_1V_1 = P_2V_2$

P ↑ V ↓

Potato Gun

Charles Law

T ↑ V ↑ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Hot Air Balloon

Gay Lussac's

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

T ↑ P ↑

Don't do this!

Closed can on a fire

Combined Gas

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Gas Laws

Avogadro's Law

1 mole of any gas that is @ 0°C & 1 atm will occupy 22.4 L of space

S.T.P.

Standard Temperature = 0°C
&
Pressure = 1 atm

Avacado's Law

1 avacado is equal to 1 bowl of guacamole per happy tummy.

Ideal Gas Law

$$PV = nRT$$

Pressure · Volume = Moles of Gas · R Value · Temperature in °K

★ If you see grams of a gas or moles of a gas in a problem you will probably need $PV=nRT$

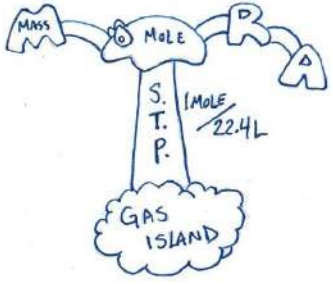
R Values

Constants based on pressure unit

Atm	0.08206	L·Atm/Mol·K
Torr	62.36	L·Torr/Mol·K
mmHg		L·mmHg/Mol·K

When using Ideal Gas Law you must have volume in liters

New Island Discovered



Ex: You are given 16.0 g of Hydrogen gas at 1.2 atm and 94°C. How much volume will it take up?

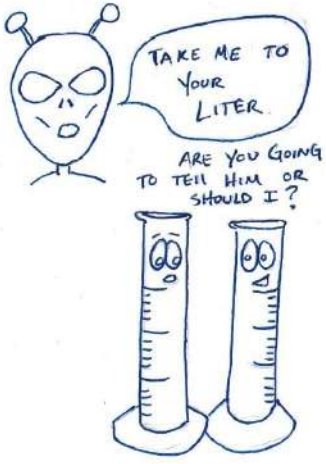
① Convert your g → Mole and °C → °K

$$\frac{16.0\text{ g } H_2}{2.016\text{ g } H_2} \times \frac{1\text{ Mole } H_2}{} = 7.94 \text{ moles}$$

$94°C + 273 = 367°K$

② Now plug it in

$$(1.2\text{ Atm})(x) = (7.94\text{ moles})(0.08206)(367°K) = 199\text{ L}$$

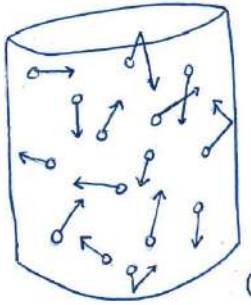


Gas Laws

Kinetic Molecular Theory (KMT)

- Gas particles are in constant random motion & exhibit perfectly elastic collisions

Elastic collisions = there is no change in the kinetic energy of the particles when they collide with each other & the sides of the container



Dalton's Law of Partial Pressure

Total pressure in a container is equal to the sum of all the gases pressure if they were individual

$$P_T = P_1 + P_2 + P_3 + P_4 \ldots \text{etc.}$$

Ex: A mixture of 7.12 g O_2 and 9.04 g CH_4 are placed in a container (15.0 L) at 0°C. What is the pressure in the container?

a) $\frac{7.12\text{ g } O_2}{32.0\text{ g } O_2} \left| \frac{1\text{ mole } O_2}{} \right. = 0.222$ moles O_2

$PV = nRT$

$(x)(15.0\text{ L}) = (0.222\text{ moles})(0.0821)(273\text{ K}) = 0.332$ atm

b) $\frac{9.04\text{ g } CH_4}{16.0\text{ g } CH_4} \left| \frac{1\text{ mole } CH_4}{} \right. = 0.565$ moles CH_4

$PV = nRT$

$(x)(15.0\text{ L}) = (0.565\text{ moles})(0.0821)(273\text{ K}) = 0.844$ atm

1.18 atm

If a king farts does that mean he made a noble gas?

Effusion

The escape of gas molecules through a tiny hole into an evacuated space

Graham's Law

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

Rate of effusion gas 1 = r_1
Rate of effusion gas 2 = r_2
Molar mass gas 1 = M_1
Molar mass gas 2 = M_2

Solutions

POP IS A SOLUTION
SUGAR = SOLUTE
WATER = SOLVENT

PRETTY SWEET...
GET IT? SUGAR, SWEET

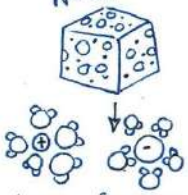
SOLUTIONS

MIXTURE THAT IS HOMOGENEOUS CONTAINS
SOLVENT — DOES THE DISSOLVING
& SOLUTE — GETS DISSOLVED

- ELECTROLYTE — IS A SOLUTION THAT CONTAINS IONS EX: SALT IN WATER NaCl
  THE Na^+ & Cl^- BREAK UP & CONDUCT AN ELECTRICAL CURRENT
- NON ELECTROLYTE — DISSOLVES BUT DOES NOT FORM IONS
  MOLECULAR COMPOUNDS LIKE SUGAR ($C_{12}H_{22}O_{11}$)
- WEAK ELECTROLYTE — MOLECULAR COMPOUNDS THAT HAVE A SMALL % BREAK UP
  EX: ACETIC ACID $HC_2H_3O_2 \longrightarrow H^+ + C_2H_3O_2$

MOLECULAR VIEW

NaCl



WATER SEPARATES EACH PART OF THE NaCl * NOTICE HOW THE ORIENTATION OF THE WATER IS DIFFERENT FOR ⊕ VS. ⊖ CHARGE DIFFERENCE

$C_{12}H_{22}O_{11}$

WATER ATTRACTS TO THE -OH GROUPS ON SUGAR BUT DOESN'T PULL THE MOLECULE APART
* NO CHARGE DIFFERENCE

POOR ATHLETE SPORT DRINK RECIPE

- 355 ml H_2O SOLVENT
- 10g SUCROSE NON ELECTROLYTE SOLUTE
- 1g NaCl ELECTROLYTE SOLUTE

WHY ARE ELECTROLYTES IMPORTANT?

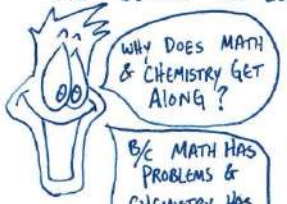
OSMOSIS

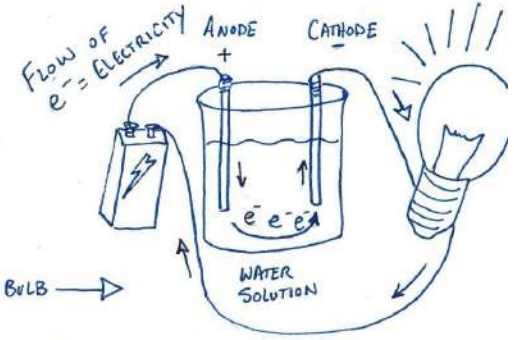
TO BALANCE THE FLOW OF H_2O INTO YOUR BODY CELLS — BETTER REHYDRATION

YOUR BODY CELLS HAVE IONS & YOUR BODY FLUIDS NEED TO MATCH

ISOTONIC

THE MORE ELECTROLYTES = IONS THE BETTER THE ELECTRICITY FLOWS





* IF A SOLUTION HAS IONS (ELECTROLYTE) IT WILL ALLOW FOR CURRENT TO FLOW

PURE H_2O = NO IONS = DOES NOT CONDUCT

Colligative means depending on the collection

Colligative Properties

When you mix substances together you will change the liquids boiling point & freezing point. These depend on the quantity of solute but not the type of solute.

Don't store diet pop in your garage in the winter. Less sugar higher freezing point = freeze & explode

So the pop will .... Pop ?!?!...

Boiling Point Elevation

The increase in boiling point relative to a pure solvent is directly proportional to solute particles per mole of solvent molecules.

↑solute = ↑ B.P.

$\Delta T_b = K_b m$

Change in boiling point = (molal boiling point constant)(molality)

$K_b H_2O = 0.52\,^\circ C/m$

Ex: Calculate the new boiling point of 250 g of H_2O with 18.2 g NaCl dissolved in it.

① $\frac{18.2\text{ g NaCl}}{250\text{ g } H_2O} \left| \frac{1\text{ mole NaCl}}{58.443\text{ g NaCl}} \right| \frac{1000\text{ g } H_2O}{1\text{ Kg } H_2O} = 1.25\,m$

Calculating the molality

- This is why we put salt on the road ice → liquid and antifreeze in our cars

② Plug & Chug

$\Delta T_b = (0.52\,^\circ C/m)(1.25\,m) = 0.65\,^\circ C$

③ Original Boiling Point 100°C

$+ \Delta T_b (0.65\,^\circ C) = \boxed{100.65\,^\circ C}$

Freezing Point Depression

$K_f H_2O = 1.86$

The decrease in freezing point, like boiling point, is directly proportional to the solute particles per mole of solvent molecules

$\Delta T_f = K_f m$

Change in freezing point = (molal freezing point constant)(molality)

Ex: same solution 18.2 g NaCl in 250 g H_2O

① $\frac{18.2\text{ g NaCl}}{250\text{ g } H_2O} \left| \frac{1\text{ mole NaCl}}{58.443\text{ g NaCl}} \right| \frac{1000\text{ g } H_2O}{1\text{ Kg } H_2O} = 1.25\,m$

② Plug & Chug

$\Delta T_f = (1.86\,^\circ C/m)(1.25\,m) = 2.33\,^\circ C$

③ Original freezing = 0°C

$0\,^\circ C - 2.33\,^\circ C = -2.33\,^\circ C$

SOLUBILITY & NET IONIC REACTIONS

1. POTASSIUM CHLORIDE IS PUT IN A CONTAINER WITH LEAD (II) NITRATE

$KCl_{(aq)}$ $Pb(NO_3)_{2(aq)}$

$$2KCl_{(aq)} + Pb(NO_3)_{2(aq)} \longrightarrow 2KNO_{3(aq)} + PbCl_{2(s)}$$

$$2K^+ + 2Cl^- + Pb^{+2} + 2NO_3^{-1} \longrightarrow 2K^+ + 2NO_3^- + PbCl_{2(s)}$$

SPECTATOR IONS K^+, NO_3^-

$$Pb^{+2}_{(aq)} + 2Cl^-_{(aq)} \longrightarrow PbCl_{2(s)}$$

① WRITE OUT THE COMPOUNDS
② DETERMINE THE TYPE OF REACTION
   ⊛ DOUBLE REPLACEMENT
③ WRITE OUT THE REACTION & BALANCE
④ LOOK UP SOLUBILITY OF PRODUCTS
⑤ WRITE OUT THE IONIC EQUATION
⑥ THE PRODUCT THAT IS SOLID IS THE ONE OF FOCUS FOR THE NET IONIC. THE OTHERS ARE SPECTATORS

2. COPPER II SULFATE WITH POTASSIUM CARBONATE

$$CuSO_{4(aq)} + K_2CO_{3(aq)} \longrightarrow CuCO_{3(s)} + K_2SO_{4(aq)}$$

NET IONIC $Cu^{+2} + CO_3^{-2} \longrightarrow CuCO_{3(s)}$

SPECTATOR IONS K^+, SO_4^{-2}

IF YOU PUT SUCROSE INTO WATER WITH LEAVES IS THAT CONSIDERED...

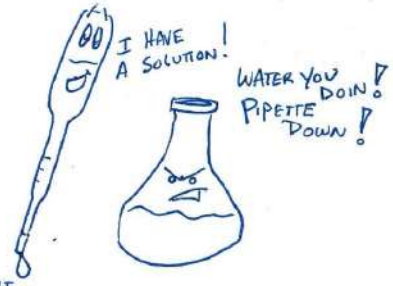
SOLUBILITY PART 1

YOU KNOW WHAT THEY SAY...

IF YOU'RE NOT PART OF THE SOLUTION, YOU'RE THE PRECIPITATE

THE AMOUNT OF A SUBSTANCE THAT CAN DISSOLVE IN A GIVEN AMOUNT OF SOLVENT

- IF A SOLUTE DISSOLVES IN A SOLVENT = SOLUBLE
- IF A SOLUTE CANNOT DISSOLVE IN A SOLVENT = INSOLUBLE



CERTAIN CATIONS WITH CERTAIN ANIONS ARE INSOLUBLE IN WATER & WHEN THEY JOIN TOGETHER WILL FORM A PRECIPITATE

SOLUBLE COMPOUNDS	EXCEPTIONS
NO_3^-	NONE
$C_2H_3O_2^-$	NONE
Cl^-	$AgCl$, Hg_2Cl_2, $PbCl_2$
Br^-	$AgBr$, Hg_2Br_2, $PbBr_2$
SO_4^{-2}	$SrSO_4$, $BaSO_4$, $HgSO_4$, $PbSO_4$

INSOLUBLE COMPOUNDS	EXCEPTIONS
S^{-2}	IF S^{-2} IS BOUND TO ALKALI METALS, Ca^{+2}, Sr^{+2}, Ba^{+2}
CO_3^{-2}	IF CO_3^{-2} IS BOUND TO NH_4^{+1} OR ALKALI METALS
PO_4^{-3}	IF PO_4^{-3} IS BOUND TO NH_4^+ OR ALKALI METALS
OH^-	IF OH^{-1} IS BOUND TO ALKALI METALS Ca^{+2}, Sr^{+2}, Ba^{+2}

A + B CATIONS
X + Y ANIONS

EX: $AX + BY \longrightarrow AY + BX$
DOUBLE REPLACEMENT

AX WAS SOLUBLE SO WE WRITE (aq) AFTER IT TO MEAN AQUEOUS = DISSOLVES IN WATER

BY WAS (aq) AS WELL

THE QUESTION IS, DOES AY & BX DISSOLVE? WE WOULD NEED TO LOOK IT UP.

IF AY FORM A PRECIPITATE WE WRITE (S) FOR SOLID.

FINAL ANSWER

$$AX_{(aq)} + BY_{(aq)} \rightarrow AY_{(s)} + BX_{(aq)}$$

IN LAB WE WOULD SEE A COLOR CHANGE.

