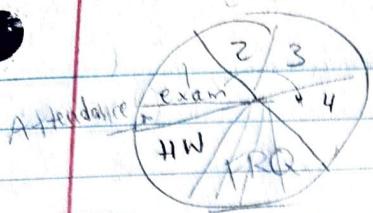


Bro Ruebush  
(Roobush)

M - F 5:00 - 7:00 Romney 277  
Chem Help Lab



FRQ - Free response question (testing center)  
HW - weekly (completion) (3 in a row)

### Activity 1.1

$O_2 \rightarrow$  element

multiple elements  $\rightarrow$  compound

Compound can be a pure substance

Same composition throughout  $\rightarrow$  homogeneous also called a solution

Visible differences in composition  $\rightarrow$  heterogeneous

Prep 1.2  $\rightarrow$  read Sections 1.4 & 1.6 & complete Model 1

length

meter

m

mass

Kilogram

kg

time

Second

s

temperature

Kelvin

K

electric current

ampere

A

amount of substance

mole

mol

luminous intensity

candela

cd

Volume

Cubic meter ( $m^3$ )  
milliliters ( $cm^3$ )

Density

$\rightarrow$  ratio of mass to volume ( $kg/m^3$ )

## 1.5 Measurement Uncertainty, Accuracy, and Precision

curve in glass  
"meniscus"  
read from bottom of meniscus

### Sig Figs

- all non-zeros are significant

3090 → captive (sf)      0.008020 → leading (not sf)  
trailing (Not sf)      trailing captive (sf)

1267 → 4 sig fig

55.0 → 3 "

70.607 → 5 "

0.00832407 → 6 "

### Sig Figs w/ Calculations

1.) Add or Sub → round to least # of decimal places

$$\text{ex;} 1.0023 + 4.383 = \underline{5.385}$$

2.) Mult / Div → Same as above

$$\text{ex;} 0.6238 * 6.6 = \underline{4.1}$$

3.) rounding → Normal unless the dropped digit is 5 followed by 0s

$$\text{ex;} 0.028675 \rightarrow 0.0287$$

$$18,3384 \rightarrow 18,3$$

$$6,8752 \rightarrow 6,88$$

$$92.85 \rightarrow 92.8 \quad (\text{Rounded down, because the retained digit is even})$$

$$0.90275 \rightarrow 0.9028$$

Same but rounded up. You want an even number

## 1.6 Mathematical Treatments of Measurement Results

### Conversion Factors & Dimensional Analysis

ex: Converting inches to cm:

$$34 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 86 \text{ cm}$$

Temperature

$$T_F = \left( \frac{9}{5} \frac{\text{F}}{\text{C}} \times T_C \right) + 32 \text{ }^{\circ}\text{F} \quad \left. \begin{array}{l} \\ \end{array} \right\} \text{F-C; C-F}$$

$$T_C = \frac{5}{9} (T_F - 32) \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$T_K = T_C + 273.15 \quad \left. \begin{array}{l} \\ \end{array} \right\} \text{C to K}$$

$$T_C = T_K - 273.15 \quad \left. \begin{array}{l} \\ \end{array} \right\} \text{K to C}$$

### Activity 1.2

1.) Write down volume of graduated cylinder in mL

$$3.91 \text{ fluid ounces} = 115.7 \text{ mL}$$

2.) How many fluid ounces in a mL?

$$1.00 \text{ oz} = 29.59 \text{ mL}$$

3.) Find ratios from #2 (Unit factors)

$$\frac{3.91 \text{ oz}}{115.7 \text{ mL}} \quad \left. \begin{array}{l} \\ \end{array} \right\} 0.034$$

4.) How many fl.oz in 51.9 mL

$$51.9 \text{ mL} \cdot \frac{3.91 \text{ oz}}{115.7 \text{ mL}} = 1.75 \text{ oz}$$

5.) Determine mL in 4.489 fl oz

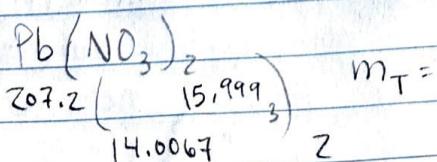
$$4.489 \text{ oz} \cdot \frac{115.7 \text{ mL}}{3.91 \text{ oz}} = 132.8 \text{ mL}$$

6.) actual equivalence equation:  $29.5735296 \text{ mL} = 1 \text{ fl oz}$   
accurate bc ratios are the same

7.) magnitude:  $29.5735296 \times 10^{-3}$ , 7

unit: mL, fl oz

uncertainty: 9 sig figs, 7 sig fig



11 km

•  $6.217 \times 10^7 \text{ m}$  to nm?

$$6.217 \times 10^{-9} \text{ m}$$

$$6.217 \text{ nm}$$

• 17 pg to g?

$$17 \text{ pg} = 17 \times 10^{-12} \text{ g}$$

• 1.091 K to C?

$$T_c = T_k - 273.15$$

$$= 1.091 - 273.15 = -272.059^\circ\text{C}$$

• -2°C to K?

$$T_k = T_c + 273.15$$

$$= -2 + 273.15 = 271.15^\circ\text{K}$$

## 1.2 Class

1.) Convert 8.12 inches to meters

$$8.12 \text{ in} \cdot \frac{2.54 \text{ cm}}{1 \text{ in}} \cdot \frac{1 \text{ m}}{100 \text{ cm}} = 0.206 \text{ m}$$

2.) Convert 294.5 nm to cm

$$294.5 \times 10^9 \text{ m} = 294.5 \times 10^{-2} \cdot 10^{-7} \text{ cm}$$
$$= 2.945 \times 10^{-5} \text{ cm}$$

3.) Calculate  $\text{cm}^2$  in  $0.0482 \text{ m}^2$

$$0.0482 \text{ m}^2 = \frac{(100 \text{ cm})^2}{(1 \text{ m})^2} \cdot \frac{10,000 \text{ cm}^2}{1 \text{ m}^2} = 482 \text{ cm}^2$$

\*  $1 \text{ cm}^3 = 1 \text{ mL}$

## 2.1 Early Ideas in Atomic Theory

Law of definite proportions / Law of constant composition

↳ all samples of a pure compound contain the same elements in the same proportion by mass

## Law of multiple proportions

↳ two elements react to form more than one compound, a fixed mass of one element will react with masses of the element in a ratio of small, whole numbers.

ex; Copper and Chlorine

result #1

$\frac{1.16 \text{ g Cl}}{1 \text{ g Cu}}$

result #2

$\frac{0.558 \text{ g Cl}}{1 \text{ g Cu}}$

$$\Rightarrow \frac{\text{result } \#2}{\text{result } \#1} = \frac{2}{1}$$

∴ the #2 compound has twice the amount of chlorine per amount of copper as #1 compound

## 2.2 → proton, electron, neutron

## 2.3 Atomic structure and symbolism

### • Unified atomic mass unit (u)

↳  $\frac{1}{12}$  the mass of a single atom of carbon - 12

$$\hookrightarrow 1.6605 \times 10^{-24} \text{ g}$$

• Dalton (Da) is the same

• Fundamental unit of charge (e)

	Charge (C)	Unit Charge	Mass (amu)	Mass (g)
electron	$-1.602 \times 10^{-19}$	$1^-$	0.00055	$0.00091 \times 10^{-24}$
proton	$1.602 \times 10^{-19}$	$1^+$	1.00727	$1.67262 \times 10^{-24}$
neutron	0	0	1.00866	$1.67493 \times 10^{-24}$

atomic number ( $Z$ ) = # of protons

mass number ( $A$ ) = protons + neutrons

$A - Z$  = number of neutrons

Atom charge = # protons - # electrons

Charged atom = ion

negatively charged  $\rightarrow$  anion

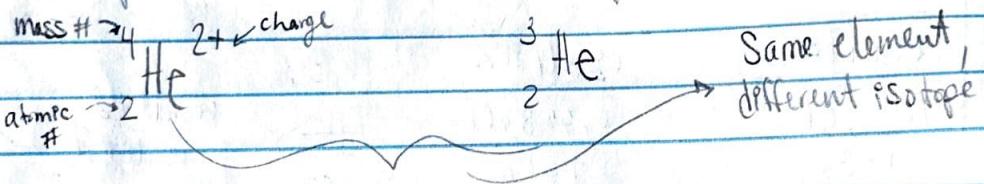
positively "  $\rightarrow$  cation

if protons = electrons  $\rightarrow$  neutral



cat = positive

Isotope  $\rightarrow$  differs in # of protons



Atomic Mass  $\approx$  Mass number

Average Atomic Mass =  $\sum_i (\text{fractional abundance} \times \text{protonic mass})$

$$\begin{aligned} \text{boron average mass} &= (0.199 \times 10.0129 \text{ amu}) + (0.801 \times 11.0093 \text{ amu}) \\ &= 1.99 \text{ amu} + 8.82 \text{ amu} \\ &= 10.81 \text{ amu} \end{aligned}$$

\* No single atom, it's an average

Mass spectrometer  $\rightarrow$  used to find the abundance of each isotope

\* { Ionization  $\rightarrow$  Acceleration  
Detection  $\leftarrow$  Deflection

$\rightarrow$  Can be used for elements and molecules

### 1.3 prepare

- 1.) Where are neutrons/protons?  $\rightarrow$  nucleus
- 2.) electrons  $\rightarrow$  orbiting
- 3.) electrons = small mass, protons/neutrons  $\approx$  1 amu
- 4.) electrons take up large volume, protons/neutrons don't
- 5.) Yes, electrons = protons
- 6.)  $^{23}_{11}\text{Na} \rightarrow 23 = \text{mass \#}$   
 $11 = \text{atomic \#}$

7.) If only  $^{A-Z}$  is given, take A-Z to find # neutrons

Fill table:

Symbol	# protons	# neutrons	# electrons	Net charge
$^{23}_{11}\text{Na}^{1+}$	11	12	10	1+
$^{53}_{26}\text{Fe}^{2+}$	26	27	24	2+
$^{59}_{26}\text{Fe}^{3+}$	26	33	23	3+
$^{85}_{31}\text{At}^{1-}$	35	125	86	1-
$^{27}_{13}\text{Al}^{3+}$	13	14	10	3+
$^{52}_{28}\text{Te}^{2-}$	28	76	54	2-

Juan Won won one won

## Worksheet 1.1

1.) 1990 won/liter  $\rightarrow$  dollars/gallon

given: 1 gallon = 3.781 L

1 USD = 1234.24 won

$$\frac{1990 \text{ won}}{\text{litter}} \cdot \frac{1 \text{ USD}}{1234.24 \text{ won}} \cdot \frac{3.781 \text{ L}}{1 \text{ gallon}} = 6.095 \text{ \$/gal}$$

2.) Plates are 6.0"  $\times$  8.0"  $\times$  6.0"  
and weigh 50 lbs

a.) Density?

$$50 \text{ lbs} \cdot \frac{1 \text{ kg}}{2.205 \text{ lbs}} = 22.68 \text{ kg}$$

$$V = 288 \text{ in}^3 \cdot \frac{2.54 \text{ cm}^3}{1 \text{ in}^3} = 4719.5 \text{ cm}^3$$

$$d = 22.68 \text{ kg} / 4719.5 \text{ cm}^3 = 4.81 \text{ g/cm}^3$$

b.) no, not pure gold.  $19.32 \neq 4.81$

3.)  $V = 4719.5 \text{ cm}^3 \cdot 0.4 = 1887.8 \text{ cm}^3$

$$d = 22.68 \text{ kg} / 1887.8 \text{ cm}^3 \approx 12.01 \text{ g/cm}^3$$

no,  $19.32 \neq 12.01$

4.) Density if 50% copper + 50% gold?

$$d \text{ of copper} : 8.23 \text{ g/cm}^3$$

$$d \text{ of gold} : 19.32 \text{ g/cm}^3$$

$$D_f = \frac{8.23 + 19.32}{2} = 13.78 \text{ g/cm}^3$$

$$b.) 12.01 = x(8.23) + (1-x)(19.23)$$

$$12.01 = 8.23x + 19.23 - 19.23x$$

$$-7.22 = -11x$$

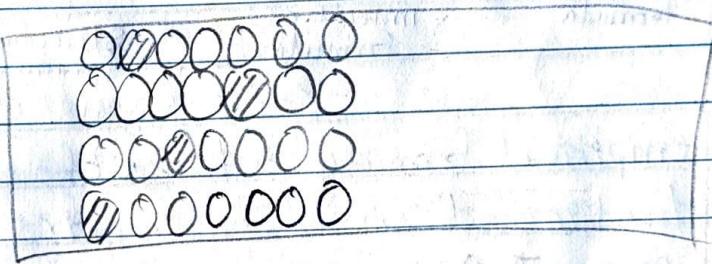
$$x = 0.66$$

→ 66% copper 34% gold

if 100 grams, 66 grams copper + 34 grams gold

c.)

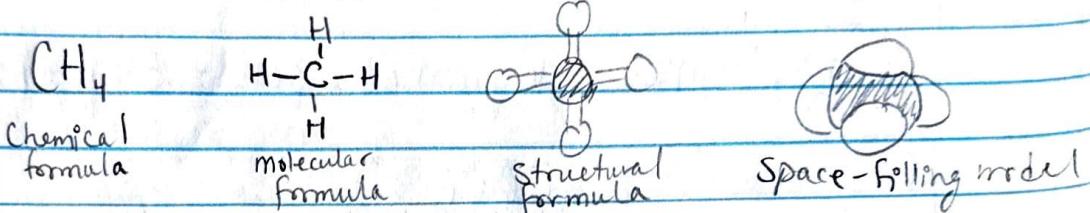
 Gold  
 Copper



## 2.4 Chemical Formulas

Molecular formula - representation of a molecule that uses chemical symbols

Structural formula - Shows how atoms are connected



Empirical formula - types of atoms present, & the simpliest whole-number ratio of the # of atoms (or ions)  
ex;  $\text{TiO}_2 \rightarrow$  titanium dioxide

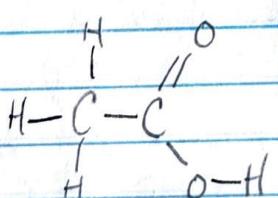
ex; acetic acid:

molecular formula  $\rightarrow \text{C}_2\text{H}_4\text{O}_2$

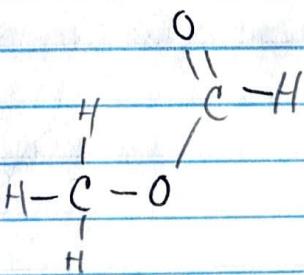
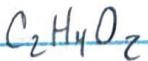
empirical formula  $\rightarrow \text{CH}_2\text{O}$

Isomers  $\rightarrow$  compounds w/ the same chemical formula but different molecular structures

ex;  $\text{C}_2\text{H}_4\text{O}_2$



Acetic Acid



Methyl Formate

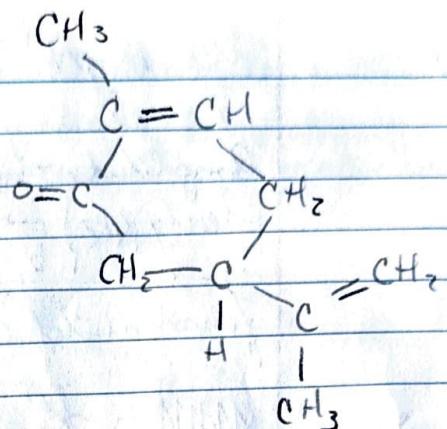
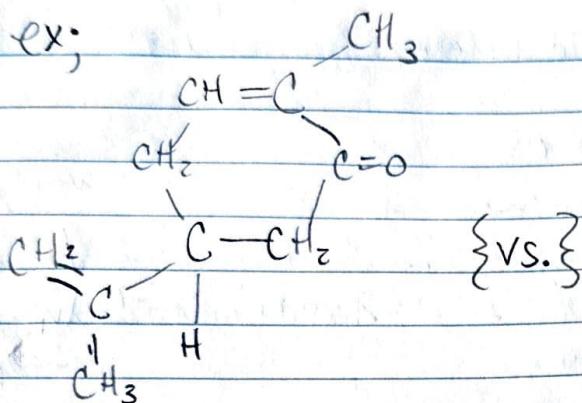


Structural Isomers - molecules differ in how the atoms are connected

Spatial Isomers - relative orientation is different

## Spatial Isomers

ex;



Mole  $\rightarrow 6.02214076 \times 10^{23}$  items (atoms or molecules)  
Avogadro's number ( $N_A$ )  
 $\downarrow 6.022 \times 10^{23}$

molar mass  $\rightarrow$  the mass of one mole of a substance

Average Atomic Mass (amu) = Molar Mass (g/mol)

Can use a mass spectrometer to learn about the structure of molecules

ex; differing isomers produce different spectra

Mass spectrometer  $\rightarrow$  different peaks?

2.5 mole Fe = ? atoms

$$2.5 = 1.51 \times 10^{24}$$

## 3.2 Electromagnetic Energy

Wavelength - distance between two peaks  
Frequency -

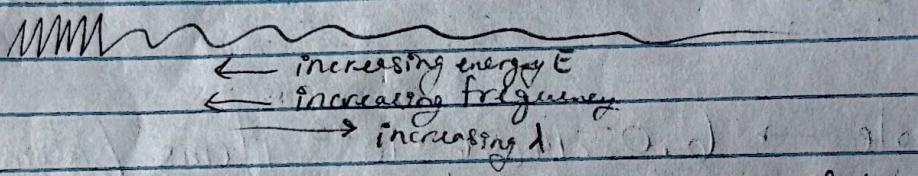
Amplitude - height

frequency (Hz) → cycles/second

wavelength

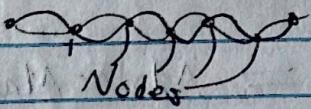
fundamental constant  $c$ :  $c = 2.998 \times 10^8 \text{ ms}^{-1} = \lambda \nu$

frequency



interference patterns → when waves come into contact

Standing waves - don't travel



light absorption - endothermic

light emission - exothermic

light has a wave-particle duality

$$E = nh\nu$$

$\hookrightarrow 6.626 \times 10^{-34} \text{ J s}$ , or Planck's constant

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

## 3.2 The Bohr Model

Ground electronic state - when electrons are in lowest energy state

Excited " " - when more electrons are received

Preparation:

$$\text{Speed of light} = 2.9979 \times 10^8 \text{ m/s}$$

$$\text{frequency purple} = 7.402 \times 10^{14} \text{ hertz}$$

$$\text{" red} = 4.612 \times 10^{14} \text{ hertz}$$

1.)  $3 \times 10^8 \text{ m/s}$

2.) red

3.) a.) purple

b.)  $7.4 \times 10^{14}, 4.6 \times 10^{14} \text{ hertz}$

4.) purple

5.)  $c = \lambda \nu$

$$\text{purple } \lambda = \frac{c}{\nu} = \frac{2.9979 \times 10^8}{7.402 \times 10^{14}} = 4.11 \times 10^{-7} \text{ m}$$

$$\text{red} \quad \quad \quad = \frac{2.9979 \times 10^8}{4.612 \times 10^{14}} = 6.5 \times 10^{-7} \text{ m}$$

$E = h \cdot \nu$  Frequency of radiation

$$\begin{matrix} \uparrow & \\ \text{Plank constant} & \end{matrix}$$

energy of photon

# ALEKS 1.5

- 1.51 kJ/mol to break molecule
- max wavelength of light to break it

$$E = h \cdot v$$

$$V = \frac{E}{h} = \frac{1.5 \text{ kJ/mol}}{6.62607 \times 10^{-34} \text{ J} \cdot \text{s}} = 2.5074 \times 10^{19} \text{ J}$$

$$V = \frac{E}{h} = \frac{2.5074 \times 10^{19} \text{ J}}{6.62607 \times 10^{-34} \text{ J} \cdot \text{s}} = 3.7841 \times 10^{14} \text{ s}^{-1}$$

Energy to break one bond

$$\lambda = \frac{c}{v} = \frac{3 \times 10^8 \text{ m/s}}{3.7841 \times 10^{14} \text{ s}} = 7.94 \times 10^{-7} \text{ m} = 7.94 \text{ nm}$$

- 155 kJ/mol

$$E = h \cdot v$$

$$V = \frac{E}{h} = \frac{155 \text{ kJ/mol}}{6.62607 \times 10^{-34} \text{ J} \cdot \text{s}} = 2.5738 \times 10^{19} \text{ J}$$

$$V = \frac{E}{h} = \frac{2.5738 \times 10^{19} \text{ J}}{6.62607 \times 10^{-34} \text{ J} \cdot \text{s}} = 3.88 \times 10^{14}$$

$$\lambda = \frac{c}{v} = \frac{2.9979 \times 10^8 \text{ m/s}}{3.88 \times 10^{14} \text{ s}} = 7.7265 \times 10^{-7} \text{ m} = 7.73 \text{ nm}$$

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

$$\lambda = \frac{hc}{E} = \frac{(6.62607 \times 10^{-34} \text{ J} \cdot \text{s}) \cdot 2.9979 \times 10^8 \text{ m/s}}{600 \times 10^3 \text{ J}}$$

n - principal quantum number

## I - angular momentum quantum number

$n \rightarrow$  how far electrons are from nucleus

$T \rightarrow$  how many orbitals in subshell

→ can hold two electrons

→ Shape of orbital. higher I = more complicated

$N + I \rightarrow$  energy of electrons in subshell

A diagram illustrating the relationship between the magnetic quantum number ( $I$ ) and the total angular momentum ( $J$ ). It shows four horizontal lines representing different values of  $I$ :  $I=0$ ,  $I=1$ ,  $I=2$ , and  $I=2$ . The first two lines are labeled  $S$  and  $P$  respectively. The third line is labeled  $D$  and the fourth line is labeled  $F$ . Arrows point from the left towards each line, with labels indicating the value of  $I$  at the arrow's end:  $n=2$  and  $I=0$  for the first arrow,  $n=2$  and  $I=1$  for the second arrow, and  $n=3$  and  $I=2$  for the third arrow.

$$\text{Summary : } E = h \cdot c \quad E = h \cdot v$$

↗ speed of light      ↗ frequency of radiation  
 ↑                       ↑  
 Planck constant      Planck constant  
 wave length          Change in energy

$$1.0 \times 10^{14} \text{ J} \xrightarrow{\text{Proton}} \frac{\text{MJ}}{\text{Mole}}$$

$$1.0 \times 10^{14} \text{ proton} \cdot \frac{M\text{J}}{10^6 \text{ J}} \cdot \frac{eV}{1 \text{ mole}}$$

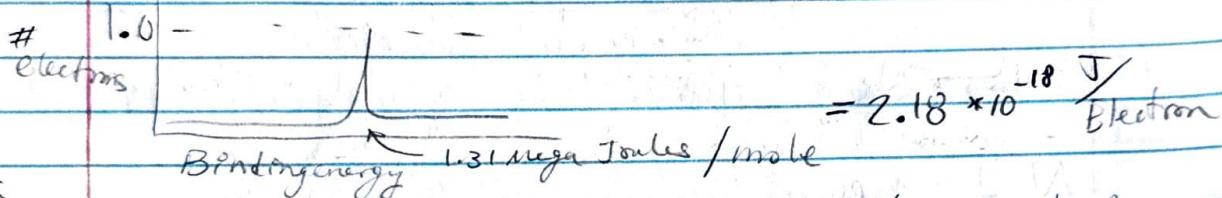
# Activity 1.6

## Photoelectron spectroscopy (PES)

→ uses UV or X-ray photons to eject electrons from atom

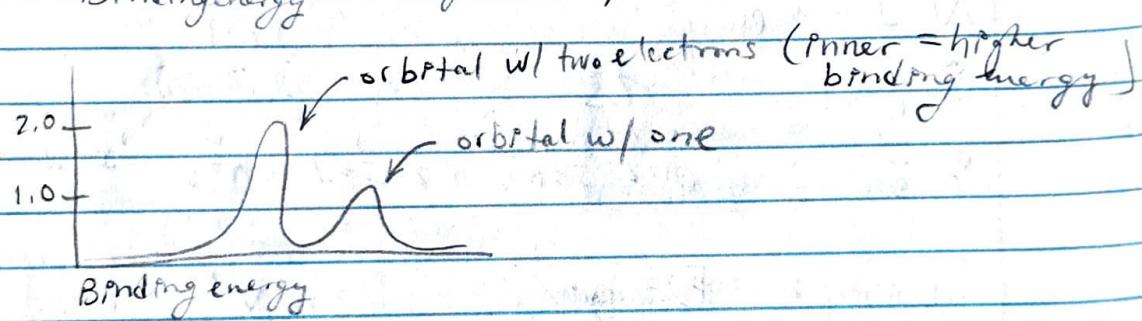
PES

helium:



PES

Lithium



ISABEL RICKS

Photoelectric effect - emission of electrons when electromagnetic radiation hits something

SETH RICKS

Class:

J → MJ/Mole?

$$\frac{-2.18 \times 10^{-18}}{\text{Electron}} \cdot \frac{1 \text{ MJ}}{10^6 \text{ J}} \cdot \frac{6.02 \times 10^{23} \text{ Electrons}}{\text{Mole}}$$

TREVOR

ALEX

DIAN

BEN

ROSE

PIERRY

With Rickst Isabel Money

With Rickst

# Worksheet 1.2

1.) frequency = 2.50 GHz ;  $\lambda = ?$

$$a.) \lambda = \frac{c}{\nu} = \frac{2.9979 \times 10^8 \text{ m/s}}{2.50 \times 10^9 \text{ Hz}} = 0.12 \text{ m}$$

b.) Microwave

$$c.) \text{Energy of photons? } E = \frac{hc}{\lambda} = \frac{6.62607 \times 10^{-34} \text{ J.s}}{0.12 \text{ m}} = 5.52 \times 10^{-24} \text{ J}$$

$$1.666 \times 10^{-24} \text{ J} \cdot \frac{\text{KJ}}{10^3 \text{ J}} \cdot \frac{6.022 \times 10^{23} \text{ atoms}}{\text{mol}} \\ = 10.0 \times 10^{-4} \text{ KJ/mol}$$

2.)  $E_{\text{photon}} = R_H \left[ \frac{1}{n_f^2} - \frac{1}{n_i^2} \right] \quad R_H = 2.18 \times 10^{-19} \text{ J}$

Finish the table

Color	Wavelength ( $\lambda$ , nm)	$n_{\text{final}}$	$n_{\text{initial}}$
red	656 nm	2	3
green	486 nm	2	4
blue	434 nm	2	5
violet	410 nm	2	6

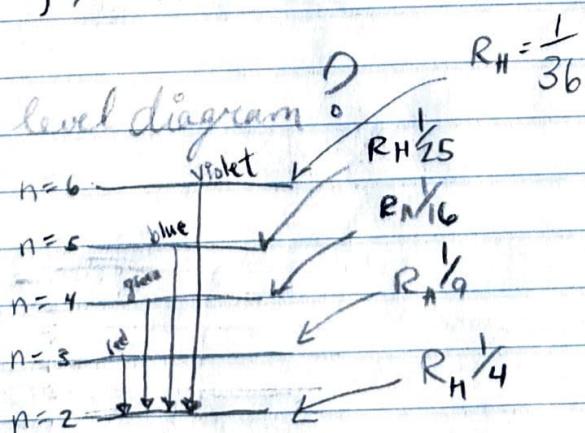
red:  $E_{\text{photon}} = \frac{hc}{\lambda} = \frac{6.62607 \times 10^{-34} \text{ J.s} \cdot 2.9979 \times 10^8 \text{ m/s}}{656 \times 10^{-9} \text{ m}} = 3.03 \times 10^{-19}$

$$3. \quad E_p = R_H \left[ \frac{1}{n_f^2} - \frac{1}{n_i^2} \right] \Rightarrow \frac{E_p}{R_H} - \frac{1}{n_f^2} = -\frac{1}{n_i^2} \Rightarrow n_i^2 = \sqrt{\frac{E_p}{R_H} + \frac{1}{n_f^2}}$$

green:  $E_p = -4.09 \times 10^{-19}$ ;  $\lambda = \frac{hc}{E} = 486 \text{ nm}$

blue:  $E_p = -4.578 \times 10^{-19}$ ;  $\lambda = 434 \text{ nm}$

Draw energy level diagram?



$$R_H = \frac{1}{36}$$

- 3.) a.) Nitrogen, hydrogen  
b.)  $\text{NH}_3 \Rightarrow 14 + 3(1) = 17 \text{ g/mol}$   
c.) If  $2.56 \times 10^{-4} \text{ g}$  were extracted, how many particles?

$$12.56 \times 10^{-4} \text{ g} \Rightarrow \text{particles?}$$

$$\text{NH}_3 = 17.03 \text{ g/mol}$$

$$2.56 \times 10^{-4} \text{ g} \cdot \frac{1 \text{ mol}}{17.03 \text{ g}} \cdot \frac{6.022 \times 10^{23} \text{ particles}}{\text{mol}} = 9.05 \times 10^{26} \text{ particles}$$

### 3.3 Development of Quantum Theory

Broglie wavelength -  $\lambda = \frac{h}{mv} = \frac{h}{p}$

ex; If electron travels @  $1.00 \times 10^7 \text{ m/s}$  + mass =  $9.109 \times 10^{-31} \text{ kg}$ ,  
 wavelength  $\lambda = \frac{h}{mv} = 7.274 \times 10^{-11} \text{ m}$

Heisenberg uncertainty principle  
 ↪ can't know the momentum & position of a particle at the same time

Principal quantum number - defines location of every level  
 \* Further from nucleus → more energy (less to take it away)

Secondary (angular momentum) quantum number

$\rightarrow l = 0, 1, 2, \dots, n-1$

$n=1 \rightarrow l=0$

$n=2 \rightarrow l=0 \text{ and } l=1$

Orbitals w/ same value  $l$  → subshell  $m_l$

$l=0 \rightarrow "s"$  orbitals

1 s-orbital in s subshell

$l=1 \rightarrow p$

3 p- " " " p "

$l=2 \rightarrow d$

5 d- " " " d "

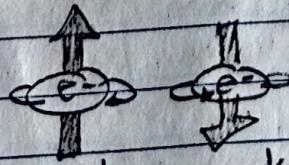
$l=3 \rightarrow f$

7 f- " " " f "

$l=4 \rightarrow g$

$l \rightarrow$  specifies what type of subshell we have

$m_s \rightarrow$  "spin quantum number"



$m_s = +\frac{1}{2}$        $m_s = -\frac{1}{2}$   
 spin-up      spin-down

No two electrons in the same atom can have the

Pauli Exclusion Principle - same  $n, l, m_l, m_s$

### Summary:

principal quantum number  $\rightarrow n$

$\hookrightarrow 1, 2, 3, 4, \dots \rightarrow$  shell, the region

Angular momentum  $\rightarrow l \rightarrow$  subshell, shape

magnetic quantum number  $\rightarrow m_l \rightarrow$  orientation of orbital

spin quantum number  $\rightarrow m_s \rightarrow$  "spinning" direction

Activity prep: \* each orbital can have max 2 electrons

Energy ↑	n=4    4s -	4p ---	4d -----	4f -----	cap is 32
	n=3    3s -	3p ---	3d -----	cap is 18	
	n=2    2s -	2p ---	cap is 8		

n=1    1s — Electron capacity 2

- shell              subshell              orbital
- $n_1 \rightarrow$  just s  $\rightarrow 1s \rightarrow$  s has 1 orbital  $\rightarrow$  max  $2e^-$
- $n_2 \rightarrow$  s+p  $\rightarrow 2s+2p \rightarrow$  s  $\rightarrow$  1 orbital  
p  $\rightarrow$  3 orbitals  $\rightarrow$  max  $8e^-$
- $n_3 \rightarrow$  s+p+d  $\rightarrow 3s+3p+3d \rightarrow$  s " p " d "  $\rightarrow$  max  $18e^-$
- $n_4 \rightarrow$  s+p+d+f  $\rightarrow 4s+4p+4d+4f \rightarrow$  s " p " d " f "  $\rightarrow$  max  $32e^-$
- $n_5 \rightarrow$  s+p+d+f+g  $\rightarrow 5s+5p+5d+5f+5g \rightarrow$  s " p " d " f " g "  $\rightarrow$  max  $50e^-$

Symbol

allowed values

n

1, 2, 3, 4, ...

l

$0 \leq l \leq n-1$

$m_l$

$-l \leq m_l \leq l$

$m_s$

$\frac{1}{2}, -\frac{1}{2}$

### Apartment Analogy:

n  $\rightarrow$  floor

l  $\rightarrow$  # of rooms in an apartment

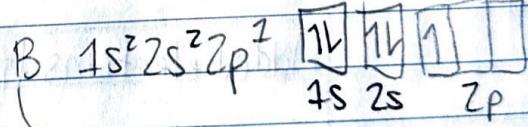
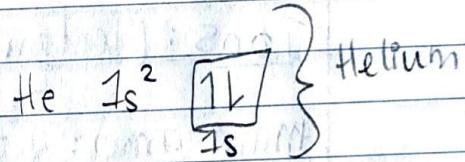
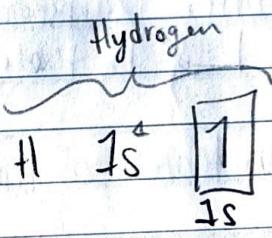
Orbital  $\rightarrow$  each room has two beds, where people could be

Adv Pictur\*

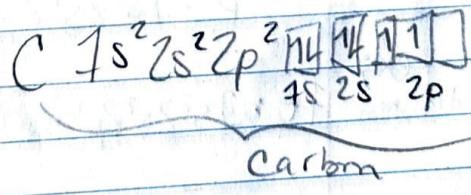
### 3.4 Electronic Structure of Atoms (electronic configurations)

$2 \underset{\substack{1s \\ \text{principle quantum number} \\ (n)}}{P} \underset{\substack{4 \\ \text{electrons}}}{\downarrow}$   
P subshell ( $l=1$ )

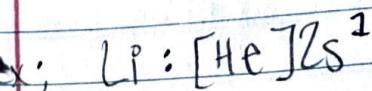
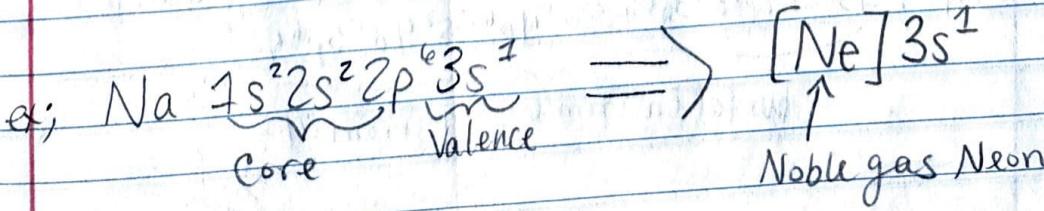
Aufbau Principle - added electrons occupy the shell of the lowest energy



Hund's rule: lowest energy configuration  
= max unpaired electrons

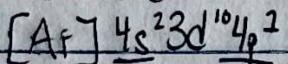


Electrons in outer shell - valence electrons  
" " inner " - core "



Main group elements (representative elements)

↳ last electron enters an s or p orbital



Transition elements (Transition metals)

↳ last electron added enters a d orbital

Inner transition elements

↳ last electron added in an f orbital

two tables of inner transitions : lanthanide  
actinide

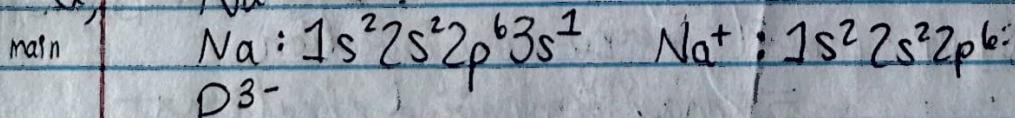
Ions: Electron config.

Main group: LIFO

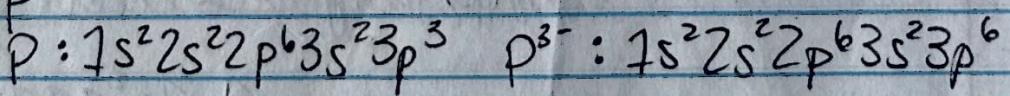
metals/inner transition metals: highest "ns" are lost  
then (n-1) d or (n-2) f

Added electrons fill according to Aufbau principle

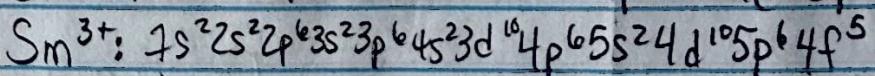
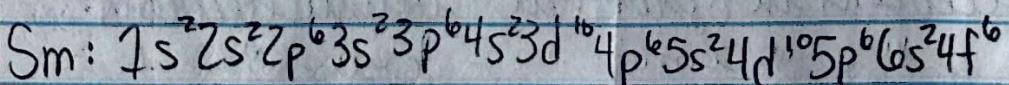
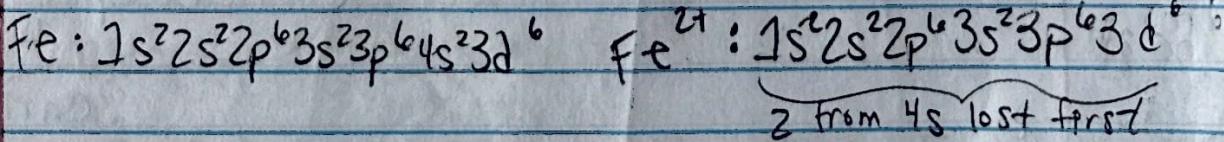
ex;  $\text{Na}^+$



$\text{P}^{3-}$



ex;  
transition



two taken from 4s, 1 from 4f

### 3.5 Periodic variation in element properties

Covalent radius : one-half distance between nuclei of two identical atoms when joined by covalent bond

Effective nuclear charge ( $Z_{eff}$ )

nuclear charge ( $Z$ )

shielding = electron shielding outer electrons  
inner

$$Z_{eff} = Z - \text{shielding}$$

activity :

S orbitals  $\rightarrow$  sphere

P "  $\rightarrow$  two spheres/ovals/dish

F further from nucleus  $\rightarrow$  more energy

Electron further from nucleus are most effective at screening the nucleus from outer electrons.

- atoms may add electrons from 4s to 3d or 5s and 4d } from  $ns^2$  to  $(n-1)d^9$

RICKS to achieve more stability

Class:

Na :  $1s^2 2s^2 2p^6 3s^1$

14	14	111111	1
1s	2s	2p	3s

Ti :  $1s^2 2s^2 2p^6 3s^2 3p^4 4s^2 3d^2$

14	14	111111	14	111111	14	1
1s	2s	2p	3s	3p	4s	3d

$\hookrightarrow [Ar]^{4s^2 3d^2}$

Valence electrons

Angular node =  $l$

Total nodes =  $n-1$

Radial node =  $n-l-1$

# 1.9 Preparation

Most elements are metals

- ↳ good conductors of heat + energy
- ↳ malleable, ductile, lustrous
- ↳ tend to lose electrons when react

Non-metals

- ↳ tend to gain electrons when react
- ↳ bond to each other w/ covalent bonds

Metalloids

- ↳ have properties of metal and nonmetal

Vertical column → groups (families)

Alkali metals = group 1

Alkaline earth metals = group 2

Halogens = group 17 (tend to be F<sub>2</sub>, Cl<sub>2</sub> etc.)