SOLUBILITY PART 2

WORK ALREADY DONE
- PREDICT PRODUCTS
- BALANCED EQUATION
- CHECKED SOLUBILITY CHART

SOLUBILITY NEEDS TO BE LOOKED AT FROM THE ION PERSPECTIVE IN ORDER TO MAKE PREDICTIONS

CONSIDER THIS EXAMPLE:

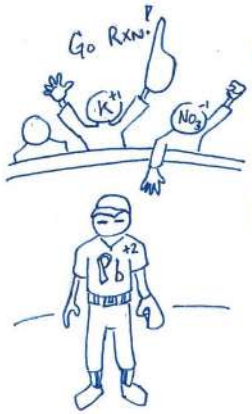
$$Pb(NO_3)_{2\,(aq)} + 2KI_{(aq)} \longrightarrow PbI_{2\,(s)} + 2KNO_{3\,(aq)}$$

NOTICE WE ARE SHOWING HOW MANY OF EACH ION IS PRESENT WITH THE COEFFICIENT

① COMPLETE IONIC EQUATION = BREAK UP ALL THE COMPOUNDS THAT DISSOLVE

$$Pb^{+2}_{(aq)} + 2NO_3^{-1}_{(aq)} + 2K^{+1}_{(aq)} + 2I^{-1}_{(aq)} \longrightarrow PbI_{2\,(s)} + 2K^{+}_{(aq)} + 2NO_3^{-1}_{(aq)}$$

NOTE WE DON'T BREAK THIS UP B/C IT IS SOLID



SPECTATOR IONS JUST WATCH THE RXN

② IDENTIFY SPECTATOR IONS

THESE ARE THE IONS IN YOUR EQUATION THAT STAY (aq) ON BOTH SIDES

K^{+1} & NO_3^{-1}

③ WRITE THE NET IONIC EQUATION

EQUATION WITHOUT SPECTATOR IONS

$$Pb^{+2}_{(aq)} + 2I^{-1}_{(aq)} \longrightarrow PbI_{2\,(s)}$$

PREVIEW

THIS CONNECTS TO ACID-BASE NEUTRALIZATIONS

$$HCl + NaOH \longrightarrow HOH + NaCl$$

ACID BASE WATER SALT

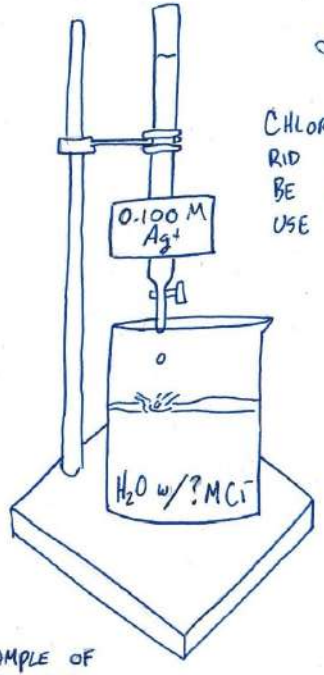
$H^+ + Cl^- + Na^+ + OH^-$

LOW pH HIGH pH

$H^+ OH^-$ $Na^+ Cl^-$

NEUTRAL = pH 7

Solution Concentrations



Chlorine is added to water in order to get rid of bacteria. Too much Cl^- in H_2O can be harmful. To test the $[Cl^-]$ in H_2O chemist use Ag^+

$$Ag^+_{(aq)} + Cl^-_{(aq)} \longrightarrow AgCl_{(s)}$$

17.6 mL of the 0.100 M Ag^+ solution were used to titratrate the H_2O sample. We can figure out the grams of Cl^- in the sample.

① Convert the Ag^+ solution to moles Ag^+

$$\frac{17.6\ mL\ Ag^+\ (\text{solution}) \quad | \quad 1\ L \quad | \quad 0.100\ \text{Moles}}{\qquad\qquad\qquad | \quad 1000\ mL \quad | \quad 1\ \text{Liter}} = 1.76 \times 10^{-3}\ \text{Moles}\ Ag^+$$

Convert to Liters | Solution Concentration

② Convert to moles of Cl^- by using balanced equation

1 mole Ag^+ to 1 mole Cl^-

$1.76 \times 10^{-3}\ Ag^+ = 1.76 \times 10^{-3}\ Cl^-$

③ $$\frac{1.76 \times 10^{-3}\ \text{Moles}\ Cl^- \quad | \quad 35.5\ g\ Cl^-}{\qquad\qquad\qquad\qquad | \quad 1\ \text{Mole}\ Cl^-} = \boxed{0.0625\ g\ Cl^-}$$

If the sample of water was 18.2 g we can calculate the % Cl^-

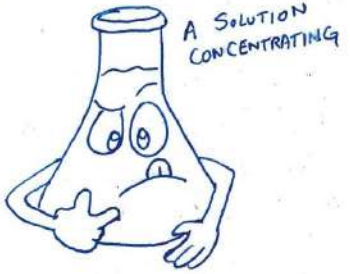
$$\frac{6.25 \times 10^{-2}\ g\ Cl^-}{18.2\ g\ \text{sample}} \times 100 = \boxed{0.343\%\ Cl^-}$$

Solution Concentration

$$\text{Molarity } (M) = \frac{\text{Moles of Solute}}{\text{Liters of Solution}}$$

$$\text{Molality } (m) = \frac{\text{Moles of Solute}}{\text{Kg of Solvent}}$$

Since a lot of reactions occur in water (aqueous) we must consider how strong their solution is to predict reactions



Titrations

Ex: 49.3 mL of 0.600 M H_2SO_4 is required to neutralize 30.0 mL of NaOH. What is the concentration of the NaOH?

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2HOH$$

Balanced Equation tells you how many moles of acid neutralize the moles of base & vice versa

Steps: Get H_2SO_4 into ① moles, Do the ② mole ratio, Apply ③ volume of NaOH

① $\frac{49.3\text{ml}}{1000\text{ml}} \mid \frac{1\text{L}}{1\text{L}} \mid \frac{0.600\text{ Moles}}{1\text{L}} = 0.0294\text{ Moles}$

② $\frac{.0294\text{ Moles } H_2SO_4}{1\text{ Mole } H_2SO_4} \mid \frac{2\text{ Moles NaOH}}{1\text{ Mole } H_2SO_4} = 0.0588\text{ Moles NaOH}$

③ $\frac{0.0588\text{ Moles NaOH}}{0.030\text{ L}} = 1.96\text{ M NaOH}$

2 Mole Solution

Calculating Dilutions

$$M_1V_1 = M_2V_2$$

(Molarity)(Volume) Initial = (Molarity)(Volume) Final

You are given 10.0 M HCl and are asked to make 250.0 mL of a 2.0 M HCl solution. How do you do it?

$(10.0\text{M})(x) = (2.0\text{M})(250.0\text{mL})$

Initial volume = 50.0 mL of 10.0 M

So put 200 mL of distilled H_2O into the flask then add the 50.0 mL of 10.0 M HCl

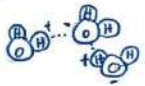
Remember Acid into water not water into acid

Intermolecular Forces

Intermolecular Forces

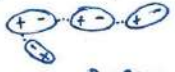
Forces between two molecules

Hydrogen Bond - Bond between the Hydrogen atom in a polar bond (H-F, H-O, H-N) and an unshared electron pair on a small electronegative ion or atom



Ion-Dipole - Between an ion and the partial charge side of a polar molecule

Dipole – Dipole - Between neutral polar molecules. Positive side of one attracted to the negative of another



London Dispersion - A temporary dispersion in one atom can influence another. How nonpolar molecules can interact

Water you doin'? I'm studying Chemistry

Water is a great solvent due to its ability to form H-bonds

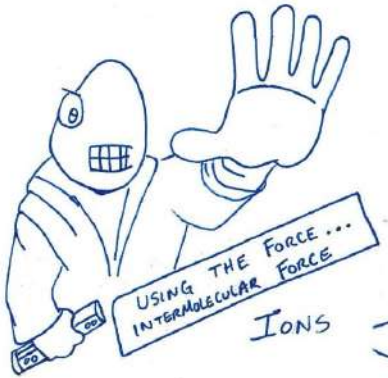
These forces help us to understand properties of different compounds like

- Viscosity - resistance to flow
- Solubility - How it dissolves other substances
- State of matter - if it is solid, liquid, gas at a specific temperature

Molasses moves slow due to the molecules all sticking together

If you add heat they break some of those forces & flow more freely

INTERMOLECULAR FORCES



INTRA MOLECULAR FORCES
BONDS WITHIN THE MOLECULE = IONIC OR COVALENT BONDS

FORCES BETWEEN MOLECULES OR IONS

		TYPE OF INTERMOLECULAR FORCE	EXAMPLES
IONS →	ALL IONS =	IONIC BONDING	$NaCl$, NH_4NO_3
IONS →	IONS WITH MOLECULES =	ION-DIPOLE FORCES	$MgCl_2$ IN H_2O
VAN DER WAAL FORCES: POLAR MOLECULES →	N, O, F BONDED TO H IN MOLECULES =	HYDROGEN BOND	H_2O, NH_3, HF
POLAR MOLECULES →	NO N, O, F =	DIPOLE-DIPOLE FORCE	H_2S, CH_3Cl
NON POLAR MOLECULES →	=	LONDON FORCES INDUCED DIPOLES	$Ar_{(g)}$, $I_{2(s)}$

HOW MOLECULES INTERACT WITH EACH OTHER HELP US PREDICT THEIR PHYSICAL PROPERTIES

EXAMPLES

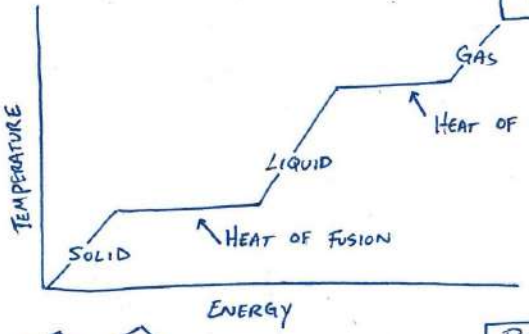
VISCOSITY - RESISTANCE TO FLOW IN LIQUIDS
BIGGER MOLECULES THAT HAVE MORE ATTRACTION
POUR SLOWLY = MOTOR OIL, MOLASSES

SURFACE TENSION - ENERGY REQUIRED TO BREAK THE SURFACE OF A LIQUID
H_2O HAS A HIGH SURFACE TENSION
B/C H_2O MOLECULES "STICK" TO EACH OTHER @ SURFACE = H-BOND

Intermolecular Forces

How substances interact with each other influences how they move through their states of matter

$S \leftrightarrow l \leftrightarrow g$



The more a substance can "stick" to itself the more energy will be required to move it from $S \rightarrow l$ & $l \rightarrow g$

Energy required to break the intermolecular forces

Vapor Pressure

The pressure exerted by vapor when the liquid & vapor are in dynamic equilibrium

Substances with high vapor pressure evaporate quickly

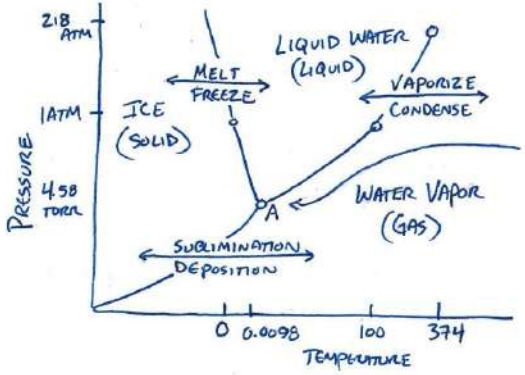
Gasoline = ↑ V.P.

Oil = ↓ V.P.

Volatile = evaporates easily

Pressure

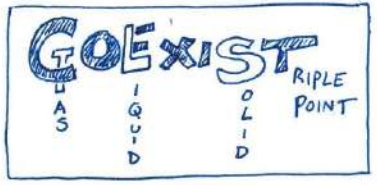
Influences how much energy is required to break intermolecular forces



A Triple point of substance

Triple point = the temperature & pressure at which the solid, liquid, and gas phase of a substance can coexist in equilibrium

Chemist Bumper Sticker



Thermochemistry

THERMOCHEMISTRY

POTENTIAL ENERGY

- THE ENERGY AVAILABLE TO DO WORK
  - ↳ BASED ON THE ARRANGEMENT OF THE ATOMS OF THE MOLECULE

KINETIC ENERGY

- THE ENERGY OF MOTION
  - ↳ ATOMS ARE CONSTANTLY MOVING

SOLID — TIGHT PACKED — JUST SHAKING

LIQUID — LOOSER — SLIDE PAST EACH OTHER

GAS — LOOSEST — SUPER FAST MOVEMENT

THE HEAT OF REACTIONS

- HEAT EITHER GOES INTO A REACTION → $A + B + \text{HEAT} \longrightarrow AB$ ENDOTHERMIC
- OR
- HEAT LEAVES A REACTION → $A + B \longrightarrow AB + \text{HEAT}$ EXOTHERMIC

TEMPERATURE - IS THE AVERAGE KINETIC ENERGY OF A SUBSTANCE. MEASURED IN CELCIUS ← BASED ON H_2O OR KELVIN

$0^\circ C$ FREEZING — $100^\circ C$ BOILING

↓ BASED ON KINETIC ENERGY

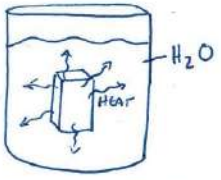
$0^\circ K$ = NO MOTION OF MOLECULES = $-273^\circ C$ OR $-459.4^\circ F$

CALLED ABSOLUTE ZERO.

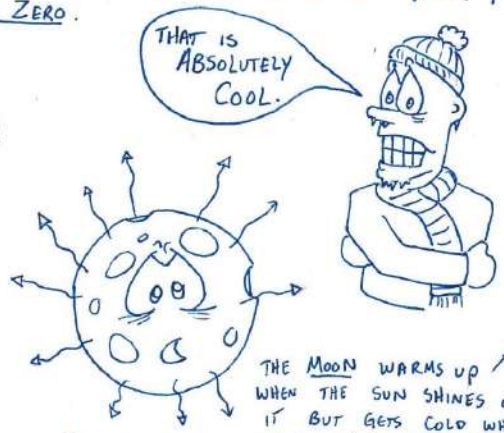
THE FIRST LAW OF THERMODYNAMICS

HEAT IS CONSERVED

HEAT LOST BY ONE OBJECT IS GAINED BY ANOTHER



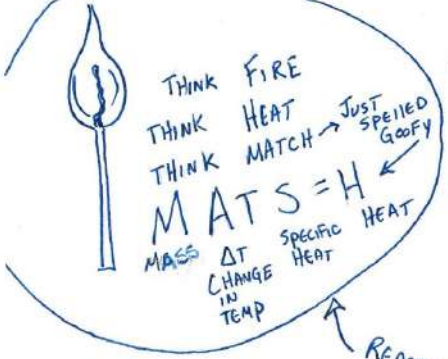
HEAT LOST BY THE HOT METAL WILL BE EQUAL TO THE HEAT GAINED BY THE WATER



EARTH STAYS NICE BECAUSE OF ATMOSPHERE

THE MOON WARMS UP → $100^\circ C$ WHEN THE SUN SHINES ON IT BUT GETS COLD WHEN IT DOESN'T → $-173^\circ C$. HEAT LOST TO SPACE

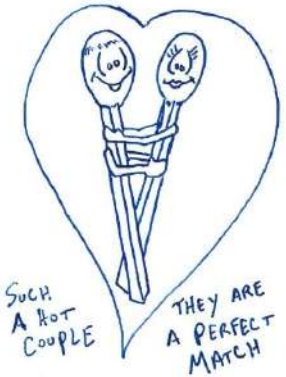
THERMOCHEMISTRY



HEAT OF A SUBSTANCE IS CALCULATED BY

HEAT = MASS OF SUBSTANCE × CHANGE OF TEMPERATURE × SPECIFIC HEAT OF THE SUBSTANCE

REARRANGE TO REMEMBER → $Q = M \times \Delta T \times C$



Ex: HOW MUCH HEAT IS REQUIRED TO WARM A 135g CUP OF WATER FROM 15.0°C TO 35.0°C ?