Noble gases = group 18

Transition metals = groups 3-12

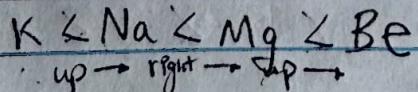
(inner transition metals (lanthanides, actinides))

↳ desirable for electronics

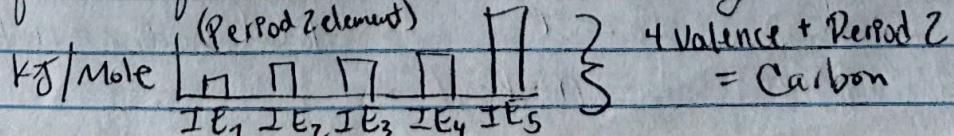
↳ transition metals

Ionization Energy → goes up to the right  
↳ goes down, down

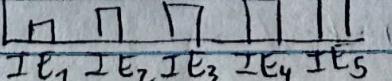
ex; IE of . . . . .



If IE of electron is low it's easy to take



ex:



Size: Atoms get smaller as we go from left to right  
due to nuclear charge  $\rightarrow$

\* Atoms get bigger as you go down  
 $\hookrightarrow$  more shells

## Practice FRQ 1

a.)  $E_p = h\nu$     $C = \lambda\nu$     $\lambda = 1064\text{ nm}$

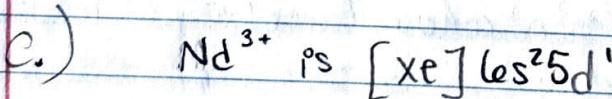
$$V = \frac{C}{\lambda} = \frac{2.9979 \times 10^8 \text{ m/s}}{1064 \text{ nm}} \times \frac{10^9 \text{ nm}}{\mu} = 2.81 \times 10^{14} \text{ /s}$$

$$E_p = h\nu = 6.626 \times 10^{-34} \text{ J.s} * 2.81 \times 10^{14} \text{ /s}$$

$$E = 1.86 \times 10^{-19} \text{ J/ photon}$$

$$\frac{0.1 \text{ J}}{\text{pulse}} \cdot \frac{\text{Photon}}{1.86 \times 10^{-19} \text{ J}} = 5.38 \times 10^{17} \frac{\text{Photon}}{\text{pulse}}$$

b.) same height shifted to the left.  
 $\hookrightarrow$  effective nuclear charge is greater.



$n$	$l$	$m_l$	$m_s$
6	0	0	$\frac{1}{2}$
6	0	0	$-\frac{1}{2}$
5	2	$\underbrace{-2, 0, 1, 2}_{\text{one of these}}$	$\frac{1}{2}$ or $-\frac{1}{2}$

## 4.1 Ionic Bonding

Strong bonds,  
high melting  
point

Ionic bond: electrostatic force of attraction  
between oppositely charged cations & anions

Binary ionic compound - a metal (cation) and a nonmetal (anion)

NaCl is not a molecule, because they aren't independent.  
They form a structure.

\* Remember to keep in mind that electron may drop from a shell to another \*

## 4.2 Covalent Bonding

Weak bonds,  
low melting  
point

When two atoms "share" an electron to fill a shell. ex;  $H_2 \rightarrow$  fill  $1s^2$

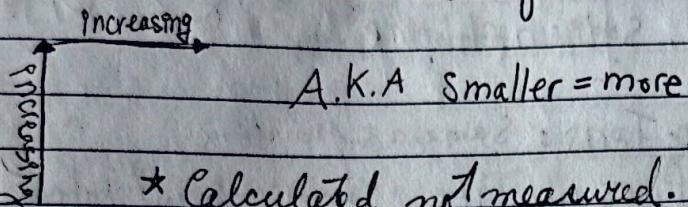
↳ frequently nonmetal + nonmetal

Bond length - distance where lowest potential energy is achieved.

Same amount of energy to break a bond as it released when making one.

Pure Covalent Bonds - identical atoms  
Polar Covalent Bonds - different, so they have partial positive & negative charges

Electronegativity - tendency of an atom to attract electrons towards itself.



\* Calculated, not measured.

Electron Affinity  $\neq$  Electronegativity

energy released/absorbed  
when an electron is acquired

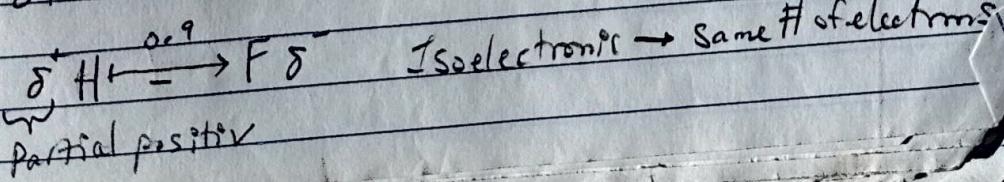
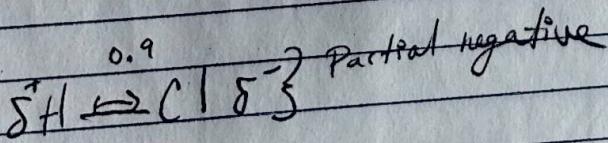
Electronegativity      |      Bond  
difference between bonding atoms      type

( $<0.4$ )	Zero	Pure Covalent
( $0.5-1.8$ )	Intermediate	Polar Covalent
( $>1.8$ )	Large	Ionic

(Ionic - with metal + nonmetal  
molecular - w/ nonmetals)

In a polar bond, the atom that is more electronegative ( $\rightarrow \uparrow$ ) will have more negative charge.

The further the atoms are apart on the table, the more polar they are.



## 4.3 Chemical Nomenclature

Monatomic Ions:

name of cation (metal) + anion (non-metal) replace ending  
ex; NaCl, sodium chloride w/-ide

Polyatomic Ions: Same as Monatomic

(sometimes w/-ate, sometimes w/-ide?)

D block  
Compounds w/ a metal ion w/ variable charge → use roman numerals ??

ex; FeCl<sub>2</sub> iron (II) chloride

FeCl<sub>3</sub> iron (III) chloride

Based off & charge of Fe → Fe<sup>3+</sup>

Ionic Hydrates → contain H<sub>2</sub>O

ex; copper(II) sulfate pentahydrate CuSO<sub>4</sub> · 5H<sub>2</sub>O

(omitted) mono

hexa

di

hepta

tri

octa

tetra

nona

penta

deca

Molecular (Covalent) Compounds

- use prefixes on both, followed by -ide

SO<sub>2</sub> → sulfur dioxide

P<sub>4</sub>O<sub>10</sub> → tetraphosphorus decaoxide

Binary Acids ( $H$  + other nonmetal)

Hydrogen  $\rightarrow$  hydro-

nonmetal  $\rightarrow$  +ic

+ acid

Gas

$HF(g)$  hydrogen fluoride

Acid  $\downarrow$  acid

$HF(aq)$  hydrofluoric acid

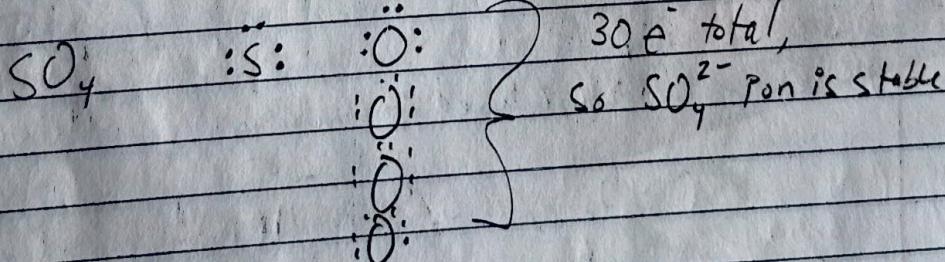
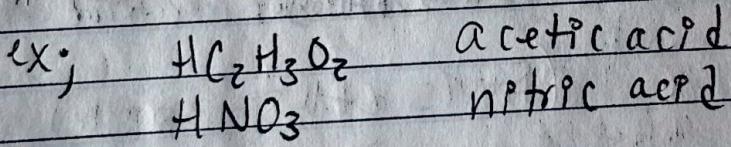
### Oxyacids

1. omit "hydrogen"

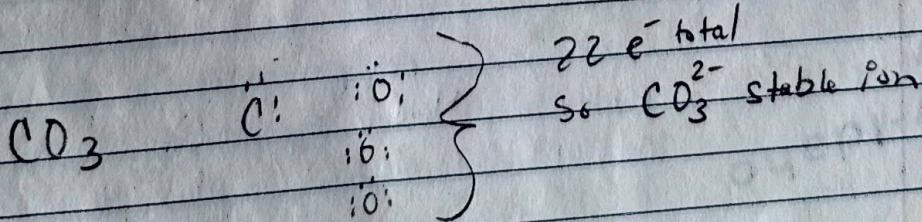
2. start w/ root name of anion

3. replace -ate w/ -ic or -ite w/ -ous

4. "acid"

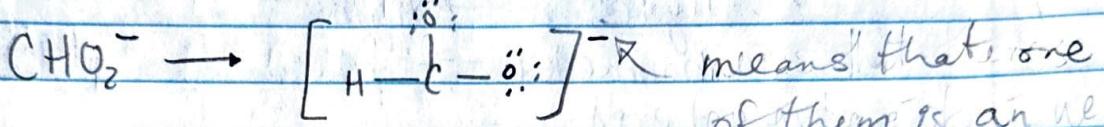
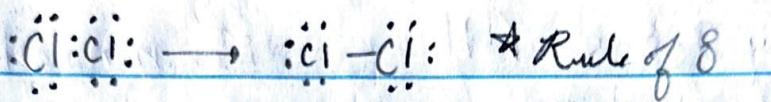


God  
Knows  
me



so  $CO_3^{2-}$  stable ion

## 4.4 Lewis Symbols & Structures



Exception to the Octet Rule anion to satisfy the

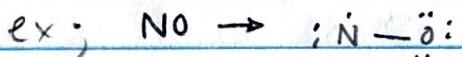
- odd electron molecules

Structure

- electron-deficient molecules

- hypervalent molecules

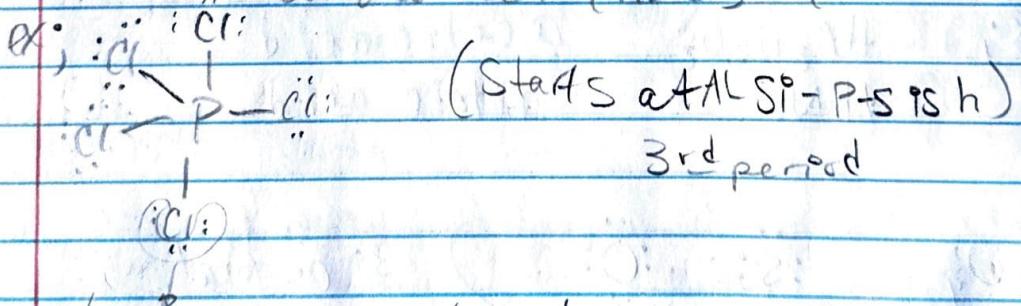
Odd-electron Molecules → "free radicals"



Electron deficient : central isn't filled

Why peravalent Molecules :

↳ d-orbitals ( $n \geq 3$ ) (filled @ 10)



one pair → not used in bonding

P

## 4.5 Formal Charges &

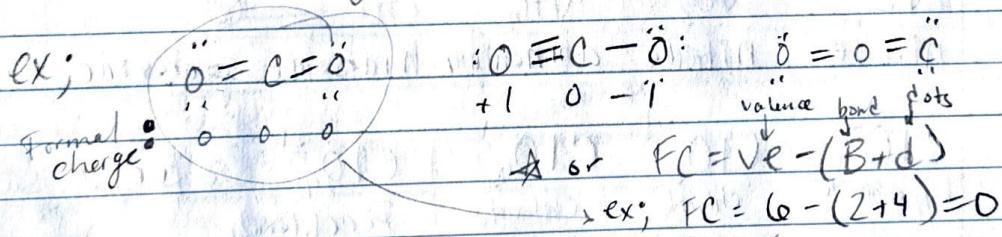
### Resonance

Formal charge = hypothetical charge the atoms would have

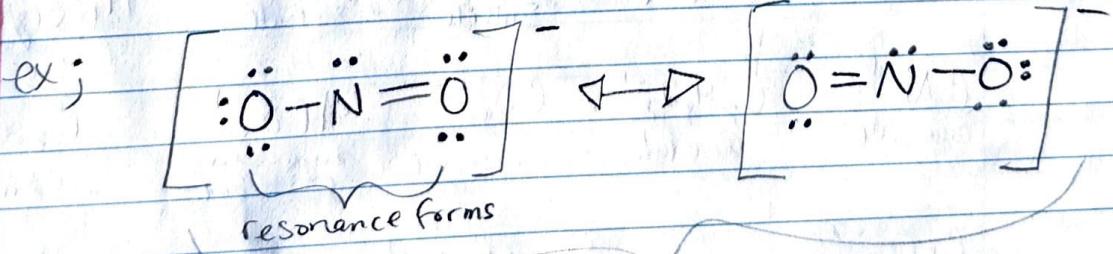
Formal charge = # valence shell electrons  
- # lone pair electrons  
-  $\frac{1}{2}$  # bonding electrons

### Molecular Structure:

- 1.) A structure in which all formal charges are 0 is preferable
- 2.) If it must have nonzero, then smallest nonzero is preferable
- 3.) Structure w/ the negative formal charges on the more electronegative atom is preferable



Resonance: if two or more structures are possible, then the distribution is the average between the two



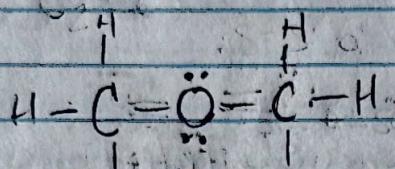
### Resonance hybrid

\* Resonance doesn't differ in which atom is bonded to which. Only where the pairs are.

# Worksheet

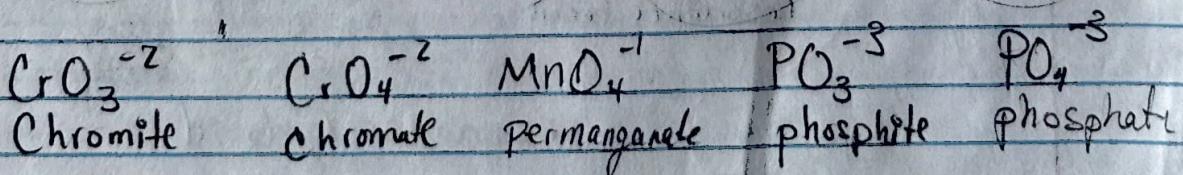
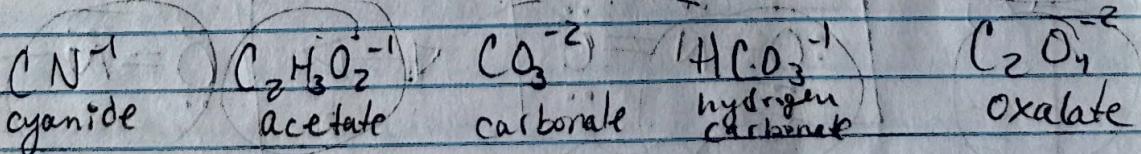
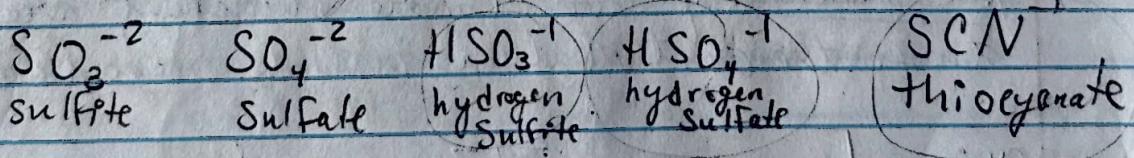
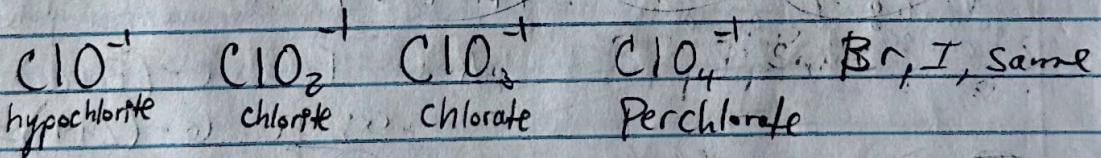
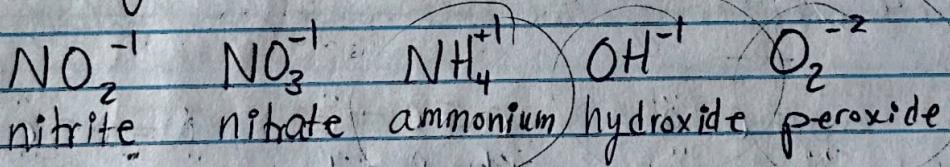
$$2(4) + 6(1) + 6 = 20 \text{ valence}$$

$\text{C}_2\text{H}_6\text{O}$  Lewis structure

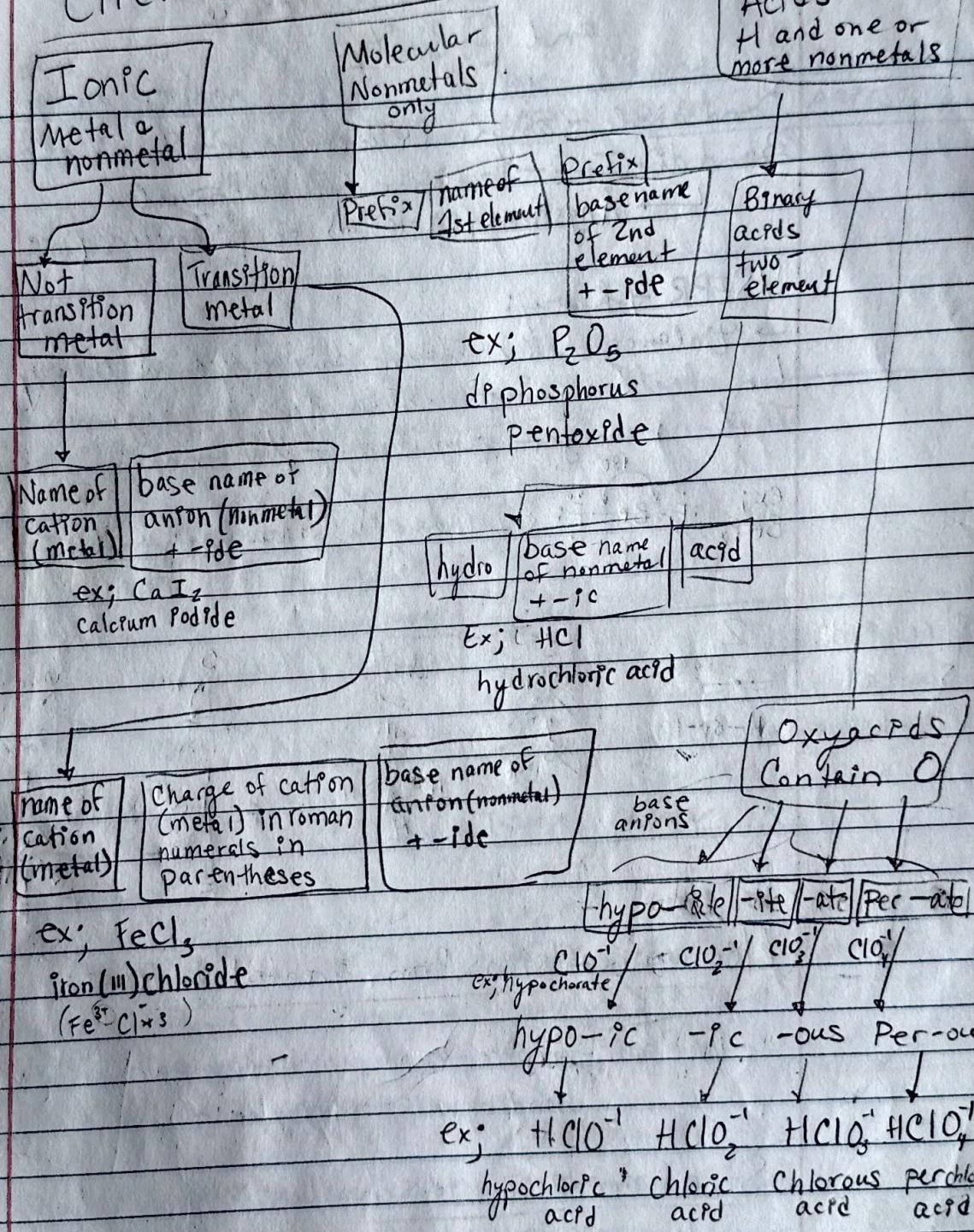


hypo-ite / -ite / ate per-ate

## Polyatomic Ions



# Chemical Nomenclature



NO<sub>3</sub><sup>-</sup> NO<sub>2</sub><sup>-</sup> NO<sub>2</sub> O<sub>3</sub><sup>-</sup> O<sub>2</sub><sup>-</sup>