M ΔT S ← Look it up

$(135\,g)(20°C)(4.18\,J/g°C) = H$

11,286 JOULES OF HEAT → (11,300 J)

Ex: IF 2,162 JOULES OF HEAT IS ADDED TO 158g CUP OF WATER THAT IS AT 21.0°C WHAT WILL ITS FINAL TEMPERATURE BE?

M ΔT S

$(158\,g)(T_f - T_i)(4.18\,J/g°C) = 2,162\,J$

$(158\,g)(x - 21.0°C)(4.18\,J/g°C) = 2,162\,J$

$\Delta T = 3.27°C$ BUT IT STARTED @ 21.0°C

SO THE T_f = (24.3°C)

SPECIFIC HEAT

THE AMOUNT OF ENERGY REQUIRED TO RAISE 1g OF THE SUBSTANCE 1°C

Ex: H_2O 4.18 J/g°C

Cu 0.385 J/g°C

WATER TAKES A LOT OF ENERGY TO HEAT IT UP.

THIS IS WHY WATER BOILS SLOW.

SPECIFIC HEAT IS ...

SPECIFIC

EACH SUBSTANCE HAS ITS OWN SPECIFIC HEAT

TYPES OF REACTIONS

THERMOCHEMISTRY

ENTHALPY = HEAT ABSORBED OR RELEASED FROM A REACTION

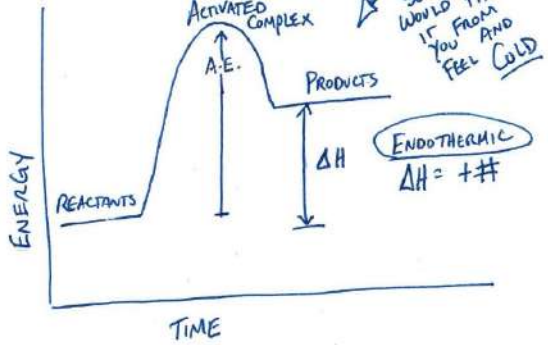
HEAT IS RELEASED AND WOULD FEEL HOT

EXOTHERMIC
ΔH = -#

ENTHALPY OF THE REACTION ΔH = $H_{FINAL} - H_{INITIAL}$

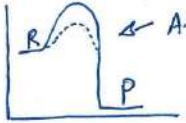
A.E. = ACTIVATION ENERGY = WHICH IS THE AMOUNT OF ENERGY REQUIRED TO GET A REACTION STARTED
CALCULATED BY THE ENERGY REQUIRED TO GET FROM REACTANTS TO THE ACTIVATED COMPLEX

ΔH = PRODUCTS - REACTANTS



ENDOTHERMIC
ΔH = +#

CATALYST = SPEED UP A REACTION BY DECREASING THE ACTIVATION ENERGY



A.E. CHANGES BUT NOT THE ΔH

Ex: $2H_2O_{2(\ell)} \rightarrow 2H_2O_{(\ell)} + O_{2(g)}$ ΔH = -196 KJ

CALCULATE THE VALUE OF Q (HEAT) WHEN 5.00g OF $H_2O_{2(\ell)}$ DECOMPOSES

REMEMBER THIS IS MOLES IN A BALANCED REACTION

$$\frac{5.00\text{g } H_2O_2}{1} \left| \frac{1\text{ MOLE } H_2O_2}{34.014\text{g}} \right| \frac{-196\text{ KJ}}{2\text{ MOLE } H_2O_2} = -28.8\text{ KJ}$$

Hess's Law

Many Enthalpy Reactions Have been tabulated & You can look them up.

Reactions are carried out in a series of steps and the ΔH of the reaction will be equal to the sum of the Enthalpy changes for each step.

Make sure you pay attention to the state of matter

Ex: Using the following Enthalpy of Combustions

1. $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H = -393.5\ KJ$
2. $CO_{(g)} + \frac{1}{2} O_{2(g)} \rightarrow CO_{2(s)}$ $\Delta H = -283.0\ KJ$

These come from known tables

Calculate the Enthalpy of Combustion of C to CO

$C_{(s)} + \frac{1}{2} O_{2(g)} \rightarrow CO_{(g)}$

Steps

1. $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\boxed{\Delta H = -393.5\ KJ}$

Notice how both C & O_2 are reactants just like the reaction Good

2. $CO_{2(g)} \rightarrow CO_{(g)} + \frac{1}{2} O_{2(g)}$ $\boxed{\Delta H = 283.0\ KJ}$

Notice I flipped the reaction this is because I wanted the $CO_{(g)}$ As a product this made the ΔH a positive value

$\Delta H = \Delta H_{step\ 1} + \Delta H_{step\ 2} = \boxed{-110.5\ KJ}$ Final Answer

$-393.5 + 283.0$

One Last Note

If your known intermediate reaction step is for 1 mole but your balanced equation is 2 or 3, you must multiple that step by 2 or 3

Ex: 1. $A + B \rightarrow C$ $\Delta H = 10\ kJ$

2. $X + Y \rightarrow Z$ $\Delta H = 20\ kJ$

ΔH for $3A \rightarrow Z$?

1. $(A + B \rightarrow C \quad \Delta H = 10\ kJ) \times 3 = 30\ KJ$
2. $X + Y \rightarrow Z \quad \Delta H = 20$

$\boxed{\Delta H = 50\ KJ}$

Heating & Cooling Curve

All Substances

Have their own Heating & Cooling Curve. They will look similar to this

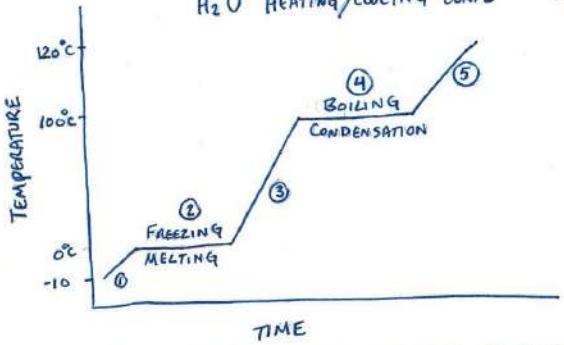
But the values will be different

Ex: Specific Heat
Heat of Fusion
Heat of Vaporization

What is the internal temperature of a Taun Taun?

How much heat is required to warm a 24.2g block of ice that is at -10.0°C to 120.0°C?

H_2O Heating/Cooling Curve



* You can't just $H = M\Delta TQ$ because it takes energy to break intermolecular forces holding water in various states
  - Solid ↔ Liquid = 6.02 kJ/1 mole
  - Liquid ↔ Gas = 40.67 kJ/1 mole

This problem will require 5 steps

① $H = M\Delta TQ$ $(24.2g)(10.0°C)(4.18 J/g°C)$ 1,010 J or 1.01 kJ

② Heat of Fusion for H_2O 6.02 kJ/1 mole
$\frac{24.2g\ H_2O}{18.01\ g\ H_2O} \left| \frac{1\ mole\ H_2O}{1\ mole} \right| \frac{6.02\ kJ}{1\ mole}$ 8.07 kJ

③ $H = M\Delta TQ$ $(24.2g)(100.0°C)(4.18 J/g°C)$ 10,116 J or 10.1 kJ

④ Heat of Vaporization for H_2O 40.67 kJ/1 mole
$\frac{24.2g\ H_2O}{18.01\ g\ H_2O} \left| \frac{1\ mole\ H_2O}{1\ mole} \right| \frac{40.67\ kJ}{1\ mole}$ 54.5 kJ

⑤ $H = M\Delta TQ$ $(24.2g)(20.6°C)(4.18 J/g°C)$ 2,023 J or 2.02 kJ

= 75.7 kJ

Entropy, Enthalpy, Gibbs Free Energy

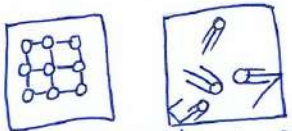
S H G

$\Delta S = S_{PRODUCTS} - S_{REACTANTS}$

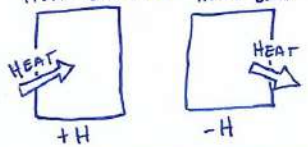
$\Delta H = H_{PRODUCTS} - H_{REACTANTS}$

$\Delta G = G_{PRODUCTS} - G_{REACTANTS}$

Entropy is a measurement of disorder. The more disorder ↑ S



Enthalpy is the measurement of energy in the thermodynamic system (the heat)



Gibbs Free Energy is the change in enthalpy minus the temperature times the change in entropy

$\Delta G = \Delta H - T\Delta S$

Think of it as available energy

$2Fe_{(s)} + O_{2(g)} \longrightarrow 2FeO_{(s)}$

Iron rusting is an example of a spontaneous reaction

ΔG	ΔH	ΔS	Spontaneous
+	+	−	Nope
+ or −	−	−	Yes but only @ low temps
+ or −	+	+	Yes but only @ high temps
−	−	+	Yes

Spontaneous means the reaction occurs without any outside influence

Kinetics

Chemical Kinetics

Burnt my Hawaiian pizza today. Guess I should have cooked it on Aloha temperature

When reactions aren't 1:1 we need to apply stoich

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

$$\text{Rate} = -\frac{1}{2}\frac{\Delta[H_2]}{\Delta t} = -\frac{1}{1}\frac{\Delta[O_2]}{\Delta t} = -\frac{1}{2}\frac{\Delta[H_2O]}{\Delta t}$$

All came from coefficients in balanced equation

Add up the exponents in the rate law equation to find the **reaction order**

$[NH_4^+]^1[NO_2^-]^1$

$1+1 =$ 2nd order

$$NH_4^+{}_{(aq)} + NO_2^-{}_{(aq)} \longrightarrow N_{2(g)} + 2H_2O_{(\ell)}$$

This can be applied to

Rate $= k[NH_4^+][NO_2^-]$

Rate Law = Rate depends on the concentration of the reactants

K = the rate constant

Exp #	$[NH_4^+]_{initial}$	$[NO_2^-]_{initial}$	Rate M/s
1	0.0100	0.200	5.4×10^{-7}
2	0.0200	0.200	10.8×10^{-7}
3	0.0400	0.200	21.5×10^{-7}
4	0.0600	0.200	32.3×10^{-7}

Solve for the rate constant K

$5.4 \times 10^{-7} M/s = k(0.0100 M)(0.200 M)$

$k = 2.7 \times 10^{-4} M^{-1} s^{-1}$

Rate Law using Initial Rates

$A + B \longrightarrow C$

Exp. #	$[A]_M$	$[B]_M$	Initial Rate
1	0.100	0.100	4.0×10^{-5}
2	0.100	0.200	4.0×10^{-5}
3	0.200	0.100	16.0×10^{-5}

* Compare experiments where only one reactant changes

Ex:
- Exp 1 + 2 = B changes but A doesn't

So $\frac{0.200}{0.100}$ = Double Concentration $\rightarrow 2^m$ $\qquad \frac{4.0\times10^{-5}}{4.0\times10^{-5}}$ = Rate stayed the same

$[B]^0$

- Exp 1+3 = A changes but B doesn't

$\frac{0.200}{0.100}$ = Double Conc. $\rightarrow 2^m$ $\qquad \frac{16.0\times10^{-5}}{4.0\times10^{-5}}$ = Rate $4\times$ $[A]^2$

$2^m = 4$ So $m = 2$

Rate $= k[A]^2$ 2nd order

How A Given Set of Reactants Turn into Products & The Speed = Rate They Do This

Chemical Kinetics

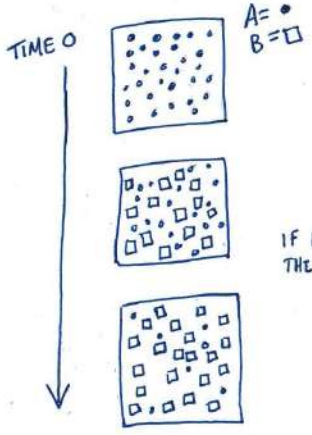
Rates of Reactions Affected By

1. Concentration of the Reactants
   - More Reactants = More Possibilities of Interaction or Collision
2. Temperature of the Reaction
   - ↑ Temp ↑ Movement of Particles = More Collisions
3. Presence of a Catalyst
   - ↑ Rate by Lowering the Activation Energy but Don't Get used as a Reactant
4. Surface Area of your Solid or Liquid
   - ↑ Surface Area ↑ Exposure of Particles to Interact

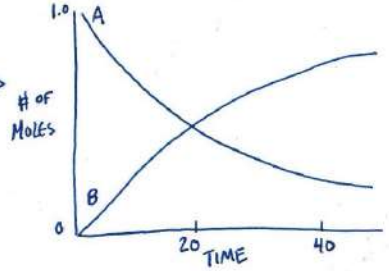
$A \longrightarrow B$

Average Rate Formula

$$\text{Avg Rate} = -\frac{\Delta \text{ Moles B}}{\Delta \text{ Time}}$$



If we Graphed the Concentrations ⇒



Instantaneous Rate = Rate within a window of time

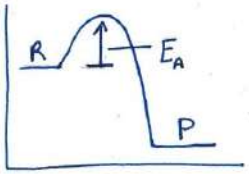
$$\text{I.R.}_{(0\text{-}20)} = -\left(\frac{[A]_{20} - [A]_{0}}{20_{sec} - 0_{sec}}\right)$$

$$\text{I.R.}_{(20\text{-}40)} = -\left(\frac{[A]_{40} - [A]_{20}}{40_{sec} - 20_{sec}}\right)$$

★ Because we have a curve our I.R. will be different all throughout the reaction

Chemical Kinetics

Temperature Related to Reactions



In order for molecules to react they must have a total kinetic energy greater or equal to the activation energy (E_A)

Arrhenius Equation: $K = Ae^{-Ea/RT}$

- K = Rate Constant
- E_a = Activation Energy
- A = Frequency Factor → Relation to the frequency of collisions & the probability that those collisions are favorable for the reaction
- T = Absolute temperature

★ As E_a gets bigger the K (rate constant) becomes smaller

Reaction rates decrease as the energy barrier increases

Catalysts

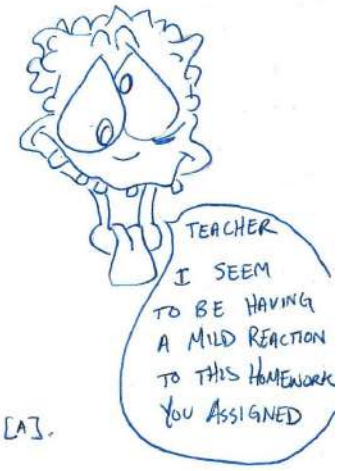
- Speed up reactions by lowering the activation energy
- It does not go through change in the reaction
- They are not used up.