## 4.6 Molecular Structure and Polarity

Bond angle - angle between a common atom

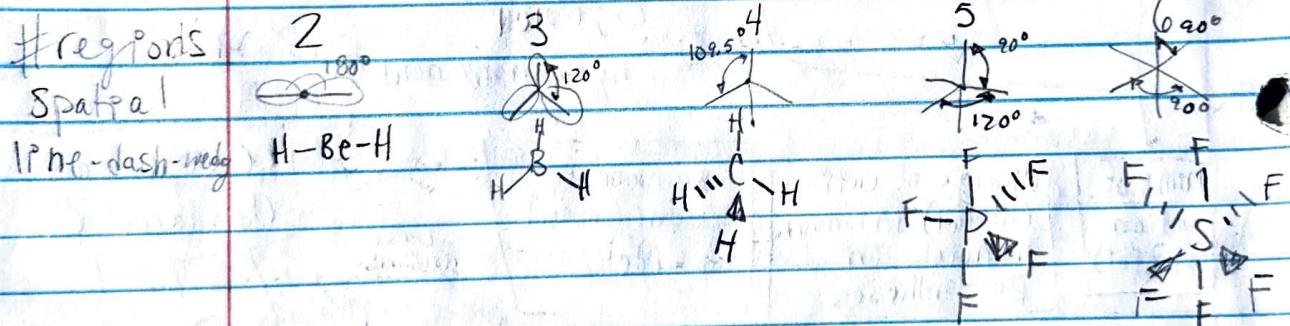
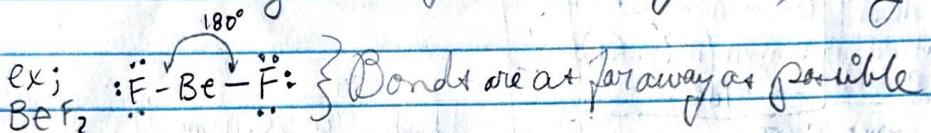
Bond distance - distance between nuclei

→ Ångströms ( $1\text{Å} = 10^{-10}\text{m}$ ) or picometers ( $10^{-12}$ )

VSEPR Theory:

↳ Valence shell electron-pair repulsion theory

↳ electron pairs will adopt an arrangement that minimizes repulsion by maximizing distance



Electron repulsions from greatest to least:

lone pair-lone pair → lone pair-bonding pair

bonding pair-bonding pair

Size from largest to smallest:

lone pair → triple bond → double bond → single bond

? axial position -  
? equatorial position -

also the electron geometry

# of  
electron  
regions

0 lone  
pairs

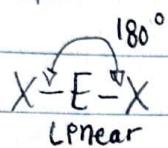
1 lone  
pair

2 lone  
pairs

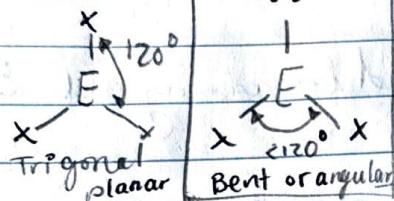
3 lone  
pairs

4 lone  
pairs

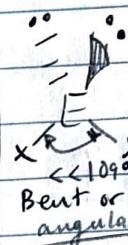
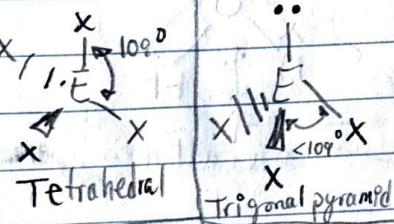
2



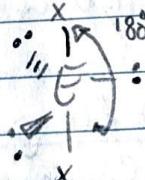
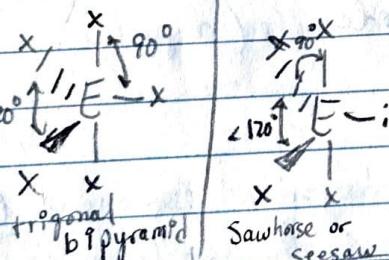
3



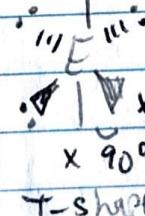
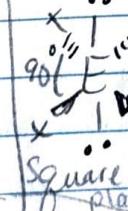
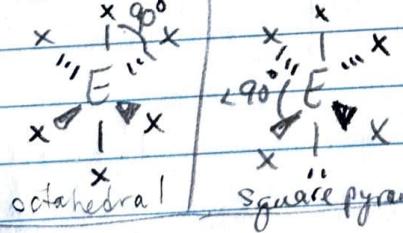
4



5



6

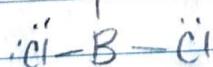


ex:  $BCl_3$

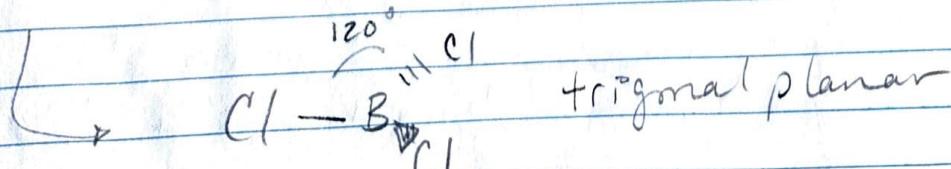


3 bonds,

Lewis structure:

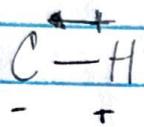


1 lone pair on B

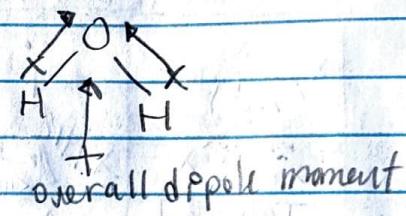
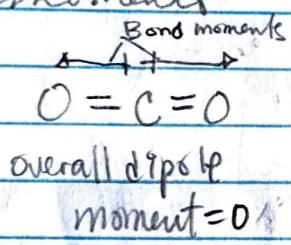


Dashes = away from you  
Wedges = towards you

Bond dipole moment - separation of charge due to differing electronegativities  
↳ represented by a vector



Dipole moment found by adding all 3D bond moments

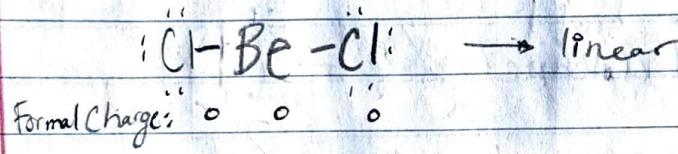
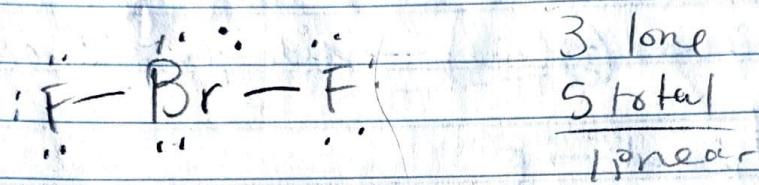
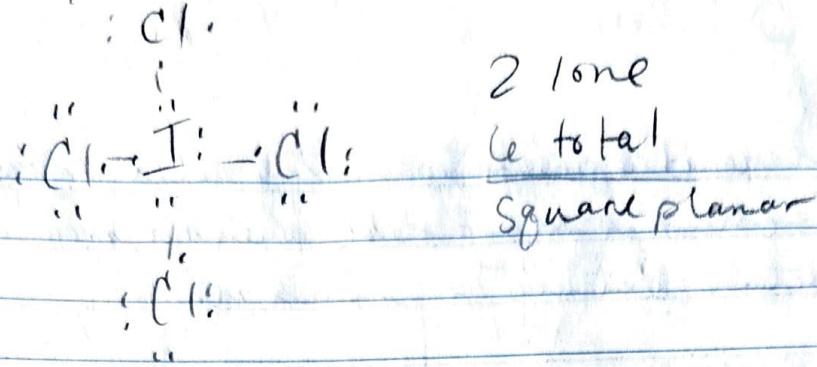


\*  $\text{H}_2\text{O}$  is a polar molecule (dipole)

To be polar:

- 1.) contain at least one polar covalent bond
- 2.) have a structure so the vectors don't cancel

# ALEKS/Class



## 5.1 Valence Bond Theory

There is a point where the total energy in a system is most stable when two atoms are a certain distance from each other.

Orientation affects overlap

end-to-end  $\rightarrow$  sigma bond (σ bond)

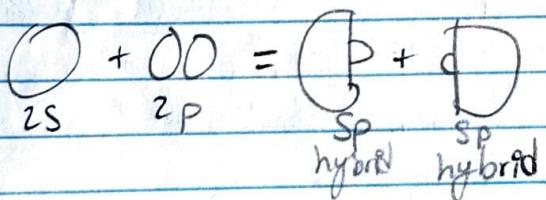
parallel (π bond)  $\rightarrow$  side-by-side of orbitals

Single bond  $\rightarrow$  σ

Multiple  $\rightarrow$  1 σ and π

## 5.2 Hybrid Atomic Orbitals

hybridization - combining orbitals to create a new orbital



Process:

- determine electron groups
- decide hybridization label

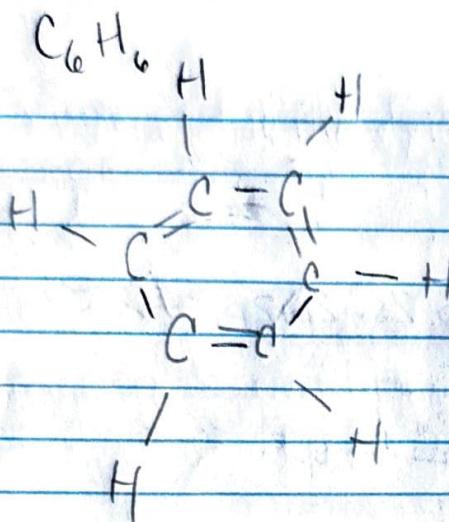
Electron groups      hybridization      Orbitals mixed

2	$\text{sp}$	$\text{S} + \text{P}$
3	$\text{sp}^2$	$\text{S} + \text{P} + \text{P}$
4	$\text{sp}^3$	$\text{S} + \text{P} + \text{P} + \text{P}$
5	$\text{sp}^3\text{d}$	$\text{S} + \text{P} + \text{P} + \text{P} + \text{D}$
6	$\text{sp}^3\text{d}^2$	$\text{S} + \text{P} + \text{P} + \text{P} + \text{D} + \text{D}$

$\pi$  bonds  $\rightarrow$  not hybridized



# Class 5/22



# e <sup>-</sup>	geometry	Required hybridization	orbitals mixed	Unhybridized orbitals	Pi bond
2	linear	SP	S+P	P+P	yes
3	trigonal planar	SP <sup>2</sup>	S+P+P	P	yes
4	tetrahedral	SP <sup>3</sup>	S+P+P+P	NA	no
5	trigonal bipyramidal	SP <sup>3</sup> D	S+P+P+P+D	D+D+D+D	yes
6	octahedral	SP <sup>3</sup> D <sup>2</sup>	S+P+P+P+D+D	D+D+D	yes

Energy:

triple > double > single bond  
closer on Pier. Table > further

Pi  $\neq$  sigma hybridized

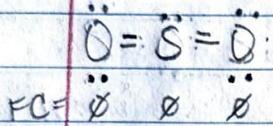
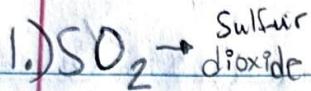
Pi  $\rightarrow$  between two P or d

hybrids are different, are the merging of two orbitals

ex; 3e<sup>-</sup>, SP<sup>2</sup> [2s — 2p — —] ↑ one left over [2s — 2p — —]

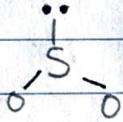
create a pi bond w/ the other orbital  
in the other atom

## Worksheet 2.2



Electron domains  
around S  $\rightarrow$  3

el. geo: trigonal planar



mol. geo: Bent

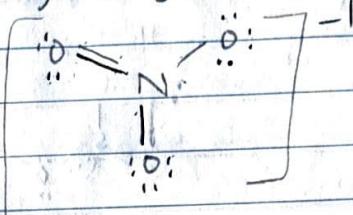
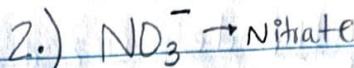
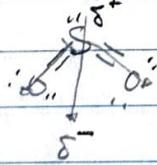
angle:  $< 120^\circ$

resonance?  $\rightarrow$  no

hybrid:  $\text{sp}^2$

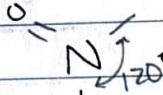
pi bond?: yes

polar?: yes



3 domains

el. geo: trigonal planar



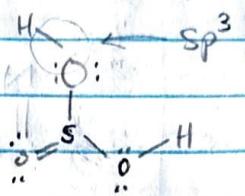
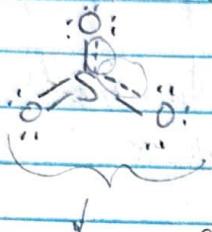
mol geo: same

resonance = yes

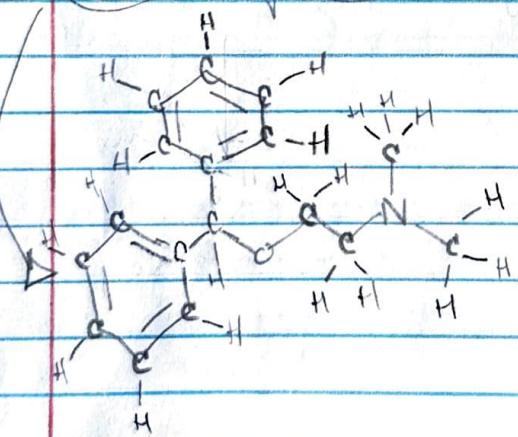
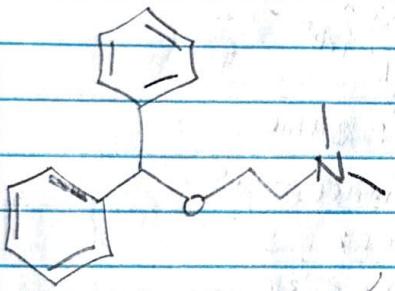
resonance: yes

hybrid:  $\text{sp}^2$  (the resonance cancels the  $\text{sp}^3$ )

2.) Where will the delocalized pi bond exist?



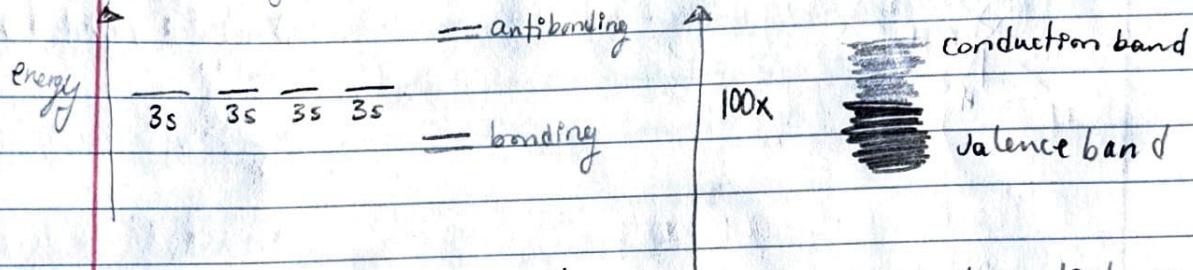
\*resonance affects bond length.  
there isn't a shortest, they're all the same



## 5.4 Molecular Orbital Theory

Paramagnetism - molecules w/ unpaired electrons have attraction to magnetic field.