Random Joke Time

Reaction Rates

Half Life ($t_{1/2}$) is the amount of time it takes for the concentration of a reactant to decrease by half its initial value

How fast a reaction turns reactants into products. This can be changed if concentration, pressure, temperature, etc. get changed



Zero Order Reaction

A reaction whose rate does not change with $\Delta[A]$.

[A]	Rate
1	1
2	1
3	1

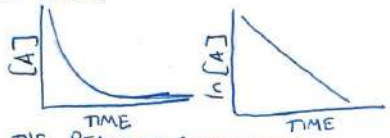
$$\text{Rate} = -\frac{\Delta[A]}{\Delta t} = k$$

First Order Reaction

A reaction whose rate depends on the concentration of a single reactant to the first power.

[A]	Rate
1	1
2	2
3	3

$$\text{Rate} = -\frac{\Delta[A]}{\Delta t} = k[A]$$

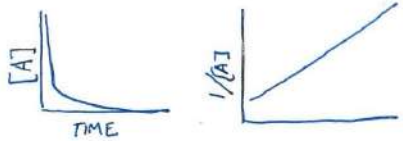


Second Order Reaction

A reaction whose rate depends on the reactant concentration raised to the second power. It could also be 2 reactants each raised to the first power

[A]	Rate
1	1
2	4
3	9

$$\text{Rate} = -\frac{\Delta[A]}{\Delta t} = k[A]^2$$



Catalysts

Heifer
Bovine
Black Angus
Long Horn
Roan

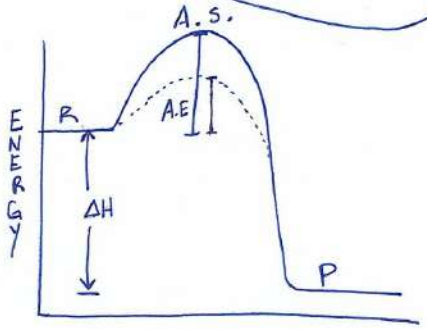
Substances that are added to a reaction to increase the rate without being consumed in the reaction.

★ Notice that adding a catalyst does not change the ΔH

Accomplished in two ways

1. Lower the activation state & in turn it lowers the activation energy
2. Change the mechanism of the reaction

★ Reactions can now occur more vigorously @ current conditions.



Acid/Base Catalyst

- Acids will donate H^+ to the reaction
- Bases will donate OH^- to the reaction

Don't get used up. "Loosen" bonds

H_2O + Sucrose ⟶ Glucose + Fructose

Heterogeneous – Surface Catalysts

Heterogeneous = the catalyst is in a different phase than the reactants

- The key component is to increase the surface area for the reaction to occur

This is how catalytic converters work. Turns bad exhaust into CO & unspent fuel.

Biological = Enzymes

- A protein with a 3-D shape that works on specific reactants (substrate). "Loosens" the bond

In order to rearrange the bonds of compounds found in a candy bar we need a surplus of 375° F. We accomplish this @ body temp with enzymes.

Equilibrium

EQUILIBRIUM

DYNAMIC EQUILIBRIUM

- REACTIONS CONTINUE TO TAKE PLACE
- REACTANTS TURN INTO PRODUCTS
- PRODUCTS CONTINUE TO TURN INTO REACTANTS
- FORWARD & REVERSE = SAME RATE

$A + B \rightleftharpoons C$

IF YOU RUN A REACTION IN A CLOSED CHAMBER THE REACTION WILL REACH EQUILIBRIUM

- IF VERY LITTLE PRODUCT IS FORMED EQUILIBRIUM LIES TO THE FAR LEFT
- IF VERY LITTLE REACTANTS ARE LEFT EQUILIBRIUM LIES TO THE FAR RIGHT

REACTION QUOTIENT

THE MEASUREMENT OF [REACTANTS] COMPARED TO [PRODUCTS] @ ANY POINT OF TIME.

★ PREDICT WHICH WAY THE REACTION WILL GO

$$Q = \frac{[\text{PRODUCTS}]}{[\text{REACTANTS}]}$$

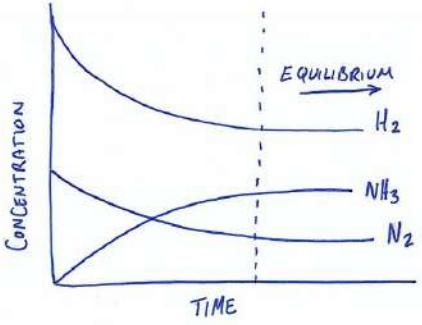
$Q > K$ TO LEFT

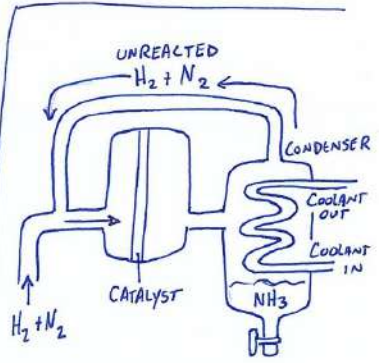
$Q = K$ NO NET Δ

$Q < K$ TO RIGHT

$$N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$$

- HYDROGEN IS GETTING CONSUMED AT 3x THE RATE OF NITROGEN
- AMMONIA IS BEING PRODUCED AT 2x THE RATE NITROGEN IS BEING USED





HABER PROCESS

- THE ARTIFICIAL PROCESS OF GETTING N_2 GAS INTO A COMPOUND USABLE FOR CROPS

$NH_{3(\ell)}$ ← #1 APPLICATION OF $NH_{3(\ell)}$

EQUILIBRIUM

* REMEMBER ONLY (aq) & (g) GET CONSIDERED FOR EQUILIBRIUM

THIS IS THE SITUATION WHERE THE FORWARD REACTION & THE REVERSE REACTION ARE GOING @ THE SAME RATE

$$aA \rightleftharpoons bB + cC$$

LAW OF MASS ACTION

EXPRESSION OF THE RELATIONSHIP BETWEEN THE CONCENTRATION OF THE REACTANTS & PRODUCTS @ EQUILIBRIUM

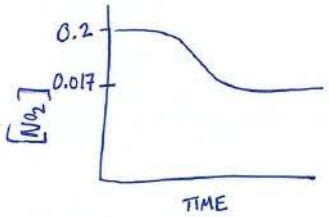
EQUILIBRIUM CONSTANT EXPRESSION

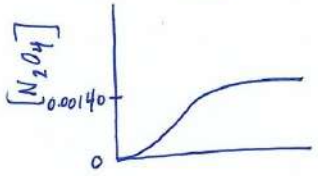
$$K_c = \frac{[B]^b[C]^c}{[A]^a}$$

$$K_c = \frac{[\text{PRODUCT CONCENTRATIONS}]^{\text{COEFFICIENT}}}{[\text{REACTANT CONCENTRATIONS}]^{\text{COEFFICIENT}}}$$

MAGNITUDE OF K

- IF $K > 1$
  EQUILIBRIUM LIES TO THE RIGHT PRODUCTS FAVORED
- IF $K < 1$
  EQUILIBRIUM LIES TO THE LEFT REACTANTS FAVORED





Ex: $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$

WRITE THE EQUILIBRIUM EXPRESSION

$$K_c = \frac{[NO_2]^2}{[N_2O_4]}$$

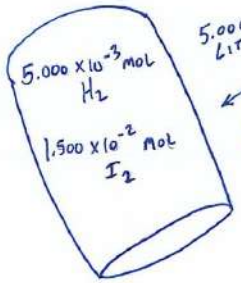
USING THE EXPERIMENT RESULTS CALCULATE THE EQUILIBRIUM CONSTANT

$$K_c = \frac{(0.0172)^2}{(0.00142)} = \boxed{0.211}$$

EXPERIMENT RESULTS

INITIAL CONCENTRATION $NO_{2(g)} = 0.0200\,M$
INITIAL CONCENTRATION $N_2O_{4(g)} = 0.0\,M$
CONCENTRATION $NO_{2(g)}$ @ EQUILIBRIUM $= 0.0172\,M$
CONCENTRATION $N_2O_{4(g)}$ @ EQUILIBRIUM $= 0.00140\,M$

EQUILIBRIUM



EXAMPLE PROBLEM

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

INFORMATION WAS GATHERED @ EQUILIBRIUM

FINDING $[HI] = 1.20 \times 10^{-3}$ M

FIGURE OUT THE K_C OF THE REACTION

① CONVERT THE H_2 & I_2 INTO A CONCENTRATION

$\frac{5.000 \times 10^{-3} \text{ mol}}{5.000 \text{ L}} = 1.000 \times 10^{-3}$ M $[H_2]$ $\quad \frac{1.500 \times 10^{-2} \text{ mol}}{5.000 \text{ L}} = 3.000 \times 10^{-3}$ M $[I_2]$

② PLUG INTO AN I.C.E. TABLE

$$H_2 + I_2 \rightleftharpoons 2HI$$

I	1.000×10^{-3} M	3.000×10^{-3} M	0 M
C	(-0.60×10^{-3})	(-0.60×10^{-3})	$+1.20 \times 10^{-3}$
E			1.20×10^{-3}

③ SINCE HI INCREASED BY 2.23×10^{-3} & BALANCED REACTION SHOWS

$H_2 : I_2 : 2HI$
$1 : 1 : 2$ RATIO, H_2 & I_2 MUST DECREASE BY ½ OF WHAT HI INCREASED

④ SO $H_2 = 0.400 \times 10^{-3}$ & $I_2 = 2.400 \times 10^{-3}$ @ EQUILIBRIUM

PLUG INTO $K_c = \frac{[HI]^2}{[H_2][I_2]} = 1.5$

EQUILIBRIUM

* IN A CLOSED CONTAINER WE DON'T NEED TO WORRY ABOUT IT WHEN EXAMING EQUILIBRIUM

$PV = nRT$

TWO HELIUM ATOMS WERE ACTING FUNNY

He He

PRESSURE OF GASES

THERE IS A RELATIONSHIP BETWEEN THE EQUILIBRIUM OF CONCENTRATIONS K_c AND THE EQUILIBRIUM OF PRESSURES K_p

$$K_p = K_c(RT)^{\Delta n}$$

- K_p: EQUILIBRIUM PRESSURE
- K_c: EQUILIBRIUM CONCENTRATION
- R: GAS CONSTANT
- T: TEMP
- Δn: CHANGE IN # OF MOLES PRODUCTS − REACTANTS

AS YOU CHANGE THE TEMPERATURE OF A SYSTEM YOU WILL INFLUENCE THE REACTION & THE CONCENTRATION OF EACH GAS IN THE REACTION SINCE THE # OF MOLES (n) INFLUENCES THE PRESSURE, YOU GET A PREDICTABLE RELATIONSHIP

Ex: $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

GIVEN THE K_c OF THE REACTION IS 9.60 AT 300.°C, CALCULATE THE K_p

① THE $\Delta n = \left(2_{NH_3} - 4_{N_2+3H_2}\right) = -2$ (PRODUCT − REACTANT)

② CONVERT YOUR TEMPERATURE °C → °K

③ $K_p = (9.60)(0.0821 \times 573)^{-2} = 4.34 \times 10^{-3}$

EQUILIBRIUM

LE CHÂTELIER

Ex:

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

4 MOLES — 2 MOLES

↑ PRESSURE = SHIFT RIGHT

↓ PRESSURE = SHIFT LEFT

$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$

1 MOLE — 2 MOLES

↑ PRESSURE = SHIFT LEFT

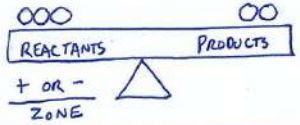
↓ PRESSURE = SHIFT RIGHT

PRESSURE WILL INFLUENCE GAS BASED EQUILIBRIUM REACTIONS

★ INCREASE THE PRESSURE & DECREASE THE VOLUME WILL PUSH THE REACTION TOWARDS THE SIDE WITH LESS MOLES OF GAS

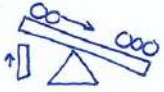
2 GAS x + 1 GAS y ⇌ 2 GAS z

★ IDENTIFY WHICH SIDE HAS THE MOST MOLES OF GAS



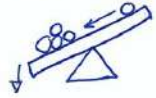
Δ PRESSURE

① INCREASE THE PRESSURE LIFTS THE REACTANT SIDE



RESULT: LESS REACTANT & MORE PRODUCT

② DECREASE PRESSURE PULLS DOWN THE REACTANT SIDE



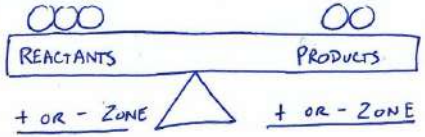
RESULTS IN MORE REACTANTS & LESS PRODUCTS

EQUILIBRIUM

LE CHÂTELIER PRINCIPLE

ENDOTHERMIC
REACTANTS + HEAT ⇌ PRODUCTS

EXOTHERMIC
REACTANTS ⇌ PRODUCTS + HEAT



ENDOTHERMIC REACTIONS:
↑ TEMP ↑ K = SHIFT RIGHT

EXOTHERMIC REACTIONS:
↑ TEMP ↓ K = SHIFT LEFT

HEAT CAN BE CONSIDERED A REACTANT OR A PRODUCT. SO WHEN YOU ADD OR REMOVE IT, THE RESULTS WILL LOOK LIKE Δ IN CONCENTRATION