Diamagnetic - all electrons are paired



If the Valence & conduction bands are a certain distance, they will be a Semiconductor

### Activity 2.8

Intramolecular forces - bonds that form within the molecule

→  
Ion-Ion  
dipole-dipole  
London dispersion forces

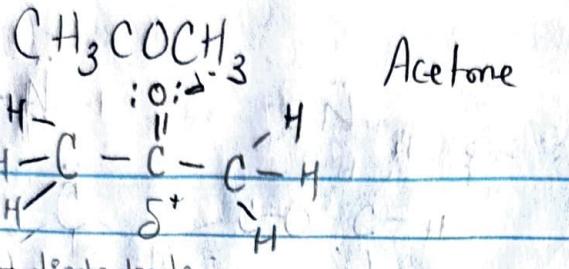
Ion-Ion forces - increasing w/ magnetic charge of ions  
 $F = \frac{Q^+ Q^-}{r^2}$   $Q \rightarrow$  charge  $r \rightarrow$  distance between charges

dipole-dipole forces -  $\delta^+$  attracted to  $\delta^-$  of molecule

↳ polar molecules

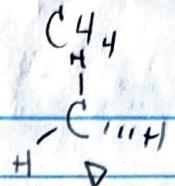
↳ hydrogen bond → very strong, + w/ N or O or F

London dispersion forces - momentary  $e^-$  distribution due to movement of  $e^-$

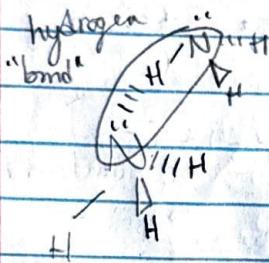


Acetone

→ dipole-dipole  
 - London dispersion



- London dispersion



Easier to boil, because  
 weak interconnections

3.564

0.3564

## 6.3 Molarity

Concentration - amount of solution component  
Solvent - concentration bigger than others

↳ where other things are dissolved

Aqueous solution - soluble in  $H_2O$

Solute - lower concentration in solution

↳ dilute - low concentration

concentrated - high "

$$\text{Molarity : } M = \frac{\text{mol solute}}{\text{L Solution}}$$

Dilution - lessened by addition of solvent

$$\begin{aligned} \text{Solute: } & \sum N_1 = M_1 L_1 \\ \text{Solvent: } & \sum N_2 = M_2 L_2 \\ \text{Total: } & \sum N_1 + N_2 = M_1 L_1 + M_2 L_2 \rightarrow M_1 L_1 = M_2 L_2 \rightarrow C_1 V_1 = C_2 V_2 \end{aligned}$$

## 6.4 Other Units for Solution Concentration

$$\text{mass percentage} = \frac{\text{mass of component}}{\text{mass of solution}} \times 100\%$$

$$\text{Volume Percentage} = \frac{\text{volume solute}}{\text{volume solution}} \times 100\%$$

Mass - Volume Percentage  $\Rightarrow$  ratio of solute's mass to  
solute's volume ex:  $\frac{\text{mg}}{\text{mL}}$

$$\text{Parts per million (PPM)} = \frac{\text{mass solute}}{\text{mass solution}} \times 10^6 \text{ PPM}$$

$$\text{Parts per billion (ppb)} = \frac{\text{mass solute}}{\text{mass solution}} \times 10^9 \text{ ppb}$$

ALEKS

dilute  $\underbrace{46.5 \text{ mL}}$  of  $\underbrace{1.46 \text{ M}}$  of  $\text{Al}_2(\text{SO}_4)_3$  until concentration falls to  $\underbrace{1.00 \text{ M}}$   
What is final volume?  $\underbrace{(\text{mL})}_{\text{v}_2}$

$$C_1 V_1 = C_2 V_2$$

$$V_2 = \frac{C_1 V_1}{C_2} =$$

$$210 \text{ mL} \rightarrow V_2 \quad (0.21 \text{ L})$$

$$100 \text{ mL} \rightarrow V_1 \quad (0.10 \text{ L})$$

$$1.46 \text{ M} \rightarrow C_1$$

$$C_2 = ?$$

$$C_2 = \frac{C_1 V_1}{V_2} = 0.576$$

$$V_1 = ?$$

$$V_2 = 700 \text{ mL} = 0.7 \text{ L}$$

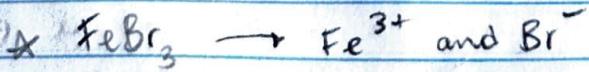
$$653 \mu\text{M} = C_2 = 653 \times 10^{-6} \text{ M}$$

$$0.00162 \text{ M} = C_1$$

$$V_1 = \frac{C_2 V_2}{C_1} = \frac{653 \times 10^{-6} \cdot 0.7}{0.00162} = 282 \text{ mL}$$

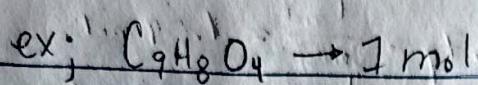
$$n_1 = M_1 L_1$$

$$L_1 = \frac{n_1}{M_1} = \frac{400 \times 10^{-3}}{0.1} =$$



$\text{Br}^-$  has 3x molarity??

## 6.2 Determining Empirical and Molecular Formulas



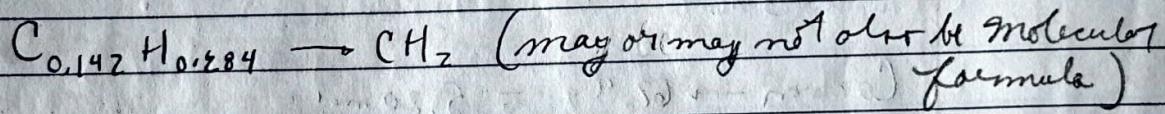
$$\% \text{ C} = \frac{1 \text{ mole} \times \text{molar mass C}}{\text{molar mass } \text{C}_9\text{H}_{10}\text{O}_4} = 60.00\% \text{ C}$$

### Determining Empirical Formula:

ex; Compound contains  $1.71 \text{ g C} + 0.287 \text{ g H}$

$$1.71 \text{ g C} \times \frac{1 \text{ mole}}{12.01 \text{ g C}} = 0.142 \text{ mol C}$$

$$0.287 \text{ g H} \times \frac{1 \text{ mole H}}{1.008 \text{ g H}} = 0.284 \text{ mol H}$$



### Determining Molecular Formula:

Empirical  $\rightarrow$  relative numbers

Molecular  $\rightarrow$  absolute number in single molecule

— Compare Empirical mass to molar mass of molecule

ex; Nicotine  $\rightarrow 40.57 \text{ g / 0.2500 mol}$

74.07% C

8.710% H

17.27% N

empirical  $\rightarrow \text{C}_5\text{H}_7\text{N} \rightarrow \frac{81.13 \text{ amu}}{\text{formula unit}}$

Nicotine molar mass  $\rightarrow \frac{162.3 \text{ g}}{\text{mol}}$

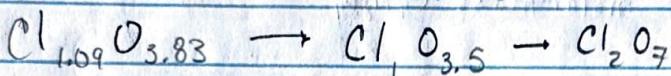
$\frac{162.3 \text{ g / mol}}{81.13 \text{ g / formula unit}} = 2 \text{ formula units / molecule}$

$(\text{C}_5\text{H}_7\text{N})_2 = \text{C}_{10}\text{H}_{14}\text{N}_2 \}$  — Molecular Formula

# ALEKS

$$\text{Chlorine} \ 38.7\% \quad 38.7g \cdot \frac{1 \text{ mol}}{35.45g} = 1.09 \text{ mol}$$

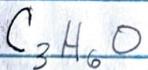
$$\text{Oxygen} \ 61.2\% \quad 61.2g \cdot \frac{1 \text{ mol}}{15.9994g} = 3.83 \text{ mol}$$



$$\text{Carbon} \rightarrow 62.1g \cdot \frac{1 \text{ mol}}{12.0096g} = 5.175$$

$$\text{Hydrogen} \rightarrow 10.5g \cdot \frac{1 \text{ mol}}{1g} = 10.5$$

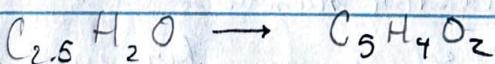
$$\text{Oxygen} \rightarrow 27.6g \cdot \frac{1 \text{ mol}}{15.9994g} = 1.725$$



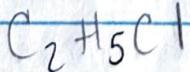
$$\text{Carbon} \rightarrow 62.4g = 5.20 \text{ mol}$$

$$\text{H} \rightarrow 4.19g = 4.19 \text{ mol}$$

$$\text{O} \rightarrow 33.2g = 2.08 \text{ mol}$$



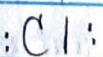
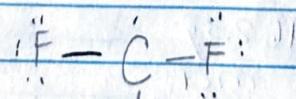
Class:



$$\text{C} - 24 \rightarrow 37.5\%$$

$$\text{H} - 5 \rightarrow 7.81\%$$

$$\text{Cl} - 35 \rightarrow 53.8\%$$



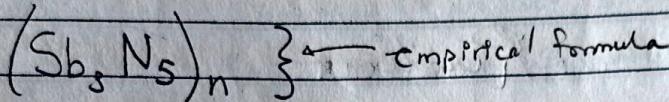
### Class:

83.9% Antimony (Sb)

16.1% N

$$83.9 \text{ g} \cdot \frac{1 \text{ mol}}{121.760 \text{ g}} = 0.689 \text{ mol} \quad | \quad 0.689 \text{ mol} : 1 = 3 \quad 3$$

$$16.1 \cdot \frac{1 \text{ mol}}{14.0067} = 1.15 \text{ mol} \quad | \quad 1.15 \text{ mol} : 0.689 \text{ mol} = 1.67 \cdot 3 \quad 5$$

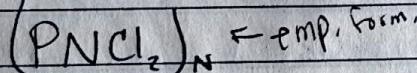


empirical & molecular formulas

$$26.7\% \text{ P} : \frac{1 \text{ mol}}{30.9738 \text{ g}} = 0.862 \quad | \quad 0.862 = 1$$

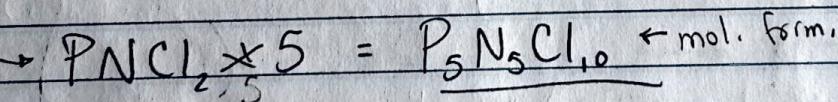
$$12.1\% \text{ N} : \frac{1 \text{ mol}}{14.0067 \text{ g}} = 0.864 \quad | \quad 0.864 = 1$$

$$61.2\% \text{ Cl} : \frac{1 \text{ mol}}{35.45 \text{ g}} = 1.73 \quad | \quad 1.73 = 2$$



molecular molar mass  $\rightarrow 580 \text{ g/mol}$

$$\text{Empirical } " " \rightarrow 30.9738 + 14.0067 + (35.45)2 = 115.88$$



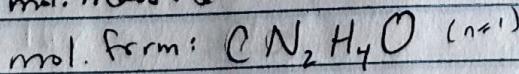
$$46.65 \text{ g N} : \frac{1 \text{ mol}}{14.0067 \text{ g}} = 3.33 \rightarrow 2.01 \quad 20 \text{ g C} \rightarrow 1$$

$$6.71 \text{ g H} : \frac{1 \text{ mol}}{1 \text{ g}} = 6.71 \rightarrow 4.04$$

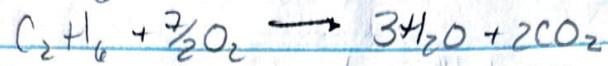
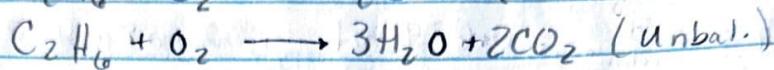
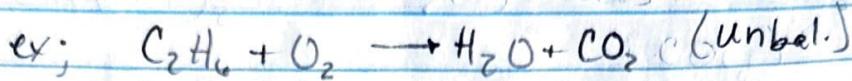
$$26.43 \text{ g O} : \frac{1 \text{ mol}}{16 \text{ g}} = 1.66 \rightarrow 1$$

$$\text{emp. form: } (\text{C}_2\text{N}_2\text{H}_4\text{O})_n \rightarrow 12 + 14 + 1 + 16 = 46$$

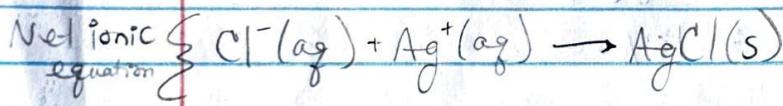
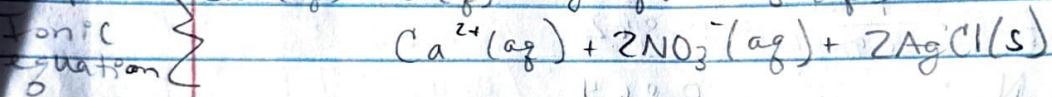
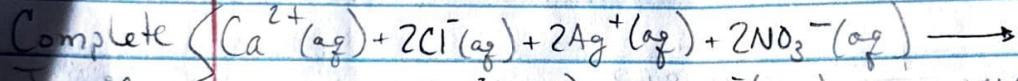
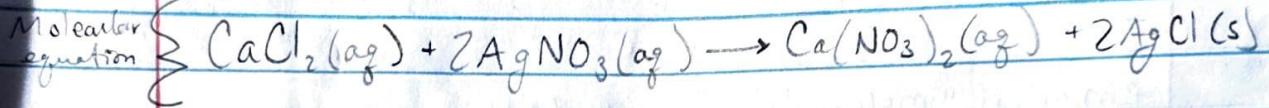
mol. mass: 46.0



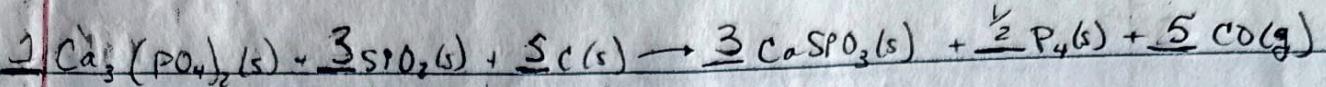
## 7.1 Writing & Balancing Chemical Equations



### Equations for Ionic Reactions



# ALEKS



\* look for elements that appear in only one of the compounds w/ unknown coeff.

Ca → 3 on 1st product, 1 on 1<sup>st</sup> reactant

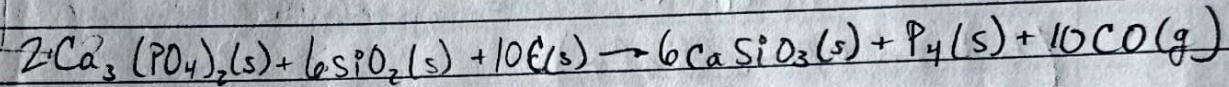
P →  $\frac{5}{2}$  on 2nd product, 1 on 1<sup>st</sup> reactant

Si → 3 on 2nd product, 3 on 2nd reactant

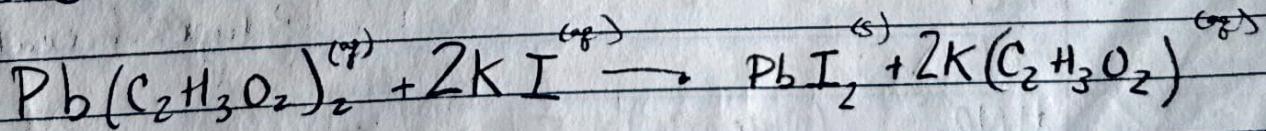
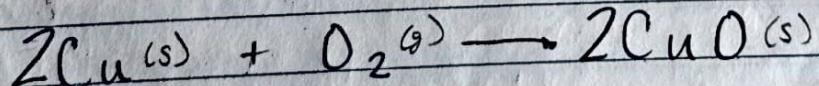
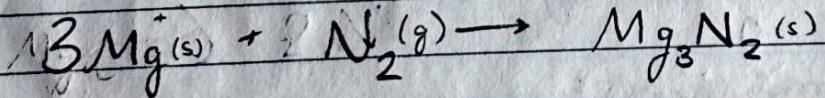
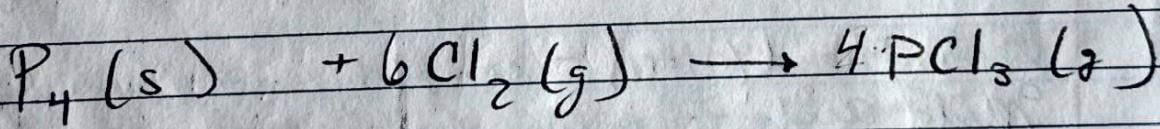
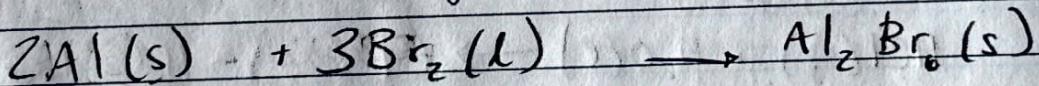
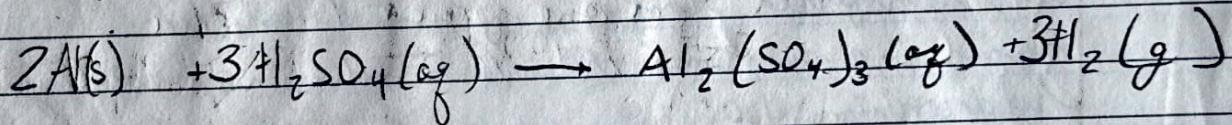
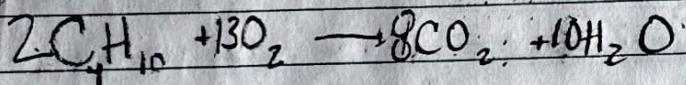
O → 5 on 3rd product, 1 on 1<sup>st</sup> reactant

C → 5 on 3rd product, 5 on 3rd reactant

\* Clear the fractions



Closes:



Isabel  
#  
Ricky  
#

1th

## 7.2 Classifying Chemical Reactions

Precipitation Reaction - dissolved substances form solid products

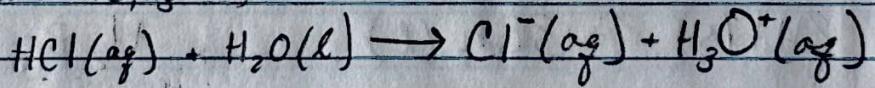
- ↳ double displacement
- ↳ double replacement
- ↳ metathesis

Solubility - extent which a substance can be dissolved in water

- ↳ large solubility = soluble (may precipitate)
- ↳ small " = insoluble

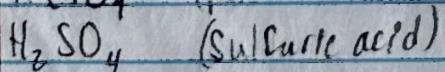
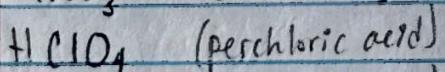
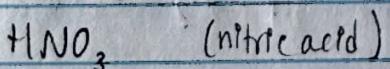
(table in exam tools)

Acid-Base Reaction - one hydroxide ion  $H^+$  is transferred from one species to another (acid is a substance that will dissolve in water to yield hydronium,  $H_3O^+$ )



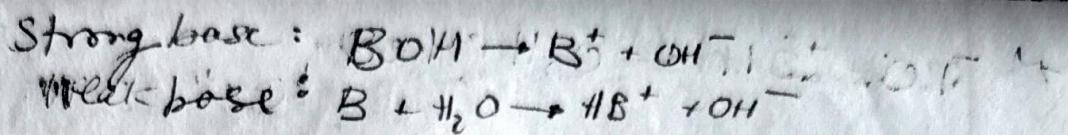
Strong acid (ex; HCl) - completely react (none left over)  
Weak acids → only partially react

Common strong acids:



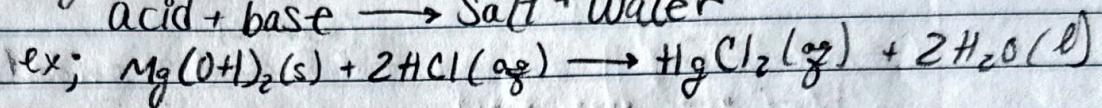
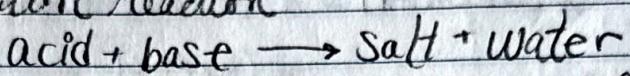
3 types of reactions

(acid-base)  
precipitation  
redox

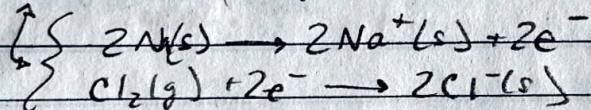
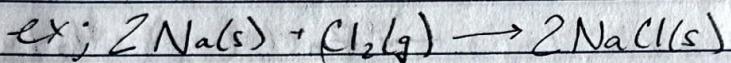


base - dissociates in water to yield hydroxide ion  $\text{OH}^-$   
ex;  $\text{NaOH(s)} \rightarrow \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq})$

Neutralization reaction:



## Oxidation - Reduction Reaction (redox)



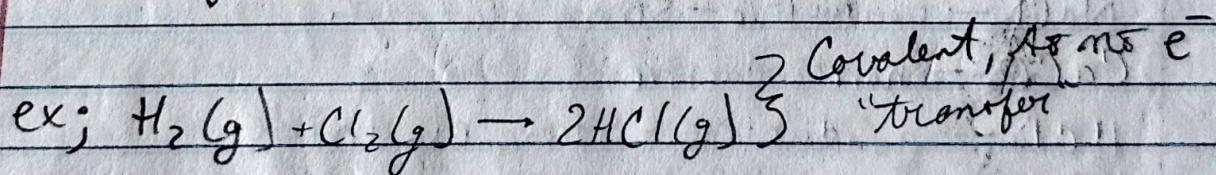
- Na loses  $e^-$ , Cl gains  $e^-$

Oxidation  $\rightarrow$  loss of electron

reduction  $\rightarrow$  gain of electron

Reducing agent  $\rightarrow$  species that is oxidized

Oxidizing "  $\rightarrow$  " " Reduced



Covalent, no  $e^-$  transfer

Oxidation number (or oxidation state)  
charge atoms would have if compound were ionic

1. Ox# of elemental  $\rightarrow 0$

2. Ox# of monatomic ion = ion charge

3. H: +1 w/ nonmetals  
-1 w/ metals

O: -2 in most, sometimes -1 (peroxide,  $\text{O}_2^{2-}$ ), rarely  $-\frac{1}{2}$

(superoxide  $\text{O}_2^-$ ), poss. when combined w/ F

Halogen: -1 for F, -1 for others except when w/ O or other halogen

4. sum of Ox# = charge of molecule

Summary : redox reaction - one or more elements undergo change in O<sub>xtt</sub>

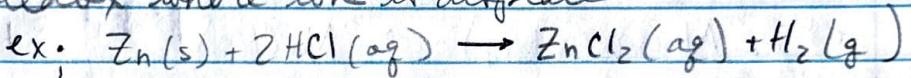
- oxidation = increase O<sub>xtt</sub>

- reduction = decrease O<sub>xtt</sub>

Combustion reaction  $\xrightarrow{\text{reductant}} \text{oxidant react vigorously}$  (redox)

Single-displacement (replacement) reaction

↳ redox where ion is displaced



Molecular compounds stay as molecules when they dissolve  
Ionic " break up into cations + anions

electrolyte - conducts electricity when dissolved in H<sub>2</sub>O

Water - non conduct.

NaCl - conductive - strong electrolyte

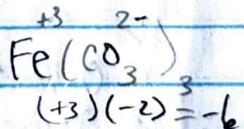
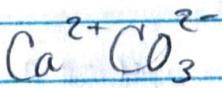
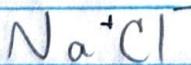
CaCO<sub>3</sub> - non conductive

HCl - conductive - strong electrolyte

H<sub>2</sub>C<sub>2</sub>H<sub>3</sub>O<sub>2</sub> - conductive - weak acid

Sugar - non conductive

Why does  
NaCl break but  
CaCO<sub>3</sub> doesn't?



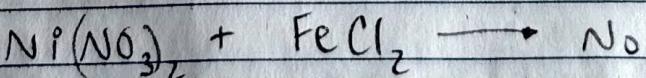
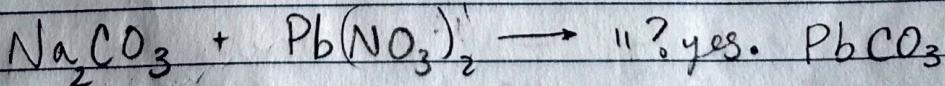
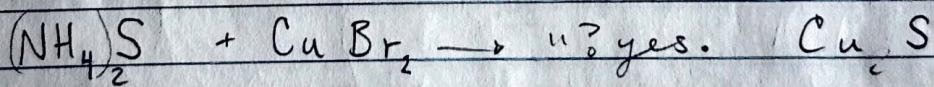
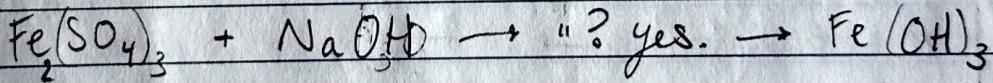
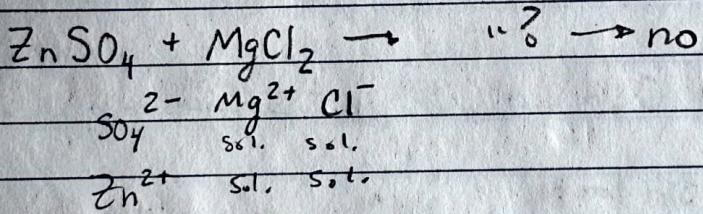
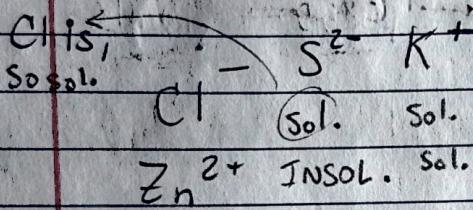
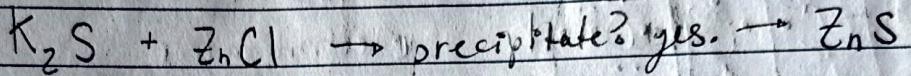
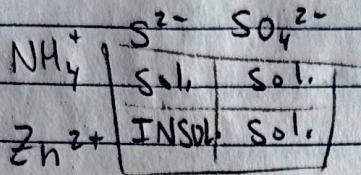
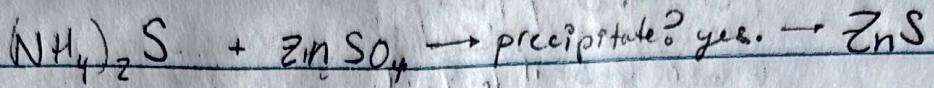
$$F_i = \frac{q_1 q_2}{r^2}$$

-1

-4

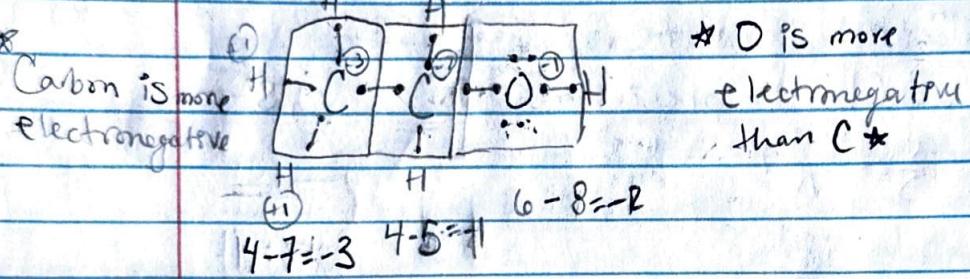
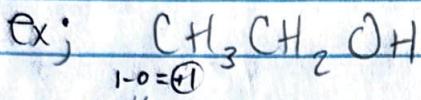
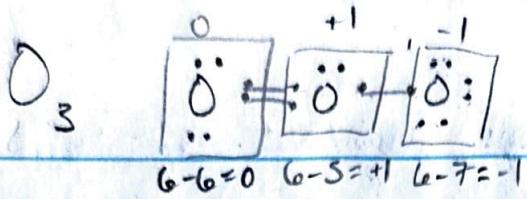
4x stronger

# ALEKS (precipitation)



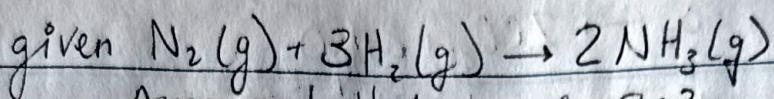
SETOH

## Actual oxidation # in ozone



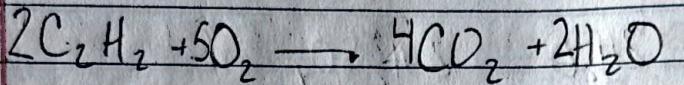
## 7.3 Reaction Stoichiometry

AKA ratios

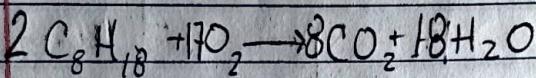


Ammonia to hydrogen is 2:3

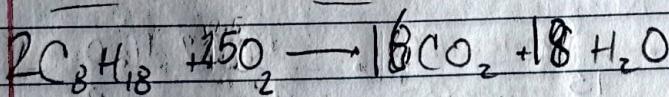
ALEKS:



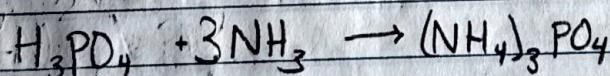
$$\frac{4}{5} = \frac{0.700}{x} \quad x = 0.875 \text{ moles}$$



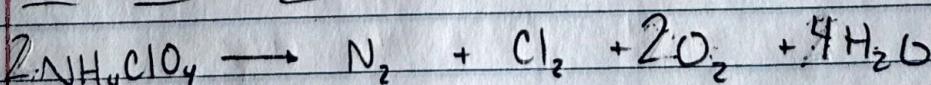
$$\frac{18}{2} = \frac{x}{1.3} \quad x = 11.7 \text{ mol}$$



$$4.0 \text{ g Octane} * \frac{1 \text{ mole}}{114.26 \text{ g}} * \frac{18 \text{ mol } H_2O}{2 \text{ mol octane}} * \frac{18.02 \text{ g } H_2O}{1 \text{ mol } H_2O} = 5.7 \text{ g}$$



$$9.05 \text{ g } (NH_3) * \frac{1 \text{ mol } NH_3}{17.03 \text{ g } NH_3} * \frac{1 \text{ mol } (NH_4)_3PO_4}{3 \text{ mol } NH_3} * \frac{149.09 \text{ g } (NH_4)_3PO_4}{1 \text{ mol } (NH_4)_3PO_4} = 26.4 \text{ g } (NH_4)_3PO_4$$

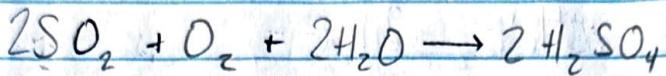


$$5.85 \text{ g } (NH_4ClO_4) * \frac{1 \text{ mol } "}{17.03 \text{ g } "} * \frac{1 \text{ mol } N_2}{2 \text{ mol } "} * \frac{28.02 \text{ g } N_2}{1 \text{ mol } N_2} = 0.698 \text{ g } N_2$$

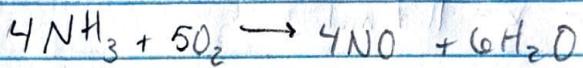
Class:



$$\frac{18.1g}{C_2H_4} * \frac{1 \text{ mol } C_2H_4}{27 \text{ g } C_2H_4} * \frac{3 \text{ mol } O_2}{\text{mol } C_2H_4} * \frac{32 \text{ g } O_2}{\text{mol } O_2} = 62.1 \text{ g } O_2$$



$$\frac{45.3g}{O_2} * \frac{2 \text{ moles } O_2}{32 \text{ g } O_2} * \frac{2 \text{ moles } SO_2}{\text{moles } O_2} * \frac{64 \text{ g } SO_2}{\text{moles } SO_2} = 181.2 \text{ g}$$



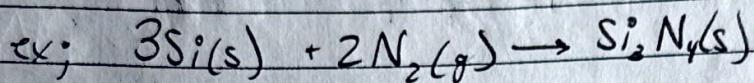
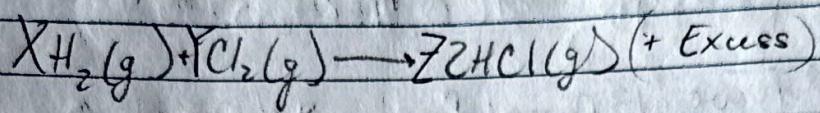
$$\frac{4.35 \text{ moles } O_2}{5 \text{ moles } O_2} * \frac{6 \text{ moles } H_2O}{1 \text{ mole } NH_3} * \frac{18 \text{ g } H_2O}{1 \text{ mole } H_2O} = 93.96 \text{ g}$$

$$\frac{1.78 \times 10^{-15} \text{ g } O_2}{32 \text{ g } O_2} * \frac{1 \text{ mole } O_2}{5 \text{ mol } O_2} * \frac{4 \text{ mol } NO}{6.022 \times 10^{23} \text{ molecules } NO} * \frac{30 \text{ g } NO}{1 \text{ mol } NO} = 2.7 \times 10^{-7} \text{ g}$$

Auth.  
Pickett

## 7.4 Reaction Yield

1 slice of cheese + 2 slices of bread  $\rightarrow$  1 sandwich



If we combine 2.00g of Si and 1.50g of N<sub>2</sub>, which is the limiting reactant

$$\begin{aligned} 2.00\text{g Si} &\times \frac{1\text{mol Si}}{28.07\text{g Si}} = 0.0712 \text{ mol Si} \\ 1.50\text{g N}_2 &\times \frac{1\text{mol N}_2}{28.02\text{g N}_2} = 0.0535 \text{ mol N}_2 \end{aligned} \quad \left. \begin{array}{l} \\ \end{array} \right\} = \begin{array}{l} 1.33\text{mol Si} \\ 1\text{mol N}_2 \end{array}$$

1.5:1

Silicon yields the lesser amount of product, so it is the limiting reactant.  
(Stoichiometric 3:2 or 1.5:1)  $\leftarrow$  Si is less than Sto. value

## Percent Yield

$$\text{Percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

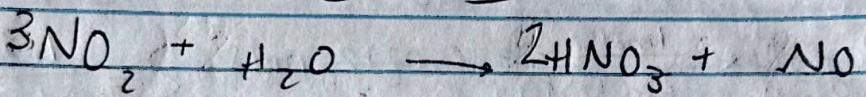
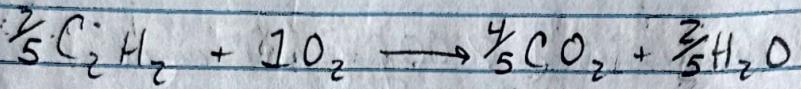
ex;

If 0.392g Cu was obtained where 0.5072g Cu was expected, the percent yield is 77.3%.

ALEKS

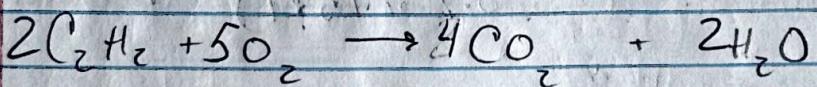


If I have 13.0 mol  $\text{C}_2\text{H}_2$  & 1.0 mol  $\text{O}_2$



1.0 mol  $\text{NO}_2$ ; 5.0 mol  $\text{H}_2\text{O}$

3 : 1       $\text{NO}_2$  is the limiting reactant  
15 : 1



Calculate largest amount of  $\text{CO}_2$  that could be produced, given 11.0 mol  $\text{C}_2\text{H}_2$  and 1.0 mol  $\text{O}_2$

Stoch: 2 : 5

given: 11 : 1  $\rightarrow$  2 :  $\frac{2}{11}$   $\text{O}_2$  is limiting

$$1 \text{ mol O}_2 * \frac{4 \text{ mol CO}_2}{5 \text{ mol O}_2} = \underline{\underline{\frac{4}{5} \text{ mol CO}_2}}$$

ALEKS cont.



✓ balanced

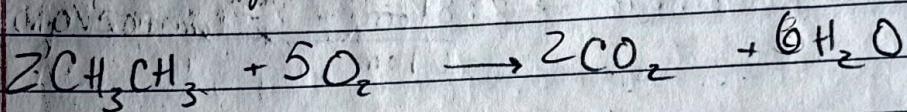
Given: 11 g HCl ; 20.1 g NaOH

min mass of HCl acid left over

$$11 \text{ g HCl} \times \frac{1 \text{ mol (Cl)}}{35.45 \text{ g (Cl)}} = 0.31 \text{ mol}$$

$$20.1 \text{ g NaOH} \times \frac{1 \text{ mol}}{40 \text{ g}} = 0.503 \text{ mol}$$

① HCl left over



45.6 g O<sub>2</sub> ; 6.9 g CH<sub>3</sub>CH<sub>3</sub>

max CO<sub>2</sub> produced?

$$4 \text{ mol } O_2 \times \frac{1 \text{ mol } O_2}{32 \text{ g } O_2} = 1.425 \text{ mol}$$

$$6.9 \text{ g } \text{CH}_3\text{CH}_3 \times \frac{1 \text{ mol } \text{CH}_3\text{CH}_3}{30 \text{ g "}} = 0.23 \text{ mol}$$

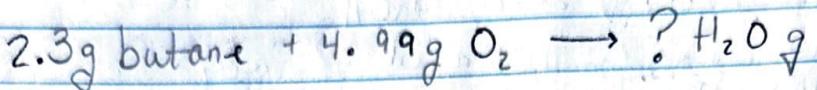
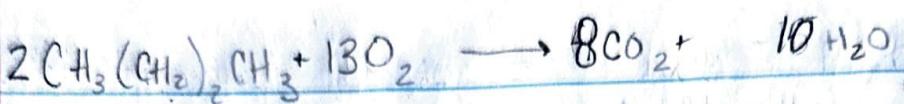
Starch: 2:5

$$\text{given: } 0.23 : 1.425 \rightarrow 0.807 : 5$$

limiting :  $\text{CH}_3\text{CH}_3$

$$0.23 \text{ mol } \text{CH}_3\text{CH}_3 \neq \frac{1 \text{ mol } \text{CO}_2}{1 \text{ mol } \text{CO}_2}$$

ALEKS cont. cont.



$$2.3\text{ g butane} * \frac{1 \text{ mol butane}}{68 \text{ g butane}} = 0.040 \text{ mol butane}$$

$$4.99\text{ g O}_2 * \frac{1 \text{ mol O}_2}{32 \text{ g O}_2} = 0.16 \text{ mol O}_2$$

Stoich: 2:13

$$\text{given: } 0.040 : 0.16 \rightarrow 2 : 8$$

O<sub>2</sub> is limiting reactant

$$0.16 \text{ mol O}_2 * \frac{10 \text{ mol H}_2\text{O}}{13 \text{ mol O}_2} = 0.8 \text{ mol H}_2\text{O} * \frac{18 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = 14.4 \text{ g}$$



$$53\text{ g Sulfuric acid} * \frac{1 \text{ mol}}{98.079} = 0.540 \text{ mol}$$

$$28.1\text{ g Sodium hydroxide} * \frac{1 \text{ mol}}{39.9971 \text{ g}} = 0.70255 \text{ mol}$$

Stoich: 1:2

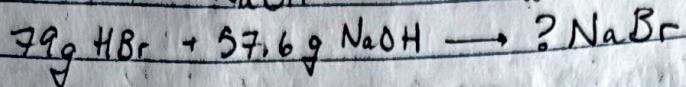
$$\text{given: } 0.540 : 0.70255 \rightarrow 1 : 1.3$$

Sodium hydroxide is limiting

$$0.70255 \text{ mol NaOH} * \frac{1 \text{ mol H}_2\text{SO}_4}{2 \text{ mol NaOH}} = 0.35 \text{ mol consumed}$$

$$= 0.189 \text{ mol left}$$

$$= 19 \text{ g}$$



$$79 \text{ g HBr} * \frac{1 \text{ mol HBr}}{80.9 \text{ g HBr}} = 0.976 \text{ mol}$$

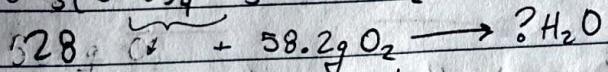
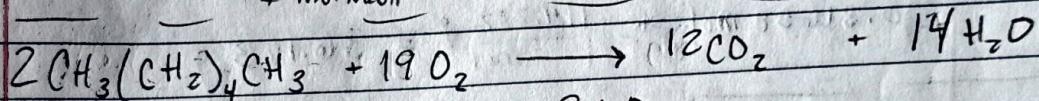
$$57.6 \text{ g NaOH} * \frac{1 \text{ mol}}{40.0 \text{ g NaOH}} = 1.44 \text{ mol}$$