Δ IN TEMPERATURE

$$\underset{\text{(PINK)}}{Co(H_2O)_6^{2+}(aq)} + 4Cl^-_{(aq)} + HEAT \rightleftharpoons \underset{\text{(BLUE)}}{CoCl_4^{2-}(aq)} + 6H_2O_{(l)}$$

① IF WE ADD HEAT TO THE RXN IT LIFTS THE REACTANT SIDE

RESULTS IN MORE PRODUCTS & LESS REACTANTS
LOOKS BLUE

② IF WE COOL THE SOLUTION IT IS A REMOVAL OF HEAT
PULL DOWN THE REACTANT SIDE

RESULTS IN MORE REACTANTS LESS PRODUCTS
PINK

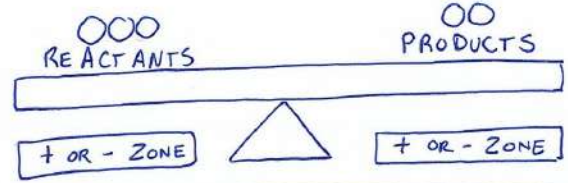
EQUILIBRIUM

LE CHÂTELIER PRINCIPLE

IF A SYSTEM AT EQUILIBRIUM IS DISTURBED BY A CHANGE IN TEMPERATURE, PRESSURE OR THE CONCENTRATION OF ONE OF THE COMPONENTS, THE SYSTEM WILL SHIFT ITS EQUILIBRIUM POSITION TO COUNTERACT THE DISTURBANCE

Ex: $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

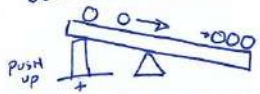
- ADDING $N_{2(g)}$ WILL RESULT IN MORE $NH_{3(g)}$ & LESS $H_{2(g)}$
- THE H_2 GETS USED UP



☆ YOU CAN'T ADD TO THE TOP OF THE BEAM
- ONLY PULL DOWN OR PUSH UP ON THE BEAM

CONCENTRATION

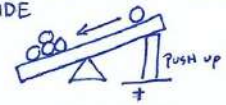
① ADD A REACTANT = LIFTS THE BALANCE BEAM ON THE LEFT



BALLS ROLL TO PRODUCTS

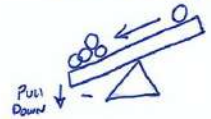
RESULT MORE PRODUCTS BUT LESS OF THE OTHER REACTANT

② ADD MORE PRODUCT LIFTS BALANCE ON PRODUCT SIDE



RESULT MORE REACTANTS

③ REMOVE REACTANTS PULLS THE BALANCE DOWN ON THE LEFT



RESULT MORE REACTANTS & LESS PRODUCTS

Acids and Bases

ACIDS & BASES

ARRHENIUS DEFINITION OF ACIDS & BASES

ACIDS = SUBSTANCE ADDED TO H_2O ↑ $[H^+]$

BASES = SUBSTANCE ADDED TO H_2O ↑ $[OH^-]$

BRØNSTED - LOWRY ACIDS & BASES

ACID = DONATES H^+ TO A SUBSTANCE

BASE = ACCEPTS H^+ FROM A SUBSTANCE

$$\underset{\text{BRØNSTED-LOWRY ACID}}{HCl_{(g)}} + \underset{\text{BRØNSTED-LOWRY BASE}}{H_2O_{(l)}} \longrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$$

- BASE TURNS INTO CONJUGATE ACID
- ACID TURNS INTO CONJUGATE BASE

AUTO IONIZATION OF H_2O

H_2O ACTS AS AN ACID OR BASE

$$2H_2O \rightleftharpoons \underset{\text{ACID}}{H_3O^+} + \underset{\text{BASE}}{OH^-}$$

EQUILIBRIUM

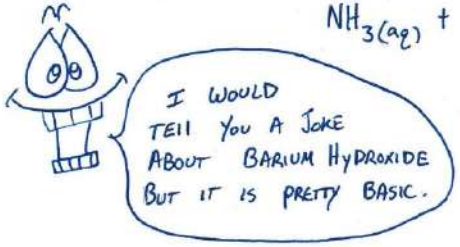
$$K_w = \frac{[H_3O^+][OH^-]}{[H_2O]^2}$$

↓ ION-PRODUCT CONSTANT OF H_2O

$$K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14} \text{ @ } 25.0^\circ C$$

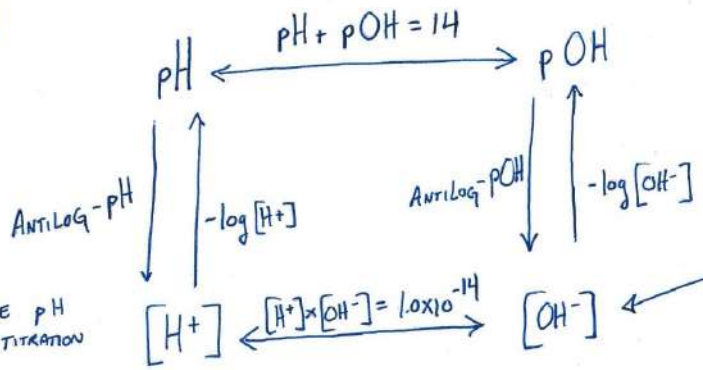
CONJUGATE ACID - BASE PAIRS

$$\underset{\text{BASE}}{NH_{3(aq)}} + \underset{\text{ACID}}{H_2O_{(l)}} \rightleftharpoons \underset{\text{CONJUGATE ACID}}{NH_4^+{}_{(aq)}} + \underset{\text{CONJUGATE BASE}}{OH^-{}_{(aq)}}$$



Acids & Bases

What do you do with a dead chemist?



You can use the pH box to solve titration problems.

Ex: How much of a 3M NaOH solution would be needed to neutralize 151ml of a 1.5 pH solution HCl?

1. Convert 1.5 pH to $[H^+]$
2. $M_1V_1 = M_2V_2$

$([H^+])(.151L) = (3M)(x)$

We can use this box to help us solve problems & convert between pH, pOH, $[OH^-]$, $[H^+]$

Ex: What is the pH of a 3.2 M NaOH solution?

- 3.2M is the concentration of NaOH. NaOH breaks up into Na^+ & OH^- so the $[OH^-]$ is 3.2M
- Enter here
- $-\log [OH^-] = -0.51$ pOH
- pH + pOH = 14
- pH of the solution is 14.51

Things to Remember

Poly Protic Acids & Bases don't have the same $[H^+]$ or $[OH^-]$ as the original solution

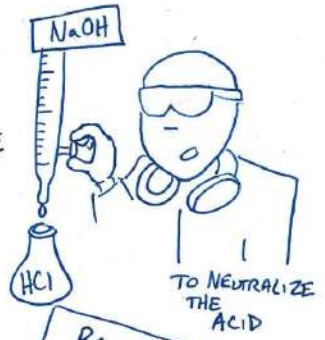
Ex: $\underline{3.2}M\ H_2SO_4 \rightarrow \underline{2}H^+ + SO_4^{-2}$

$6.4M = [H^+]$

$2 \times 3.2M$

ACIDS & BASES

HELP! NaCl / NaOH
MY BASE IS UNDER ASSAULT



ACIDS - SUBSTANCES THAT RELEASE H^+ IONS INTO AN AQUEOUS SOLUTION. THIS ↑ $[H^+]$

BASES - SUBSTANCES THAT ACCEPT H^+ IN AN AQUEOUS SOLUTION. OFTEN RELEASE OH^- WHICH REACTS WITH H^+. THIS ↓ $[H^+]$

ACID PROPERTIES
- TASTE SOUR
- pH LOWER THAN 7
- BLUE LITMUS RED
- RELEASE H^+

BASE PROPERTIES
- TASTE BITTER
- TURN RED LITMUS BLUE
- pH HIGHER THAN 7
- RELEASE OH^-

ACIDS & BASES THAT ARE STRONG ELECTROLYTES ARE CALLED STRONG ACIDS & STRONG BASES.
- THEY COMPLETELY IONIZE IN SOLUTION.

STRONG ACIDS

HBr, HCl, HI
$HClO_3$, $HClO_4$, HNO_3
H_2SO_4

STRONG BASES

ALKALI METAL HYDROXIDES
$LiOH$, $NaOH$, KOH, $RbOH$, $CsOH$
SOME ALKALINE EARTH METAL HYDROXIDES
$Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$

NEUTRALIZATION REACTION

ACID MIXED WITH BASE & PRODUCTS ARE NEITHER ACIDIC OR BASIC

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$$

ACID BASE WATER SALT

NET IONIC

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

WEAK ACIDS & WEAK BASES REQUIRE I.C.E. TABLES

RULE OF THUMB

IF THE INITIAL CONCENTRATION IS 100X BIGGER THAN THE K_a YOU CAN NEGLECT X

$$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

REACTANTS $\rightleftharpoons$ PRODUCTS

I	INITIAL CONCENTRATION	[BEGINNING]	[BEGINNING]
C	CHANGE	$-X$	$+X$
E	EQUILIBRIUM	BEGINNING $-X$	BEGINNING $+X$

DETERMINE THE pH OF 0.30M $HC_2H_3O_2$ WITH K_a OF 1.8×10^{-5}

* USE THE ICE TABLE

	$HC_2H_3O_2$	$\rightleftharpoons$	H^+	+	$C_2H_3O_2^-$
INITIAL	0.30 M		0.0M		0.0M
CHANGE	$-X$		$+X$		$+X$
EQUILIBRIUM	$0.30 - X$		X		X

$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

PLUG IN

1. $1.8 \times 10^{-5} \quad \frac{[X][X]}{[0.30 - X]}$

YOU CAN DISREGARD THE X BECAUSE THE K_a IS SO SMALL COMPARED TO THE 0.30M

* AVOID USING THE QUADRATIC EQUATION

2. $1.8 \times 10^{-5} = \frac{x^2}{0.30}$

3. $x = 2.3 \times 10^{-3}$ OR $[H^+] = 2.3 \times 10^{-3}$

4. $pH = -\log[H^+]$ SO $pH = 2.64$

Acids & Bases

Example Weak Acids	
Formic	$HCOOH$
Acetic	CH_3COOH
Hydro Flouric	HF
Conjugate Acid of a Weak Base	NH_4^+
Example Weak Bases	
Ammonia	NH_3
Ammonium Hydroxide	NH_4OH
Conjugate Bases of Weak Acids	$HCOO^-$

Weak Acids & Bases

- Acids/Bases that partially ionize in water

HX = our weak acid

$$HX_{(aq)} \rightleftharpoons H^+_{(aq)} + X^-_{(aq)}$$

Form an Equilibrium Expression

$$K_a = \frac{[H^+][X^-]}{[HX]} \qquad K_a = \frac{[\text{Products}]}{[\text{Reactants}]}$$

Pigeon Acid
Cooh Cooh

$$HC_2H_3O_2 \rightleftharpoons H^+ + C_2H_3O_2^-$$

Write the Equilibrium Expression if the $K_a = 1.8 \times 10^{-5}$

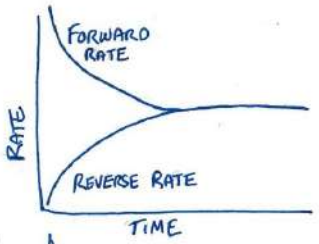
$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

To calculate the pH of the solution?
You need to take it a step further

I.C.E. tables

Equilibrium = Balance

where the forward reaction & reverse are happening at an equal rate



I'M AN EYE SCREAM CONE!

MORE ICE

PROBLEMS ACID/BASE

A SOLUTION IS MADE BY ADDING CRYSTAL BLEACH (SODIUM HYPOCHLORITE) TO ENOUGH WATER TO MAKE A 3.00L SOLUTION. THE SOLUTION HAS A pH OF 10.50. HOW MANY MOLES OF BLEACH WERE ADDED?

1. WRITE OUT THE REACTION

$$NaClO_{(s)} + H_2O_{(\ell)} \rightleftharpoons HClO_{(aq)} + NaOH_{(aq)}$$

SODIUM IS A SPECTATOR ION SO $\longrightarrow$ $ClO^-_{(aq)} + H_2O_{(\ell)} \rightleftharpoons HClO_{(aq)} + OH^-_{(aq)}$

2. REMEMBER YOUR pH/pOH SQUARE

(a) $pH + pOH = 14$ So $pOH = 3.50$

$10.50 + (x)$

(b.) $[OH^-] = 10^{-3.50} = 3.2 \times 10^{-4} M$

3. ICE TABLE

$$ClO^-_{(aq)} + H_2O_{(\ell)} \rightleftharpoons HClO_{(aq)} + OH^-_{(aq)}$$

I	xM	–	0	0
C	-3.2×10^{-4} M	–	$+3.2\times10^{-4}$ M	$+3.2\times10^{-4}$ M
E	$x-3.2\times10^{-4}$ M	–	3.2×10^{-4} M	3.2×10^{-4} M

★ REMEMBER WE DON'T HAVE TO WORRY ABOUT H_2O. IT IS A LIQUID

Look it up

K_b OF $ClO^- = 3.3 \times 10^{-7}$

$$K_b = \frac{[HClO][OH^-]}{[ClO^-]} \quad \frac{(3.2\times10^{-4})^2}{x-3.2\times10^{-4}} = 3.3\times10^{-7} \quad 0.31\,M = [ClO^-]$$

CAN IGNORE IT

4. $0.31\,M\,[ClO^-] = \frac{0.31\,M}{1L} = \frac{x}{3\,\text{LITER}} = 0.93\,M$ ★

Acids Bases Buffers

Solutions that maintain a certain pH even after acids or bases are added to a solution, are called **Buffers**.

Strong acids & strong bases cannot be buffers because they fully dissociate

We can find the pH of a buffer solution by using the Henderson-Hasslebach equation

$$pH = pK_a + \log\left(\frac{[A^-]}{[HA]}\right)$$

A^- = Acid

HA = Conjugate Base

$$pOH = pK_b + \log\left(\frac{[B^+]}{[BOH]}\right)$$

B^+ = Base

BOH = Conjugate Acid

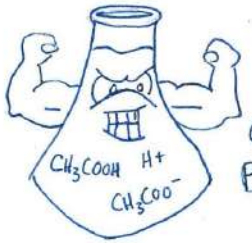
Ex: If you are looking for a buffer of weak acid/base you should pick one based on the fact that they will hold ± 1 pH around its pK_a.

Acetic Acid ($pK_a = 4.7$) so it is good for

$pH = 5.7 - 3.7$

* You should also pick a buffer based on its concentration

2M Formic Acid has a greater buffering capacity than 1M formic acid



Gettin Buffer

Human blood has a buffering system

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+$$

Average Human Blood Normal pH = 7.35

- So if too much CO_2 is in the blood it will lower the pH.

  The nervous system responds by causing hyperventilation

- Conversely, Alkatosis (↑pH) will cause breathing to slow down

Acids & Bases

Why are strong acids & bases bad to get on your skin?

Strong acids will hydrolyze fats in the skin & (break apart) denature (change its form) proteins if you change the form of proteins you change their function the reaction also releases substantial heat.

ILLEGAL

Tripping on acid

The pH Scale

* A number that is associated with the concentration of H^+ in a solution

The amount of H^+ in an aqueous solution is generally pretty small Ex: $1.0 \times 10^{-6} M$

So pH is expressed in the negative logarithm base of 10 of $[H^+]$

$$-\log[H^+] = pH$$

Tripping Point

A solution with a lot of H^+ gives you a lower pH

$1.0 \times 10^{-1} M = pH = 1$

-vs-

$1.0 \times 10^{-4} M = pH = 4$

10.0M NaOH

pH = 15

* Notice the pattern

12.0M HCl

pH = -1.08

Base

Small amounts of H^+ more OH^-

pH = 14

$[H^+] = 1 \times 10^{-14}$

$[OH^-] = 1 \times 10^{-0}$

pOH = 0

Bleach & Ammonia

pH = 12

$[H^+] = 1 \times 10^{-12}$

$[OH^-] = 1 \times 10^{-2}$

pOH = 2

Neutral

$[H^+] = [OH^-]$

Rain

Human blood

pH = 7

$[H^+] = 1.0 \times 10^{-7}$

$[OH^-] = 1.0 \times 10^{-7}$

pOH = 7

pH = 3

$[H^+] = 1.0 \times 10^{-3}$

$[OH^-] = 1.0 \times 10^{-11}$

pOH = 11

Pop, Vinegar

Acid

Large amounts of H^+ less OH^-

Stomach acid

pH = 1

$[H^+] = 1.0 \times 10^{-1}$

$[OH^-] = 1.0 \times 10^{-13}$

pOH = 13

ElectroChem

ELECTROCHEM

REDOX REACTIONS

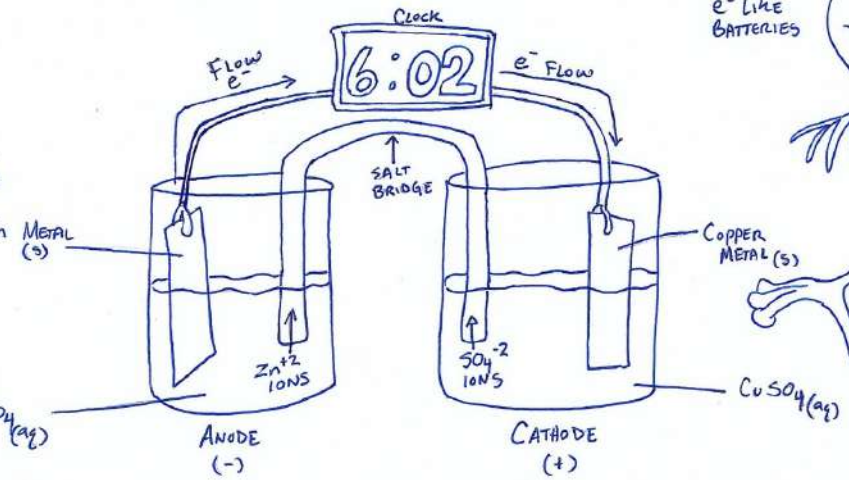
THE FLOW OF e^- CAN ALLOW US TO DO WORK

GALVANIC / VOLTAIC CELL

ELECTROCHEMICAL CELL THAT GETS ITS ENERGY FROM THE TRANSFER OF ELECTRONS IN A REDOX REACTION

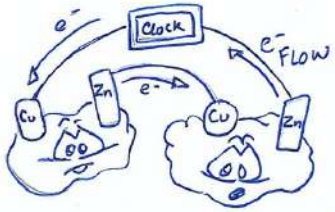
ANODE IS THE ELECTRODE WHERE LOSS OF ELECTRONS TAKES PLACE

CATHODE IS THE ELECTRODE WHERE THE GAIN OF ELECTRONS TAKE PLACE



★ BECAUSE $Zn_{(s)}$ IS MORE REACTIVE IT LOSES ITS e^- ACROSS THE WIRE (CLOCK) TO COPPER METAL.

- THIS MAKES Zn^{+2} IONS & THE $Zn_{(s)}$ METAL WEARS AWAY
- Cu^{+2} IONS PULL OUT OF SOLUTION & IS REDUCED TO BECOME $Cu_{(s)}$

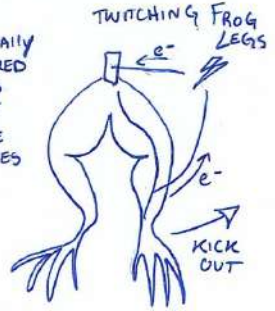


POTATO CLOCK

- THE POTATO JUST SERVES AS A SALT BRIDGE FOR e^- FLOW

LUIGI GALVANI = DISCOVERED ANIMAL ELECTRICITY

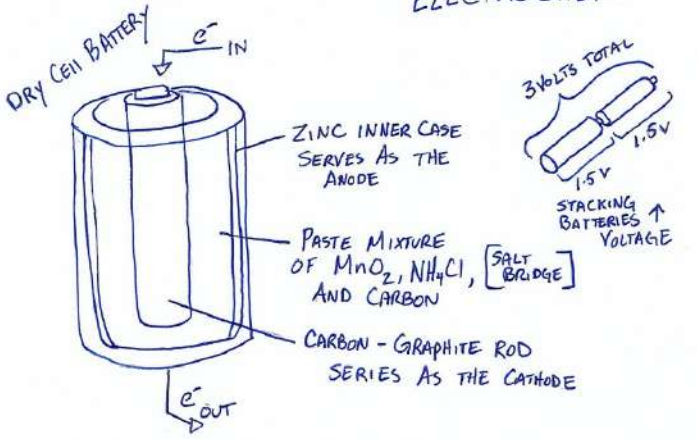
★ ACTUALLY DISCOVERED NEURONS CONDUCT e^- LIKE BATTERIES

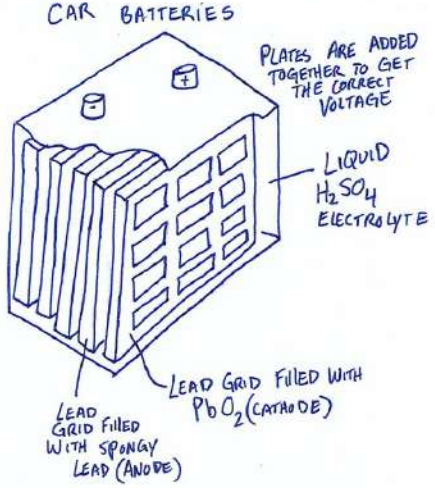


IVE HEARD ABOUT GETTING A LEG UP ON A SITUATION, BUT THIS IS CRAZY

BATTERIES

ELECTROCHEM





- IN A RECHARGEABLE BATTERY YOU PUT THE BATTERY INTO A DEVICE THAT REVERSES THE FLOW OF e^-.

CATHODE

$$2MnO_{2(s)} + 2H_2O_{(l)} + 2e^- \longrightarrow 2MnO(OH)_{(s)} + 2OH^-_{(aq)}$$

ANODE

$$Zn_{(s)} + 2OH^-_{(aq)} \longrightarrow Zn(OH)_{2(s)} + 2e^-$$

CATHODE

$$PbO_{2(s)} + HSO_4^-{}_{(aq)} + 3H^+_{(aq)} + 2e^- \longrightarrow PbSO_{4(s)} + 2H_2O_{(l)}$$

ANODE

$$Pb_{(s)} + HSO_4^-{}_{(aq)} \longrightarrow PbSO_{4(s)} + H^+_{(aq)} + 2e^-$$

$$PbO_{2(s)} + Pb_{(s)} + 2HSO_4^-{}_{(aq)} + 2H^+_{(aq)} \longrightarrow 2PbSO_{4(s)} + 2H_2O_{(l)}$$

ELECTROCHEM

NERST EQUATION

$$E_{CELL} = E^{\circ}_{CELL} - (RT/nF) \times \ln Q$$

THIS SHOULD NOT BE CONFUSED WITH THE NERD EQUATION

AUTHOR SELF PORTRAIT

$$N_{ERD} = \frac{(\#\text{ STAR WARS QUOTES})(\text{SCIENCE FACTS})(\text{DR. WHO REFERENCES})}{(\text{ABILITY TO MAKE FREE THROWS OR KICK A GOAL})}$$

E_{CELL} IS THE CELL POTENTIAL

E°_{CELL} THE STANDARD CELL POTENTIAL

R GAS CONSTANT (8.3145 J/MOL·K)

T IS THE ABSOLUTE TEMPERATURE

n # OF MOLES OF ELECTRONS TRANSFERRED

F FARADAY'S CONSTANT (96485.337 C/MOL)

Q REACTION QUOTIENT

$$Q = \frac{[C]^c \cdot [D]^d}{[A]^a \cdot [B]^b} \quad \} \quad aA + bB \rightarrow cC + dD$$

FIND THE CELL POTENTIAL BASED ON THE ½ REACTION @ 25°C

$Cd^{2+} + 2e^- \rightarrow Cd \quad E^{\circ} = -0.403\,V$

$Pb^{2+} + 2e^- \rightarrow Pb \quad E^{\circ} = -0.126\,V$

$[Cd^{2+}] = 0.020\,M$ &

$[Pb^{2+}] = 0.200\,M$

$Pb^{2+}_{(aq)} + Cd_{(s)} \rightarrow Cd^{2+}_{(aq)} + Pb_{(s)}$

① $\left(\frac{RT}{nF}\right)$ (25°C → K)

$$\left(\frac{(8.3145\,J/mol\cdot K)(300\,K)}{(2\,mol)(96485.337\,C/mol)}\right) = 0.013\,V$$

② $\ln Q$

$$Q = \frac{[Cd^{2+}]}{[Pb^{2+}]} \quad \frac{0.020\,M}{0.200\,M} = 0.100$$

③ $E^{\circ} = (Cd \rightarrow Cd^{2+} + 2e^-) + (Pb^{2+} + 2e^- \rightarrow Pb) = 0.277$

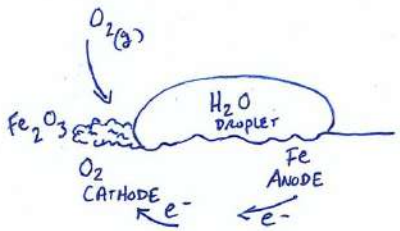
$0.403\,V + -0.126\,V$

$$E_{CELL} = \underset{E^{\circ}_{CELL}}{0.277} - \underset{\left(\frac{RT}{nF}\right)}{(0.013V)} \times \ln \underset{Q}{(0.100)}$$

$$\boxed{E_{CELL} = 0.300V}$$

Corrosion

THE UNDESIRABLE REDOX REACTIONS
WHEN A METAL IS ATTACKED BY A SUBSTANCE IN THE ENVIRONMENT CREATING AN UNWANTED COMPOUND



- THE MORE O_2 = ↑ RUST
- SALT INCREASES THE REACTION ↑[ELECTROLYTE]

THE CORROSION OF IRON IS A COMMON REACTION WITH OXYGEN BUT IT REQUIRES WATER AS WELL

RUST:
- IRON III OXIDE
BRITTLE ORANGE/RED COMPOUND
- MILLIONS OF DOLLARS OF DAMAGE IN THE ECONOMY
- PREVENTING IT IS BIG BUSINESS

CATHODE

$$O_{2(g)} + 4H^+_{(aq)} + 4e^- \longrightarrow 2H_2O_{(l)} \quad E°_{RED} = 1.23V$$

ANODE

$$Fe \longrightarrow Fe^{2+}_{(aq)} + 2e^- \quad E°_{RED} = -0.44V$$

$$4Fe^{+2}_{(aq)} + O_{2(g)} + 4H_2O_{(l)} + 2xH_2O_{(l)} \longrightarrow 2Fe_2O_3 \cdot x H_2O_{(s)} + 8H^+_{(aq)}$$

PREVENTION

CATHODIC PREVENTION - THE PROCEDURE OF USING ANOTHER METAL TO SERVE AS THE ANODE.

* PAINTING IRON PREVENTS O_2 FROM GETTING TO THE SURFACE.

GALVANIZED IRON IS IRON COATED IN ZINC. THE ZINC WILL OXIDIZE WITH O_2 IN THE AIR. EVEN IF THE SURFACE IS BROKEN THE ZINC WILL STILL SERVE AS THE ANODE (MORE NEGATIVE $E°_{RED}$)

ZINC IS A **SACRIFICIAL ANODE**

$Fe^{2+}_{(aq)} + 2e^- \rightarrow Fe_{(s)}$ $-0.44V$

$Zn^{2+}_{(aq)} + 2e^- \rightarrow Zn_{(s)}$ $-0.76V$

WHEN ADHERING TO METALS TOGETHER WE MUST CONSIDER THE REDUCTION POTENTIALS. *IDEALLY USE THE SAME METAL
↳ ALUMINUM SIDING W/ ALUMINUM NAILS

IRON GUTTER WITH ALUMINUM NAILS?