Stoich: 1:1

$$\text{Given: } 0.976 : 1.44 \longrightarrow 1 : 1.075$$

\* NaOH is limiting

$$1.44 \text{ mol} * \frac{\text{NaOH}}{2 \text{ mol NaOH}} * \frac{1 \text{ mol NaBr}}{1 \text{ mol NaOH}} * \frac{107.894 \text{ g NaBr}}{1 \text{ mol NaBr}} = 148 \text{ g}$$



$$528 \text{ g hexane} * \frac{1 \text{ mol}}{86.18 \text{ g hexane}} = 6.0349 \text{ mol}$$

$$58.2 \text{ g O}_2 * \frac{1 \text{ mol}}{32 \text{ g O}_2} = 1.81875 \text{ mol}$$

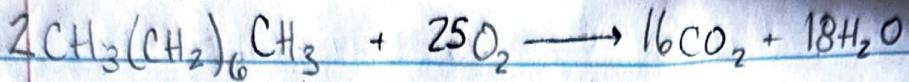
Stoich: 2:19

$$\text{Given: } 6.0349 : 1.81875$$

hexane is limiting

$$6.0349 \text{ mol} * 18 \text{ g/mol} = 108.62 \text{ g}$$

# ALEKS



79 g octane + 150 g O<sub>2</sub> → Octane left over?

$$\text{octane} = 114.232 \text{ g/mol} \rightarrow 79 * \frac{1}{114.232} = 0.692 \text{ mol}$$

$$\text{O}_2 = 32 \text{ g/mol} \rightarrow 150 * \frac{1}{32} = 4.6875 \text{ mol}$$

— O<sub>2</sub> is all used

$$4.6875 \text{ mol} \cdot \frac{2 \text{ mol octane}}{25 \text{ mol O}_2} = 0.375 \text{ mol octane used}$$

$$0.692 - 0.375 = 0.31658 \text{ mol octane left over}$$

$$0.31658 \text{ mol} * \frac{114.232 \text{ g}}{\text{mol}} = 36.163 \text{ g}$$



18 g ethane + 24.4 g O<sub>2</sub> → max CO<sub>2</sub> produced?

$$24.4 \text{ g O}_2 * \frac{1 \text{ mol O}_2}{32 \text{ g O}_2} = 0.7625 \text{ mol O}_2$$

$$18 \text{ g ethane} * \frac{1 \text{ mol}}{30.07 \text{ g}} = 0.5986 \text{ mol ethane}$$

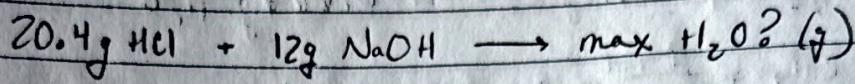
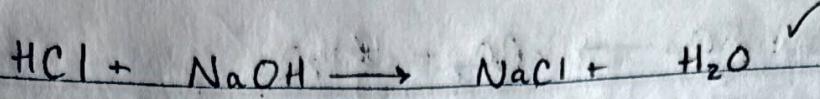
stoch: 2:7

$$\text{given: } 0.5986 : 0.7625 \rightarrow 2 : 2.547597$$

O<sub>2</sub> is limiting

$$0.7625 \text{ mol O}_2 * \frac{4 \text{ mol CO}_2}{7 \text{ mol O}_2} * \frac{44 \text{ g CO}_2}{1 \text{ mol CO}_2} = 19.17 \text{ g CO}_2$$

ALEKS cont. cont. cont. cont. cont.



$$20.4 \text{ g HCl} * \frac{1 \text{ mol}}{36.46 \text{ g}} = 0.5595 \text{ mol HCl}$$

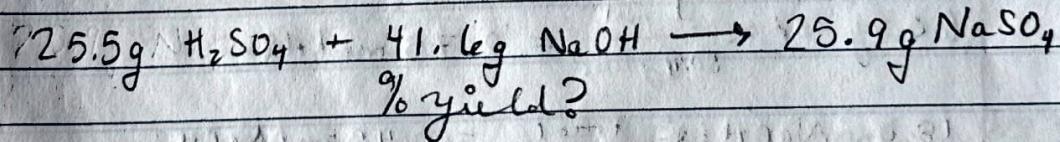
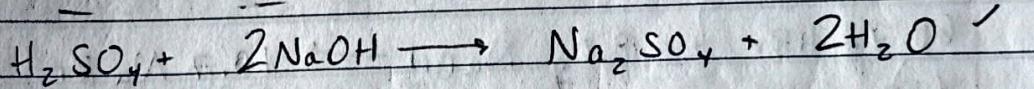
$$12 \text{ g NaOH} * \frac{1 \text{ mol}}{39.997 \text{ g}} = 0.3 \text{ mol NaOH}$$

Stoich: 1:1

$$\text{given: } 0.5595 : 0.3 \rightarrow 1 : 0.53622$$

NaOH is limiting

$$\text{Max H}_2\text{O} : 0.3 \text{ mol H}_2\text{O} * \frac{18 \text{ g H}_2\text{O}}{\text{mol H}_2\text{O}} = 5.4 \text{ g}$$



$$25.5 \text{ g H}_2\text{SO}_4 * \frac{1 \text{ mol}}{98.07 \text{ g}} = 0.25999 \text{ mol H}_2\text{SO}_4$$

$$41.6 \text{ g NaOH} * \frac{1 \text{ mol}}{39.997 \text{ g}} = 1.040075 \text{ mol NaOH}$$

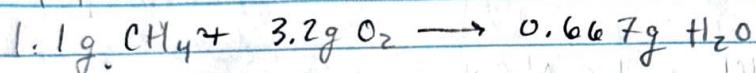
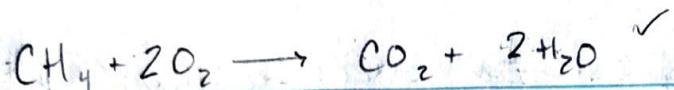
Stoich: 1:2

$$\text{given: } 0.25999 : 1.04 \rightarrow 0.24998 : 1$$

H<sub>2</sub>SO<sub>4</sub> is limiting

$$0.24998 \text{ mol H}_2\text{SO}_4 * \frac{1 \text{ mol Na}_2\text{SO}_4}{1 \text{ mol H}_2\text{SO}_4} * \frac{142.04 \text{ g Na}_2\text{SO}_4}{1 \text{ mol Na}_2\text{SO}_4} = 36.9296 \text{ g}$$

act  $\approx 100\%$   
theor



$$1.1\text{ g CH}_4 * \frac{1\text{ mol}}{16\text{ g}} = 0.06875\text{ mol}$$

$$3.2\text{ g O}_2 * \frac{1\text{ mol}}{32\text{ g}} = 0.1\text{ mol}$$

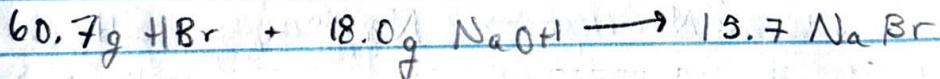
St : 1:2

$$\text{Given: } 0.06875 : 0.1 \rightarrow 7 : 1.45$$

O<sub>2</sub> is limiting

$$0.1\text{ mol O}_2 * \frac{1\text{ mol H}_2\text{O}}{2\text{ mol O}_2} * \frac{18\text{ g H}_2\text{O}}{1\text{ mol H}_2\text{O}} = 1.8\text{ g H}_2\text{O}$$

$$\frac{0.667\text{ g}}{1.8} = 37\% \text{ yield}$$



$$60.7\text{ g HBr} * \frac{1\text{ mol}}{80.91\text{ g HBr}} = 0.75\text{ mol HBr}$$

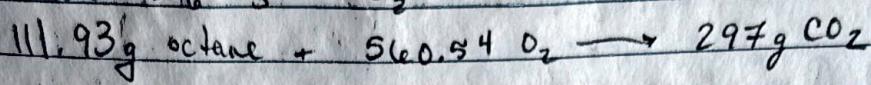
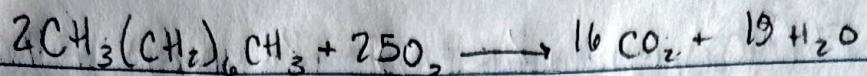
$$18.0\text{ g NaOH} * \frac{1\text{ mol}}{39.92\text{ g NaOH}} = 0.45\text{ mol NaOH}$$

S : 7:1

$$\text{g : } 0.75 : 0.45 \rightarrow 7 : 0.6$$

NaOH is limiting

$$0.45\text{ mol NaOH} * \frac{1\text{ mol NaBr}}{1\text{ mol NaOH}} * \frac{102.894\text{ g NaBr}}{1\text{ mol NaBr}} = 46.3023\text{ g}$$



$$111.93 \text{ g} * \frac{1 \text{ mol}}{114.232 \text{ g}} = 0.97985 \text{ mol octane}$$

$$560.54 \text{ g O}_2 * \frac{4 \text{ mol}}{32 \text{ g}} = 17.516875 \text{ mol O}_2$$

S: 2:25

$$19 : 0.97985 : 17.516875 \longrightarrow 1.3984 : 25$$

Octane is limiting

$$0.97985 \text{ mol octane} * \frac{16 \text{ CO}_2}{2 \text{ octane}} * \frac{44 \text{ g CO}_2}{1 \text{ mol CO}_2} = 344.907$$

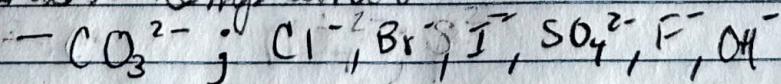
### Worksheet 3.1

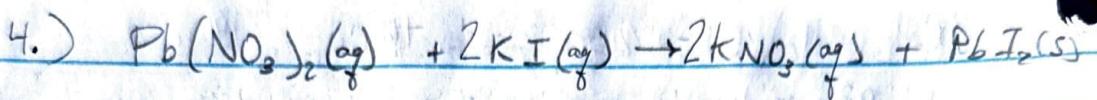
$$1.) \frac{5 \times 10^{-6} \text{ g Pb}}{100 \text{ mL}} * \frac{\text{mol Pb}}{207.2 \text{ g Pb}} * \frac{10^3 \text{ mL}}{1 \text{ L}} = 2.41 \times 10^{-7} \text{ M}$$

$$2.) \text{is this } \leq 15 \text{ ppb?} \rightarrow \frac{15 \text{ g Pb}}{10^9 \text{ g H}_2\text{O}} * \frac{1 \text{ mol}}{207.2 \text{ g Pb}} * \frac{1 \text{ g H}_2\text{O}}{1 \text{ mL}} * \frac{1000 \text{ mL}}{1 \text{ L}} = 7.24 \times 10^{-8} \text{ M}$$

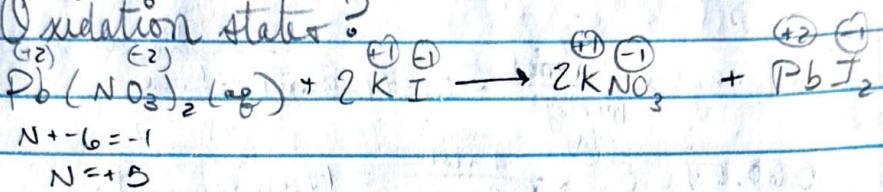
Not safe,  $6.28 \times 10^{-5} \text{ M} > 7.24 \times 10^{-8} \text{ M}$

3.) What can combine w/  $\text{Pb}^{2+}$  to make an insoluble compound?

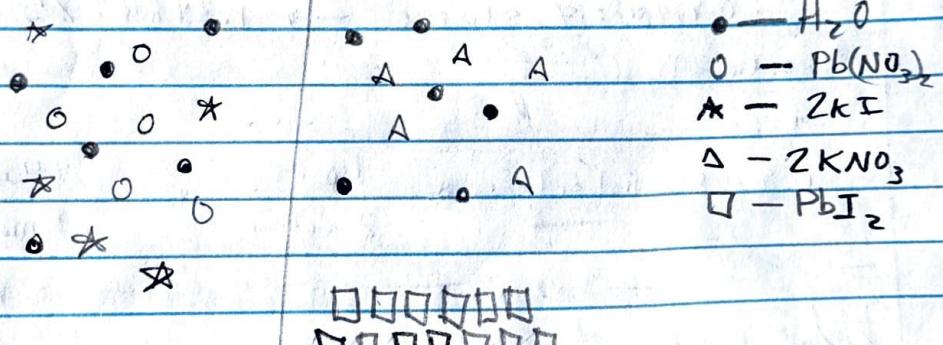




## 5.) Oxidation states?

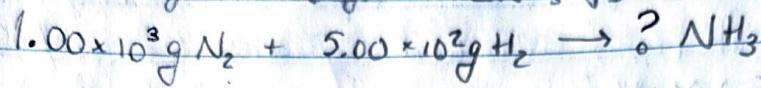
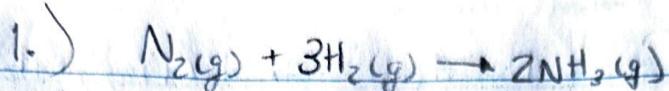


## (b.) Reactants



7.) What volume of 0.005M KI to get to react w/ all the  $Pb^{2+}$  ions in 750-L water

$$6.28 \times 10^{-5} \frac{\text{mol}}{\text{L}} + \frac{750 \text{ L}}{7 \text{ mol Pb}^{2+}} \times \frac{2 \text{ mol KI}}{0.005 \text{ mol KI}} = 18.8 \text{ L KI}$$



$$1.00 \times 10^3 \text{ g } N_2 * \frac{1 \text{ mol}}{28.02 \text{ g}} = 35.689 \text{ mol } N_2$$

$$5.00 \times 10^2 \text{ g } H_2 * \frac{1 \text{ mol}}{2 \text{ g}} = 25.00 \text{ mol } H_2$$

$N_2$  is limiting

$$35.689 \text{ mol } N_2 * \frac{2 \text{ mol } NH_3}{1 \text{ mol } N_2} * \frac{17.03 \text{ g}}{1 \text{ mol }} NH_3 = 121 \times 10^3 \text{ g } NH_3$$

2.) 70% yield?

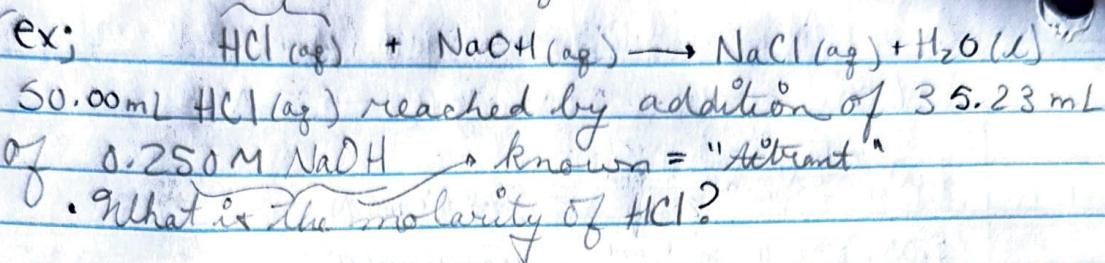
$$70\% = \frac{x}{121 \times 10^3} \quad x = 84.7 \text{ g } NH_3$$

3.) Redox

4.)  $\frac{14}{17}$  of N is 82% Ammonia  $\frac{3}{17}$  of H is 17% of Ammonia

## 7.5 Quantitative Chemical Analysis

Titration  
Analysis

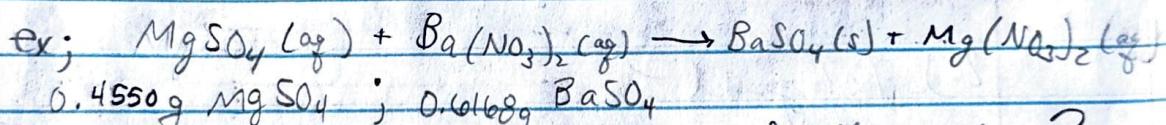


$$35.23 \text{ mL NaOH} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.25 \text{ mol NaOH}}{1 \text{ L}} \times \frac{1 \text{ mol HCl}}{1 \text{ mol NaOH}} = 8.81 \times 10^{-3} \text{ mol HCl}$$

$$M = \frac{\text{mol HCl}}{\text{L solution}} = \frac{8.81 \times 10^{-3} \text{ mol HCl}}{50.00 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}}} = 0.176 \text{ M}$$

Gravimetric Analysis:

↳ analyte changes physical state, so it separates



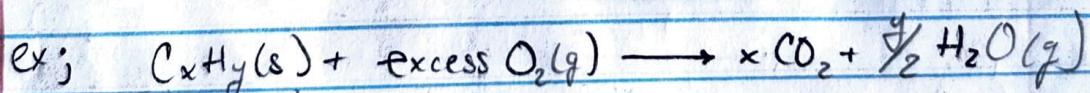
What is the concentration of MgSO<sub>4</sub> in the mixture?

$$0.6168 \text{ g BaSO}_4 \times \frac{1 \text{ mol BaSO}_4}{233.43 \text{ g BaSO}_4} \times \frac{1 \text{ mol MgSO}_4}{1 \text{ mol BaSO}_4} \times \frac{120.37 \text{ g MgSO}_4}{1 \text{ mol MgSO}_4} = 0.3181 \text{ g MgSO}_4$$

$$\% \text{ MgSO}_4 = \frac{\text{mass MgSO}_4}{\text{mass sample}} \rightarrow 69.91\%$$

Combustion Analysis:

↳ analyte is burned



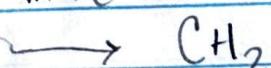
$$0.00126 \text{ g} \rightarrow 0.00394 \text{ g CO}_2; 0.00161 \text{ g H}_2\text{O}$$

What is empirical formula for polyethylene?

$$\text{mol C} = 0.00394 \text{ g CO}_2 \times \frac{1 \text{ mol CO}_2}{44 \text{ g}} \times \frac{1 \text{ mole}}{1 \text{ mole O}_2} = 8.95 \times 10^{-5} \text{ mol C}$$

$$\text{mol H} = 0.00161 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g}} \times \frac{2 \text{ mol H}}{1 \text{ mol H}_2\text{O}} = 1.79 \times 10^{-4} \text{ mol H}$$

$$\frac{\text{mol H}}{\text{mol C}} = \frac{2 \text{ mol H}}{1 \text{ mol C}}$$



# ALEKS 3.8

8.00 g of X (C; H; maybe O) have a mol. mass of 192 g/mol

Burned, result is 11.00 g CO<sub>2</sub>, 3.00 g H<sub>2</sub>O

— Formula of X?