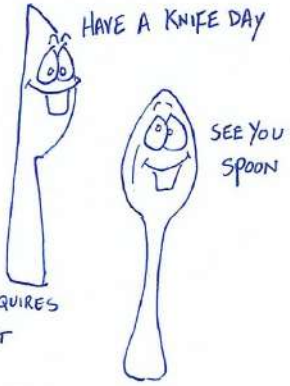
ALUMINUM = ANODE $E°_{RED}$ -1.66V
IRON = CATHODE $E°_{RED}$ -0.44V = NAIL DISAPPEARS

ELECTROLYSIS

THE PROCESS OF USING ELECTRICITY TO CAUSE NON SPONTANEOUS REDOX REACTIONS

PROCESS CAN BE USED WITH MOLTEN SUBSTANCES

$2NaCl_{(\ell)} \rightarrow 2Na_{(\ell)} + Cl_{2(g)}$



AQUEOUS SOLUTIONS

EASIER TO WORK WITH BECAUSE MOLTEN METAL REQUIRES VERY HIGH TEMPERATURES PROBLEM IS THAT WE MUST CONSIDER THAT $H_2O_{(\ell)}$, AS THE SOLVENT, MAY BE THE MORE FAVORABLE REDUCTION (H_2) OR OXIDIZED (O_2)

SODIUM FLOURIDE, NaF, DISSOLVED IN H_2O

CATHODE POSSIBILITIES

$Na^+_{(aq)} + e^- \rightarrow Na_{(s)} \quad E^\circ_{RED} = -2.71V$

$2H_2O_{(\ell)} + 2e^- \rightarrow H_{2(g)} + 2OH^-_{(aq)} \quad E^\circ_{RED} = -0.83V$ ← * MORE POSITIVE SO $H_{2(g)}$ FORMED @ CATHODE

ANODE POSSIBILITIES

$2F^-_{(aq)} \rightarrow F_{2(g)} + 2e^- \quad E^\circ_{RED} = +2.87V$

$2H_2O_{(\ell)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^- \quad E^\circ_{RED} = +1.23V$ ← * MORE NEGATIVE SO $O_{2(g)}$ IS PRODUCED @ ANODE

$4OH^-_{(aq)} \rightarrow O_{2(g)} + 2H_2O_{(\ell)} + 4e^- \quad E^\circ_{RED} = +0.40V$ ← EVEN BETTER OPTION

PRODUCT @ CATHODE

CATHODE $4H_2O_{(\ell)} + 4e^- \rightarrow 2H_{2(g)} + 4OH^-_{(aq)} \quad E^\circ_{RED} = -0.83V$

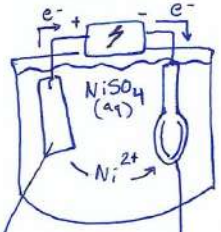
ANODE $4OH^-_{(aq)} \rightarrow O_{2(g)} + 2H_2O_{(\ell)} + 4e^- \quad E^\circ_{RED} = +0.40V$

$2H_2O_{(\ell)} \rightarrow 2H_{2(g)} + O_{2(g)} \quad E^\circ_{RED} = -1.23V$ CATHODE − ANODE

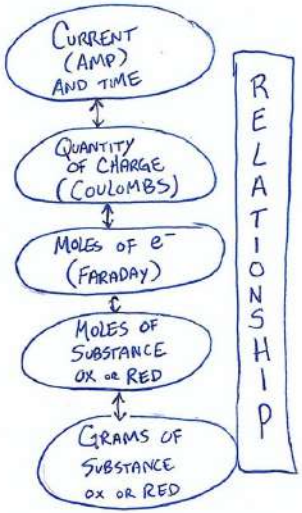
NEED +1.23V OR HIGHER TO RUN THIS REACTION

ACTIVE ELECTRODES ELECTROPLATING

- PURPOSELY PUTTING A METAL ONTO THE METAL CATHODE



ELECTRICAL WORK



THAT JOKE IS SODIUM FUNNY?

IT SURE AS HECK DOESN'T BORON

HALF REACTIONS CAN SHOW US HOW MANY e^- ARE FLOWING IN A REDOX REACTION

$Na^+ + e^- \longrightarrow Na$ 1 MOLE e^- = 1 MOLE Na

$Cu^{2+} + 2e^- \longrightarrow Cu$ 2 MOLES e^- = 1 MOLE Cu

- ELECTRICAL CIRCUITS ARE MEASURED IN COULOMBS (C)

1 F = 96,500 C/MOL } EVERY MOLE OF e^- IS 96,500 COULOMBS
FARADAY

- A COULOMB IS A MEASUREMENT OF AMPHERES x SECONDS (AMPS)

$C = Amps \times SEC$

- WORK PERFORMED IN THE REACTION

$$WORK = \left(\text{MOLES OF } e^-\right)\left(\text{FARADAY CONSTANT}\right)\left(\text{EXTERNAL ENERGY VOLTS}\right)$$

REMEMBER $\Delta G = -nFE$

Ex: CALCULATE KWH NEEDED TO PRODUCE 1.0×10^3 kg OF Al FROM Al^{+3} AND THE USED ELECTRICAL (emf) FORCE IS 450V

① FIND THE COULOMBS FIRST

$$\frac{1.0\times10^3\,kg}{1\,kg}\left|\frac{1{,}000\,g}{27.0\,g\,Al}\right|\frac{1\,Mole\,Al}{1\,Mol\,Al}\left|\frac{3\,F}{1\,F}\right|\frac{96{,}500\,C}{} = 1.07\times10^{10}\ Coulombs \times 4.50\ Volts$$

$\downarrow$

4.82×10^{10} C-V

② CONVERT C $\longrightarrow$ KWH

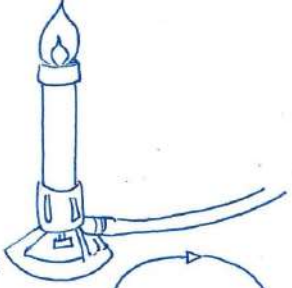
$$\frac{4.82\,C\text{-}V}{1\,C\text{-}V}\left|\frac{1\,J}{3.6\times10^6\,J}\right|\frac{1\,KWH}{} = 1.34\times10^4\,KWH$$

1 WATT = 1 JOULE/SEC

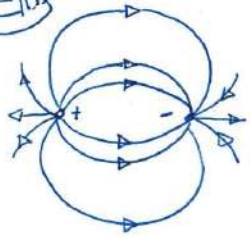
MICHAEL FARADAY

NOTHING IS TOO WONDERFUL TO BE TRUE, IF IT BE CONSISTENT WITH THE LAWS OF NATURE.

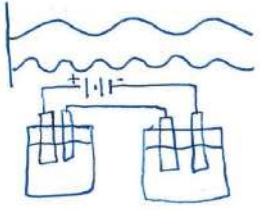
BRITISH PHYSICIST & CHEMIST
1791 – 1867



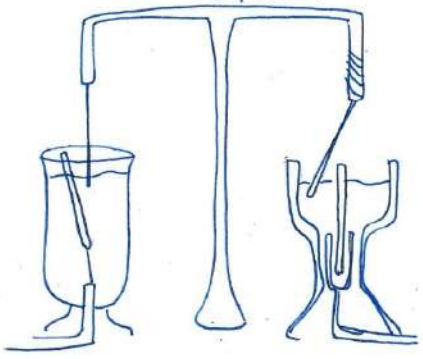
ONE OF THE MOST NOTABLE SCIENTISTS IN HISTORY. FROM BATTERIES TO MOTORS



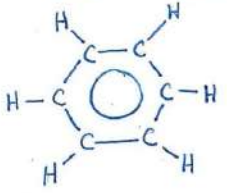
- RESEARCH LOOKING INTO A CONDUCTOR CARRYING CURRENT = DEVELOPMENT OF THE ELECTROMAGNETIC FIELD
- DETERMINED MAGNETISM COULD AFFECT RAYS OF LIGHT
  ELECTROMAGNETIC SPECTRUM



ELECTROMAGNETIC ROTATION EXPERIMENT



- ELECTROMAGNETIC INDUCTION & DIAMAGNETISM DEVELOPED LAWS OF ELECTROLYSIS
- ELECTROMAGNETIC ROTARY DEVICES



- DISCOVERED BENZENE & FIRST PROTOTYPE OF A BUNSEN BURNER
- OXIDATION #'S Li^{1+}, Mg^{2+}, O^{2-}
- BATTERY TERMS ANODE, CATHODE, ELECTRODE, ION

Nuclear

NUCLEAR CHEMISTRY PART 1

ISOTOPES
SAME # OF PROTONS
DIFFERENT # OF NEUTRONS
EX: $^{233}_{92}U$, $^{235}_{92}U$
233 MASS # = 92 PROTONS, 141 NEUTRONS

CHANGES IN MATTER ORIGINATING IN THE NUCLEUS OF THE ATOM. ALL THE OTHER CHEMISTRY OF REACTIONS WERE FOCUSED ON THE ELECTRONS

RADIOACTIVITY THE RELEASE OF ENERGY/PARTICLES CAUSED BY THE SPONTANEOUS DISINTEGRATION OF THE ATOMIC NUCLEUS

WHAT DID THE NUCLEAR PHYSICIST HAVE FOR LUNCH?

FISSION CHIPS

THREE TYPES OF RADIATION

	ALPHA α	BETA β	GAMMA γ
RELEASED SUBSTANCE	$^{4}_{2}He$ HELIUM NUCLEI	$^{0}_{-1}e$ ELECTRONS	0 HIGH ENERGY PHOTONS

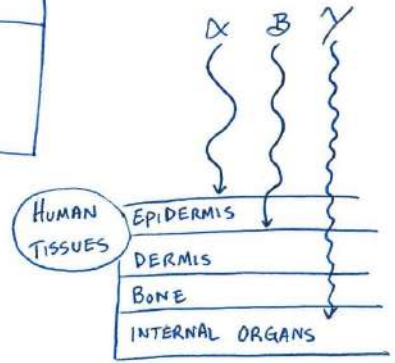
EX: $^{238}_{92}U \rightarrow {}^{4}_{2}He + {}^{234}_{90}Th$

SINCE THE HELIUM NUCLEI IS RELATIVELY LARGE IT CANNOT PENETRATE AS MUCH AS β & γ

$^{131}_{53}I \rightarrow {}^{0}_{-1}e + {}^{131}_{54}Xe$

THE ATOMIC # INCREASES BECAUSE A NEUTRON IS CONVERTED INTO A PROTON

RADIATION = JUST MEANS ENERGY OR PARTICLES LEAVING A SOURCE

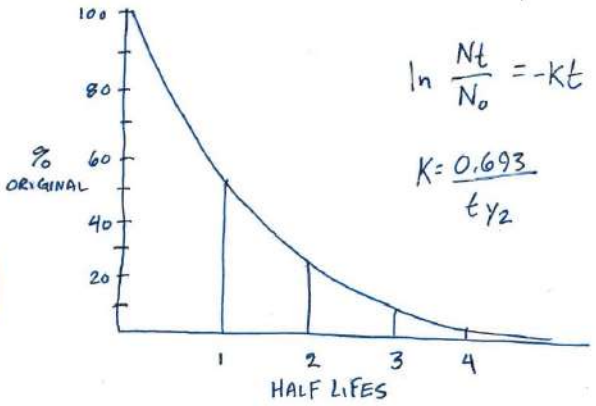


GAMMA RADIATION HAS THE HIGHEST PENETRATING POWER

NUCLEAR CHEMISTRY

RADIOACTIVE DECAY PART 2

HALF LIFE
TIME REQUIRED FOR ½ OF THE SUBSTANCE TO REACT ($t_{1/2}$)



$$\ln \frac{N_t}{N_0} = -Kt$$

$$K = \frac{0.693}{t_{1/2}}$$

★ EACH ISOTOPE HAS ITS OWN CHARACTERISTIC HALF LIFE

EX: STRONTIUM-90 HAS A ½ LIFE OF 28.8 YEARS SO IF YOU HAD 100g OF $^{90}_{38}Sr$ AND 28.8 YEARS PASSED YOU WOULD HAVE 50g LEFT. AFTER ANOTHER 28.8 YEARS YOU WOULD HAVE 25g LEFT.

THE STRONTIUM TURNS INTO YTTRIUM

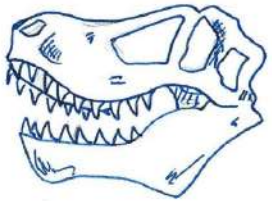
β DECAY

$$^{90}_{38}Sr \longrightarrow {}^{90}_{39}Y + {}^{0}_{-1}e$$

OTHER RADIOACTIVE ISOTOPES USED BY SCIENTISTS		
$^{235}_{92}U$	α DECAY	7.0×10^8 YEARS ½ LIFE
$^{232}_{90}Th$	α DECAY	1.4×10^{10} YEARS ½ LIFE
$^{40}_{19}K$	β DECAY	1.3×10^9 YEARS ½ LIFE
$^{14}_{6}C$	β DECAY	5,715 YEARS ½ LIFE

THIS IS HOW WE ARE ABLE TO DATE FOSSILS & ANCIENT ARTIFACTS

BY USING THE % RADIOACTIVE ISOTOPE COMPARED TO THE STABLE ELEMENT IT TURNS INTO WE CAN DATE THE MATERIAL IN QUESTION.



THE ROCK THIS FOSSIL WAS FOUND IN HAS 0.231 mg OF Pb FOR EVERY mg OF URANIUM-238

WE CAN USE THIS TO DATE THE FOSSIL

NUCLEAR CHEMISTRY

PART 3

WE CAN DATE A FOSSIL BY UNDERSTANDING THAT RADIOACTIVE DECAY & ½ LIFE ARE 1ST ORDER RATE LAW, SO WE CAN USE TWO EQUATIONS TO SOLVE HOW OLD A FOSSIL IS.

Ex: 0.231mg OF Pb FOR EVERY 1mg OF URANIUM-238

$^{238}_{92}U$ DECAYS INTO $^{206}_{82}Pb$ WITH A HALF LIFE OF 4.5×10^{9} YEARS

- WON A NOBEL PRIZE IN PHYSICS WITH HER HUSBAND & ANOTHER IN CHEMISTRY
- DEVELOPED THE THEORY OF RADIOACTIVITY
- DEVELOPED TECHNIQUES FOR ISOLATING RADIOACTIVE ISOTOPES
- DISCOVERED TWO ELEMENTS POLONIUM & RADIUM
- MOBILE X RAY SERVICES DURING WORLD WAR I

2 NOBEL PRIZES!

95 Cm CURIUM 247

CURIUM IS NAMED IN HER HONOR

WE CAN USE TWO EQUATIONS

① $K = \frac{0.693}{t_{y_2}}$ $\left\{ k = \frac{0.693}{4.5\times10^{9}\ \text{YEARS}} \right.$ $K = 1.5\times10^{-10}\ yr^{-1}$

② $t = -\frac{1}{k}\ln\frac{Nt}{No}$ $\left\{ t = -\frac{1}{1.5\times10^{-10}}\ln\frac{1.000\,mg}{1.267\,mg} = \boxed{1.6\times10^{9}\ \text{YEARS}} \right.$

TO GET THE ORIGINAL AMOUNT OF URANIUM 238

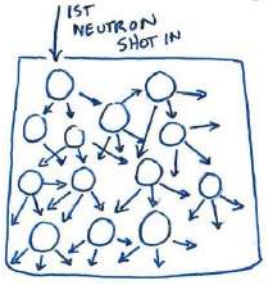
$1.000\,mg + \frac{238}{206}(0.231\,mg) = 1.267\,mg$

Nuclear Chemistry

Part 4

Nuclear Fission

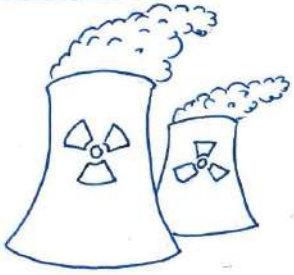
THE SPLITTING OF HEAVY NUCLEI



A CONTAINER OF URANIUM WILL EXHIBIT A CHAIN REACTION OF NUCLEAR FISSION REACTIONS. THE 1ST NEUTRON SHOT IN WILL SPLIT THE 1ST URANIUM NUCLEUS WHICH WILL THEN RELEASE 3 NEUTRONS. THESE 3 NEUTRONS WILL SPLIT 3 MORE NUCLEI. THIS CHAIN CONTINUES AND THE REACTION BECOME EXPONENTIAL

USES OF FISSION REACTIONS

- NUCLEAR POWER PLANTS HARVEST THIS ENERGY OUT OF THIS RXN
- NUCLEAR BOMBS

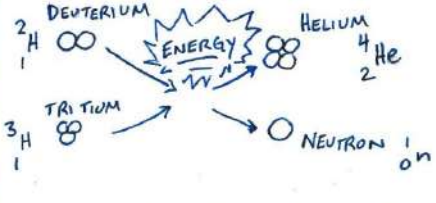


Vs.

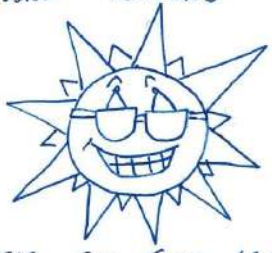
Nuclear Fusion

THE UNION OF LIGHT NUCLEI

BOTH OF THESE REACTIONS ARE HIGHLY EXOTHERMIC



THE SUN IS A STAR & ALL STARS EXHIBIT BOTH FISSION & FUSION REACTIONS



THE SUN FUSES 620,000,000 TONS OF HYDROGEN NUCLEI A SECOND THAT IS A LOT OF ENERGY RELEASED. WHEN THE HYDROGEN IS USED UP THE SUN WILL EXPAND & DIE. ← WON'T HAPPEN ANYTIME SOON

Organic Chemistry

ORGANIC CHEMISTRY

INTRODUCTION

PART 1

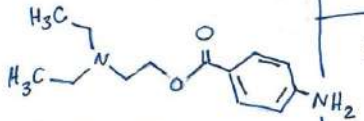
ORGANIC does not mean healthy or that it is sold at a special store. It means it contains carbon atoms

3 MAJOR COMPONENTS THAT DETERMINE THE NAMING AND BEHAVIOR OF ORGANIC COMPOUNDS

1. TYPES OF BONDS
2. # OF CARBON ATOMS
3. FUNCTIONAL GROUPS ATTACHED

REALLY BAD ORGANIC COMPOUNDS

COCAINE



$C_{17}H_{21}NO_4$

TOLUENE

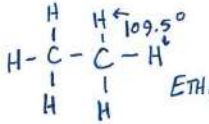
PAINT THINNER

C_7H_8

TYPES OF BONDS

SINGLE BOND = ALKANE

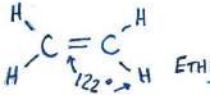
GET "ANE" ENDING



ETHANE

DOUBLE BOND = ALKENE

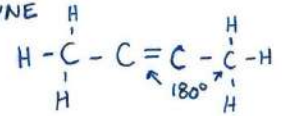
GET "ENE" ENDING



ETHENE

TRIPLE BOND = ALKYNE

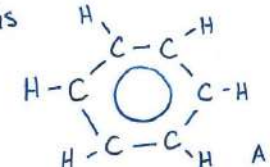
GET "YNE" ENDING



2-BUTYNE

AROMATIC = RINGS

CYCLO



CYCLO HEXENE

RESONANCE

THE CIRCLE SIGNIFIES A ROTATING DOUBLE BOND

WHY DOES ORGANIC CHEMISTRY GET ITS OWN BRANCH OF CHEMISTRY?

ALL LIFE AS WE KNOW IT IS COMPOSED OF ORGANIC COMPOUNDS

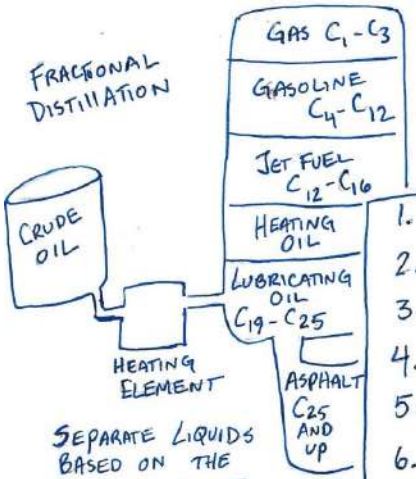
1. CARBOHYDRATES
2. LIPIDS
3. NUCLEIC ACIDS
4. PROTEINS

YOU ARE WHAT YOU EAT

SO POOR ANOTHER BOWL OF SEXY BEAST

ORGANIC CHEMISTRY

INTRODUCTION PART 2



# OF CARBON ATOMS			BOILING POINT (°C)
1. METH	CH_4	METHANE	-161
2. ETH	C_2H_6	ETHANE	-89
3. PROP	C_3H_8	PROPANE	-44
4. BUT	C_4H_{10}	BUTANE	-0.5
5. PENT	C_5H_{12}	PENTANE	36
6. HEX	C_6H_{14}	HEXANE	68
7. HEPT	C_7H_{16}	HEPTANE	98
8. OCT	C_8H_{18}	OCTANE	125
9. NON	C_9H_{20}	NONANE	151
10. DEC	$C_{10}H_{22}$	DECANE	174

INTERMOLECULAR FORCE CONNECTION

THE BIGGER THE MOLECULE THE MORE THE MOLECULES "STICK" TOGETHER = HIGHER TEMPERATURE REQUIRED TO GO FROM $l \rightarrow g$

← ALL OF THESE MOLECULES ARE NONPOLAR

FORMULAS | SHORT CUT

$C_n H_{(2n+2)}$ = ALKANE

HEXANE → C_6H_{14}

$C_n H_{(2n)}$ = ALKENE

3-HEPTENE → C_7H_{14}

$C_n H_{(2n-2)}$ = ALKYNE

1-HEPTYNE → C_7H_{12}

THE MORE C-H BONDS THE COMPOUND HAS THE MORE POTENTIAL ENERGY AVAILABLE

OCTANE C_8H_{18} = GASOLINE

THE HIGHER THE OCTANE RATING THE MORE RESISTANT THE FUEL IS TO COMPRESSION BEFORE IT IGNITES

ORGANIC CHEMISTRY

INTRODUCTION PART 3

FUNCTIONAL GROUPS

SPECIFIC COMBINATIONS OF ATOMS THAT HAVE VERY SPECIFIC CHARACTERISTICS

ALCOHOL

-OL ENDING

ETHANOL

ETHER

ETHER

DIMETHYL ETHER

AMINE

AMINE

METHYL AMINE

CARBONYL

ALDEHYDE

-AL ENDING

ETHANAL

KETONE

ONE ENDING

PROPANONE

AMIDE

-AMIDE

ETHANAMIDE

CARBOXYLIC

OIC ACID

ETHANOIC ACID

ESTER

-OATE

METHYL ETHANOATE

ETHER BUNNY

ORGANIC CHEMISTRY

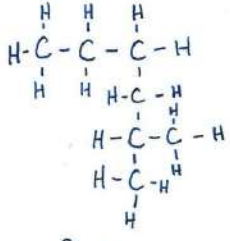
INTRODUCTION

REMEMBER

ISOMERS HAVE SAME FORMULA DIFFERENT ARRANGEMENT

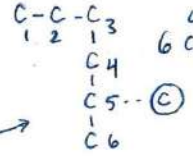
NAMING PART 4

1.



C_7H_{16}

(a) ALTHOUGH THE MOLECULE IS BENT, COUNT THE FARTHEST YOU CAN (C-C) BEFORE YOU HAVE TO BACK TRACK



LONG CHAIN

6 CARBONS = HEX

(b) THAT ONE OFF TO THE SIDE = SIDE CHAIN 1 CARBON = METH & COUNT TO ITS LOCATION = (2)

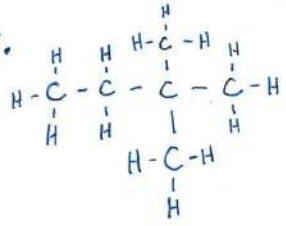
* REVERSE OUR NUMBERING TO GET THE SMALLEST #

ANSWER

2 METHYL HEXANE

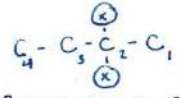
↖ SINGLE BONDS

2.



(a) FARTHEST COUNTING = 4 CARBONS BUT

(b)



2 SIDE CHAINS OFF THE SAME CARBON (CARBON #2)

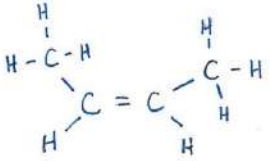
(c) BOTH SIDE CHAINS = A SINGLE CARBON = METH

2,2 DIMETHYL BUTANE

↑↑ BOTH METH @ SAME LOCATION

↑ SUFFIX FOR SIDE CHAINS

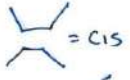
3.



(a) FOUR CARBONS & NO SIDE CHAINS THERE IS A DOUBLE BOND

(b) NOTE THE LOCATION OF THE DOUBLE BOND STARTS @ THE SECOND CARBON

(c) THE MOLECULE'S SHAPE AROUND THE DOUBLE BOND IS IMPORTANT



= CIS

= TRANS

2 CIS BUTENE

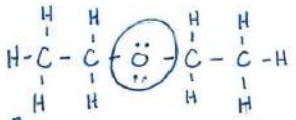
↑ DOUBLE BOND

ORGANIC CHEMISTRY

INTRODUCTION PART 5

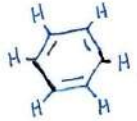
★ FIND IMPORTANT FEATURES (DOUBLE BOND, FUNCTIONAL GROUPS, SIDE CHAINS, ETC.) & CIRCLE THEM

1.



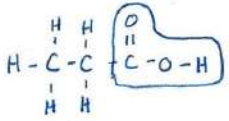
DIETHYL ETHER

2 TWO CARBON CHAINS ON EITHER SIDE OF THE ETHER FUNCTIONAL GROUP



BENZENE RING

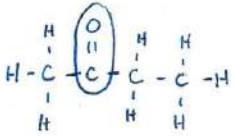
2.



PROPANOIC ACID

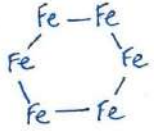
3 CARBONS & A CARBOXYLIC ACID FUNCTIONAL GROUP ON THE END

3.



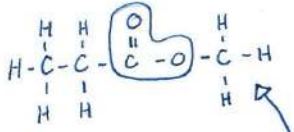
2-BUTANONE

A KEYTONE FUNCTIONAL GROUP ON THE 2ND CARBON IN A 4 CARBON CHAIN



FERROUS WHEEL

4.

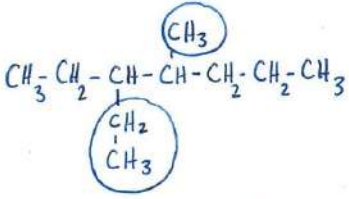


METHYL PROPANOATE

ESTER FUNCTIONAL GROUP

NAME THE CARBON CHAIN OFF THE OXYGEN 1ST THEN THE REST OF THE CARBON CHAIN WITH THE OATE ENDING.

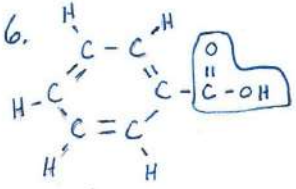
5.



3 ETHYL 4 METHYL HEPTANE

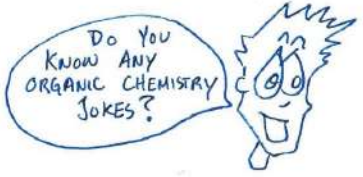
- FIND THE LONGEST CHAIN THEN COUNT TO GET TO THE FIRST SIDE CHAIN THE FASTEST

6.



BENZANOIC ACID

BENZENE RING "CYCLO HEXENE" & A CARBOXYLIC ACID FUNCTIONAL GROUP



ISOMERS

DIFFERENT STRUCTURE EQUALS DIFFERENT FUNCTION

* MOLECULES ARE 3-D AND PARTS CAN ROTATE

COMPOUNDS THAT HAVE THE SAME FORMULA BUT DIFFERENT ARRANGEMENT

ISOMER
- SAME
- PART

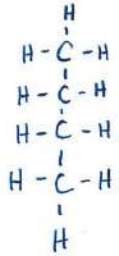
FORMULA FOR A YELLOW FRUIT

$BaNa_2$

THAT IS APPEELING

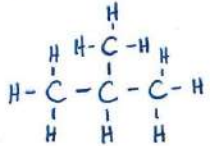
STRUCTURAL

SAME MOLECULAR FORMULA BUT DIFFERENT BONDING PATTERN



C_4H_{10}

BUTANE

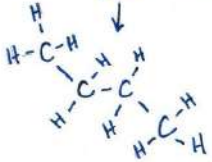


C_4H_{10}

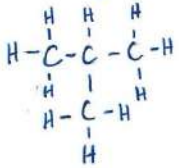
2 METHYL PROPANE

CAREFUL

SAME



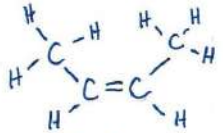
SAME



GEOMETRIC

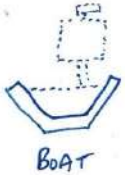
TWO MOLECULES THAT ONLY DIFFER AROUND A DOUBLE BOND OR RING

CAN'T ROTATE AROUND DOUBLE BOND

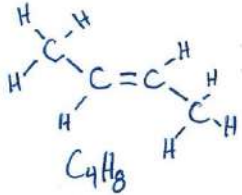


C_4H_8

2-CIS BUTENE



BOAT



C_4H_8

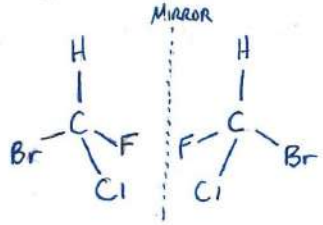
2-TRANS BUTENE

CHAIR

ENANTIOMERS

(OPPOSITE IN GREEK)

MIRROR IMAGES OF EACH OTHER



LIKE A LEFT & RIGHT HAND

By Jeff Grant

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Printed copy available at LuLu