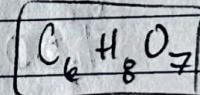
$$11.00 \text{ g CO}_2 \times \frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} \times \frac{1 \text{ mol C}}{1 \text{ mol CO}_2} = 0.25 \text{ mol C}$$

$$3.00 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18 \text{ g H}_2\text{O}} \times \frac{2 \text{ mol H}}{1 \text{ mol H}_2\text{O}} = 0.33 \text{ mol H}$$

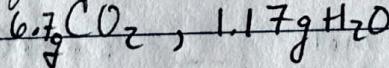
$$0.25 \text{ mol C} \times \frac{12 \text{ g C}}{\text{mol C}} = 3.00 \text{ g C} \quad 0.33 \text{ mol H} \times \frac{1 \text{ g H}}{\text{mol H}} = 0.33 \text{ g H}$$

$$18 - 3 - 0.33 = 4.67 \text{ g O} \rightarrow \frac{1 \text{ mol O}}{16 \text{ g O}} = 0.29 \text{ mol O}$$

mol O: 0.29	1.16		7
mol H: 0.33	0.25	* 6	8
mol C: 0.25	1.00		6



3.00 g of X (C; H; maybe O) → 138 g/mol, result:

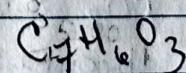


$$6.7 / 44.01 \rightarrow 0.15 \text{ mol C} \rightarrow \frac{12 \text{ g C}}{\text{mol C}} = 1.83 \text{ g C}$$

$$1.17 / 18 * 2 \rightarrow 0.13 \text{ mol H} \rightarrow 0.13 \text{ g H}$$

$$3 - 1.83 - 0.13 = 1.04 \text{ g O} \rightarrow \frac{1 \text{ mol O}}{16 \text{ g O}} = 0.065 \text{ mol O}$$

mol C: 0.15	2.31	7
mol H: 0.13	0.065	* 3
mol O: 0.065	1.04	4



# ALEKS

8.50g of X (C, H, maybe O) have 128g/mol

$$29.22 \text{ g CO}_2 + 4.79 \text{ g H}_2\text{O}$$

$$29.22 \text{ g} * \frac{70 \text{ mol}}{44 \text{ g}} = 0.664 \text{ mol CO}_2 \rightarrow 0.664 \text{ mol C}$$

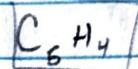
$$4.79 \text{ g} * \frac{2 \text{ mol}}{18 \text{ g}} = 0.2661 \text{ mol H}_2\text{O} \xrightarrow{*2} 0.532 \text{ mol H}$$

$$0.664 \text{ mol C} * \frac{12 \text{ g}}{1 \text{ mol}} = 7.9691 \text{ g C}$$

$$0.532 \text{ mol H} * \frac{1 \text{ g}}{1 \text{ mol}} = 0.532 \text{ g H}$$

$$\begin{array}{ccc} 0.664 \text{ mol C} & 1.24777 & \xrightarrow{*4} 5 \\ 0.532 \text{ mol H} & 1.00 & \xrightarrow{*4} 4 \end{array} \quad \begin{array}{l} 5 * 12 \\ 4 * 1 \end{array} = 64$$

$$128/64 = 2$$

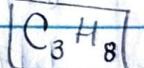


7.50g of X (C, H, maybe O) have 44g/mol

$$\text{CO}_2 22.50 \text{ g} * \frac{1}{44} = 0.51136 \text{ mol C} \rightarrow 6.186 \text{ g C}$$

$$\text{H}_2\text{O} 12.28 \text{ g} * \frac{1}{18} * 2 = 1.364 \text{ mol H} \rightarrow 1.364 \text{ g H}$$

$$\begin{array}{ccccc} 0.51136 \text{ mol C} & \rightarrow & 1 \text{ mol C} & \xrightarrow{*3} 3 \text{ mol C} & 3 * 12 = 36 \text{ g} \\ 1.364 \text{ mol H} & & 2.668 & \xrightarrow{*8} 8 \text{ mol H} & 8 * 1 = 8 \text{ g} \end{array}$$



5.50g of X (C, H, maybe O) have 150g/mol

$$\text{CO}_2 8.07 \text{ g} / 44 = 0.1834 \text{ mol C} \rightarrow 2.2009 \text{ g C}$$

$$\text{H}_2\text{O} 3.30 \text{ g} / 18 * 2 = 0.36 \text{ mol H} \rightarrow 0.36 \text{ g H}$$

$$= 2.932 \text{ g O}$$

$$= 0.18328 \text{ mol O}$$

$$\begin{array}{ccccc} 0.1834 \text{ mol C} & \rightarrow & 1.00 & & \\ 0.36 \text{ mol H} & & 2.00 & & \\ 0.18328 \text{ mol O} & & 1.00 & & \end{array}$$



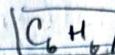
# ALEKS

$$1.00 \text{ g} \times (C, H, O) \rightarrow 78 \text{ g/mol}$$

$$3.39 \text{ g } CO_2 / 44 = 0.07705 \text{ mol C} \rightarrow 0.9245 \text{ g C}$$

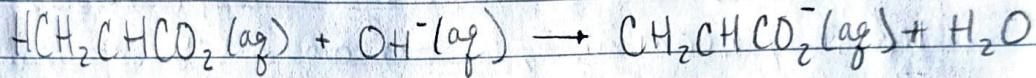
$$0.49 \text{ g } H_2O / 18 \times 2 = 0.076 \text{ mol H} \rightarrow 0.076 \text{ g H}$$

$$\begin{array}{rcl} 0.07705 \text{ mol C} & \xrightarrow{1.00} & CH = 13 \text{ g/mol} \\ 0.076 \text{ mol H} & \xrightarrow{1.00} & \times 6 \\ & & 78 \end{array} = 0 \text{ g O}$$



0.131 g HCH<sub>2</sub>CHCO<sub>2</sub> (acrylic acid) into 250 mL, to top w/ H<sub>2</sub>O  
Titrate it w/ 0.0800 M NaOH

Calculate volume of NaOH solution will need to reach equivalence



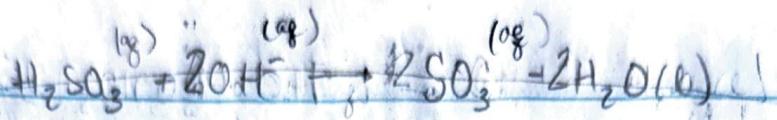
$$0.131 \text{ g} \times \frac{1 \text{ mol}}{72.0590 \text{ g}} = 0.0018180 \text{ mol acrylic acid}$$

$$0.0018180 \text{ mol } HCH_2CHCO_2 \text{ consumed} \times \left( \frac{1 \text{ mol } OH^- \text{ needed}}{1 \text{ mol } HCH_2CHCO_2 \text{ consumed}} \right) = 0.0018180 \text{ mol } OH^- \text{ needed}$$

$$0.0018180 \text{ mol}$$

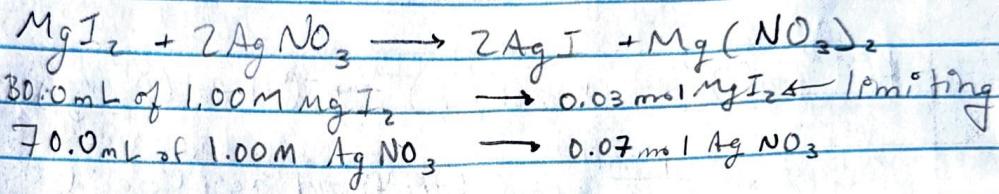
$$0.0800 \text{ M}$$

# ALEKS



$$\frac{0.0569 \text{ g}}{90.09 \text{ g/mol}} = 6.316 \times 10^{-4} \text{ mol} \times \frac{2 \text{ mol OH}^-}{1 \text{ mol HC}_3\text{H}_5\text{O}_3} = 0.00126 \text{ mol OH}^- \text{ needed}$$

$$\frac{0.00126 \text{ mol}}{0.1800 \text{ M}} = 0.007 \text{ L} \rightarrow 7.02$$



$$0.03 \text{ mol MgI}_2 \times \frac{2 \text{ mol AgI}}{1 \text{ mol MgI}_2} \times \frac{361.7 \text{ g}}{\text{mol AgI}} = 21.7 \text{ g AgI}_2$$

left over  $\text{Ag}^+$ ?

$$0.01 \text{ mol AgI}_2 \times \frac{1 \text{ mol Ag}^+}{1 \text{ mol AgI}_2} \times \frac{1000 \text{ mol}}{1 \text{ L}} = (0.1 \text{ M Ag}^+)$$

## 8.1 Gas Pressure

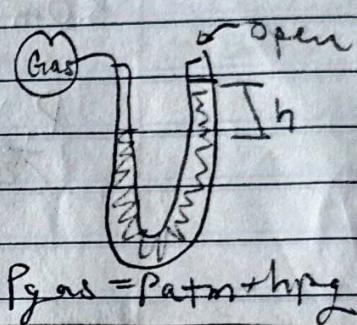
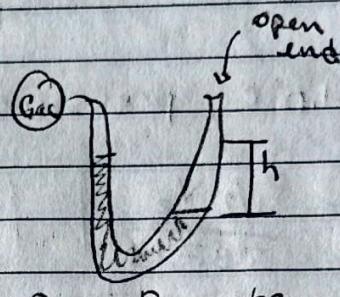
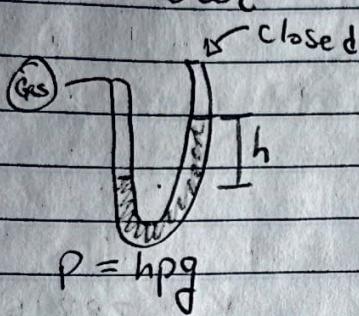
$$P = h \rho g$$

$h$  → height of fluid

$\rho$  → density of fluid

$g$  → accel due to gravity

### Manometer



## 8.2 Pressure, volume, Amount, temp

Amontons's law:  $P = kT$

Pressure = constant \* Temperature

Charles's Law:  $V = kT$

Volume = constant \* Temperature

Boyle's law:  $P = k/V$

Pressure =  $\frac{\text{constant}}{\text{volume}}$

Avogadro's Law:  $V = k * n$

Volume = constant \* # moles

Ideal Gas Law: Combined!

$$PV = nRT$$

Pressure \* volume = moles \*  $\frac{\text{ideal gas constant}}{\text{constant}} * \text{temp}$

Ideal gas constant  $\rightarrow 0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$

and  $8.314 \text{ K Pa L mol}^{-1} \text{ K}^{-1}$

STP - Standard temp & pressure ( $273.15 \text{ K} + 1 \text{ atm}$ )

$\hookrightarrow$  at STP, one mole has  $22.4 \text{ L} \rightarrow$  standard molar volume

## 8.3 Stoichiometry of Gaseous Substances, Mixtures, and Reactions

Gas Density & Molar Mass

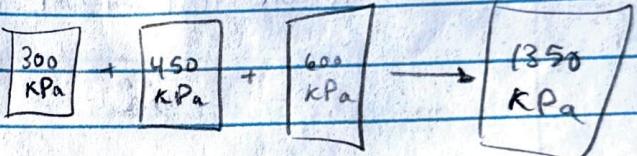
$$d = \frac{MP}{RT}$$

ex;  $N_2 \rightarrow 28.01 \text{ g/mol} + \text{standard temp & pressure}$

$$d = \frac{(28.01 \text{ g/mol})(1.00 \text{ atm})}{(0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1})(273\text{K})} = 1.25 \text{ g/L}$$

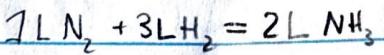
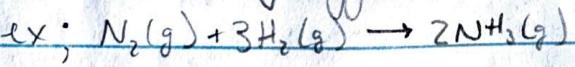
Mixed Gas Pressure: Dalton's Law

$$P_T = P_A + P_B \dots$$



$$P_A = X_A \times P_T \rightarrow X_A = \frac{P_A}{P_{\text{Total}}}$$

\* Stoichiometry applies to volume \*



\*

## 8.4 Effusion and Diffusion of Gases

Mean free path - average distance a molecule travels between collisions. Increases w/ decreasing pressure

Diffusion - process of molecules dispersing due to differing concentrations

rate of diffusion =  $\frac{\text{amount of gas passing through an area}}{\text{unit of time}}$

Effusion - escape of gas into vacuum through a pinhole

Graham's law of effusion: rate of effusion  $\propto \frac{1}{\sqrt{M}}$

## 8.5 Kinetic Molecular Theory

Kinetic molecular theory (KMT):

- 1.) Gases are always in motion. They travel in straight lines until they collide
- 2.) molecules are tiny compared to space between them
- 3.) pressure from gas in container it from collision w/ each other and container wall
- 4.) Gas molecules don't attract or repel each other or the container. Collision are elastic (no loss of energy)
- 5.) Average kinetic energy is proportional to temp of gas

$$\frac{1}{2} M u_{\text{rms}}^2 = \frac{3}{2} R T$$

$$(\text{where}) \quad u_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

M = mass in kg/mol

R = gas constant

T = temp

$$\text{rate of effusion} \propto u_{\text{rms}}$$

$$\frac{\text{effusion rate A}}{\text{effusion rate B}} = \sqrt{\frac{M_B}{M_A}}$$

For two diff. elements:

\* Temp is same, volume is same  $\rightarrow$  same  $k_B$   
diff mass  $\rightarrow$  diff velocity

## 9.1 Energy Basics

Thermochemistry - heat w/ chemical & physical changes  
Energy - capacity to do heat or work

- Thermal Energy - kinetic energy w/ random motion of atoms and molecules
- Temperature - quantitative "hot" or "cold"  
↳ A.K.A. amount of KE
- Heat(q) - transfer of thermal energy between two bodies @ different temperatures

Change that releases heat - exothermic reaction  
" absorbs" - endothermic "

Calorie (cal) - amount of energy to raise one gram of water by 1 degree C

joule (J) - " " " 1 newton of force moves an object 1 meter

heat capacity (C) - quantity of heat absorbed or released

$$C = \frac{Q}{\Delta T} \quad \text{when } \Delta T = 1 \text{ C}$$

specific heat capacity - heat capacity of a certain substance, regardless of mass

$$C_s = \frac{Q}{m \Delta T}$$

Equation for heat(q):  $q = C \times m \times \Delta T$

## 9.2 Calorimetry

(use a calorimeter)

Calorimetry - technique to measure heat involved in a process

system - substance undergoing change

surroundings - all other matter

$$q_{\text{reaction}} + q_{\text{solution}} = 0$$

(No heat lost or gained in heat transfer)

$$q_{\text{reaction}} = -q_{\text{solution}}$$

"Bomb" calorimeter - more accurate & can be used @ any pressure

One calorie "in food" is actually 1 kcal!

↳ "nutritional calorie"

$$W = -P \cdot \Delta V$$

ALEKS:  $W = -50.0 \cdot 9.0 = -450 \text{ L} \cdot \text{atm} \cdot \frac{8.31446 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}}{0.0820574 \text{ L} \cdot \text{atm} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}}$

## 9.3 Enthalpy

- chemical thermodynamics → heat + work w/ chemicals

internal energy ( $U$ ) - total of all possible energies

$$\Delta U = q + w \quad \left. \begin{array}{l} \text{first law of thermodynamics} \\ \text{+ } q \rightarrow \text{heat flow in} \end{array} \right.$$

\* energy is conserved

-  $q$  → heat flow out

+  $w$  → work done on system

-  $w$  → work done by system

expansion work - when a system pushes back on the system

↳ the chemical reaction

System

Surroundings

$$\Delta H = \Delta E + P\Delta V \rightarrow \Delta H = \Delta E - W$$

$$\left. \begin{array}{l} \Delta E = - \\ \Delta H = + \end{array} \right\} \rightarrow \text{endothermic exothermic} \quad \left. \begin{array}{l} \Delta E = + \\ \Delta H = - \end{array} \right\}$$

State function → value only depends on the state it is in, not how it is reached

$$\text{Enthalpy (H)} \rightarrow H = U + PV \quad \begin{matrix} \text{Pressure} \\ \text{Volume} \end{matrix}$$

↑ internal

enthalpy change:  $\Delta H = \Delta U + P\Delta V$  Energy

$$\Delta H = q + w + -w = q_p$$

ex; 0.05 mol HCl,  $q = -2.9 \text{ kJ}$

$$\Delta H = 1 \text{ mol HCl} * \frac{-2.9 \text{ kJ}}{0.05 \text{ mol}} = -58 \text{ kJ}$$

Standard Enthalpy of Combustion ( $\Delta H_c^\circ$ )

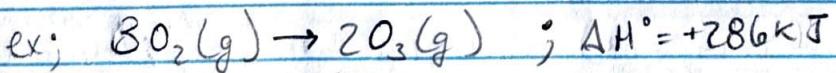
↳ enthalpy change when 1 mole burnt

↳ "heat of combustion"

↳ high  $\Delta H_c^\circ$  used for fuel

Standard enthalpy of formation ( $\Delta H_f^\circ$ )

↳ 1 mole of pure substance from free elements



ratio:  $\frac{286 \text{ kJ}}{2 \text{ mol O}_3}$

$$\Delta H^\circ \text{ for } 1 \text{ mol O}_3(\text{g}) = 1 \text{ mol O}_3 * \frac{286 \text{ kJ}}{2 \text{ mol O}_3} = 143 \text{ kJ}$$

Hess's Law: If process is several steps, the total  $\Delta H = \sum \Delta H \text{ of steps}$

$$\Delta H = \frac{\text{q}_{\text{reaction}}}{\text{moles of limiting reactant}} / \text{coefficient of limiting reactant}$$

ALEKS

heat capacity  $\text{H}_2\text{O} \rightarrow 4.184 \frac{\text{J}}{\text{g}\text{C}}$

~~51.4 g substance,  $C_s = 0.670$~~

~~250.0 g  $\text{H}_2\text{O}$   $T_{wp} = 15.0^\circ\text{C}$   $T_{wf} = 17.5^\circ\text{C}$   $\Delta T_w = -2.5^\circ\text{C}$~~

$T_i$  of sample?

$$\Delta T \cdot C_s = \frac{q}{m} \quad q = C \cdot m \cdot \Delta t = -418.75$$

$$q_s = -418.75$$

$$\Delta T = \frac{q}{m C_s}$$

$$T_E = \frac{q}{m C_s} + T_F$$

① 53.7 g Al,  $C_s = 0.897$ ,  $T_f = 22.9^\circ\text{C}$ ,  $T_i = ?$

150.0 g  $\text{H}_2\text{O}$ ,  $T_i = 18.0^\circ\text{C}$ ,  $C_s = 4.184$

$$q_w = C \cdot m \cdot \Delta T = 4.184 \cdot 150 \cdot 4.9 = 3075.24 \text{ J}$$

$$q_{Al} = -3075.24 \text{ J}$$

$$(41) \Delta T = \frac{q}{m C_s}$$

$$T_i = \frac{q}{m C_s} + T_F = 26.7^\circ\text{C}$$

quartz;  $C_s = 0.730$ ;  $T_f = 27.6^\circ\text{C}$ ;  $T_i = 93.2^\circ\text{C}$

250.0 g  $\text{H}_2\text{O}$ ;  $T_i = 25.0^\circ\text{C}$ ;  $T_f = 27.6^\circ\text{C}$ ;  $C_s = 4.184$

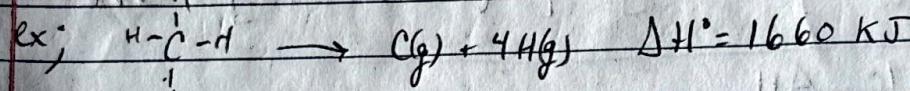
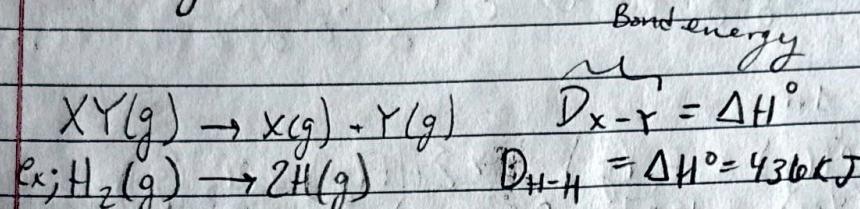
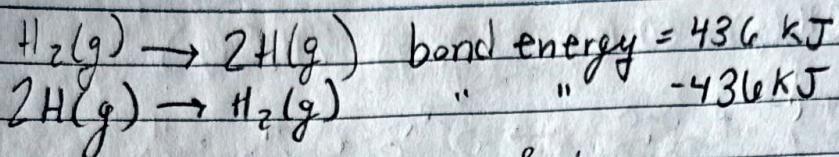
mass of quartz?

$$q_w = C_s \cdot m \cdot \Delta T = 4.184 \cdot 250 \cdot 2.6 = 2719.6 \text{ J}$$

$$q_f = -2719.6 \text{ J}$$

$$m = \frac{q}{C_s \Delta T} = \frac{-2719.6 \text{ J}}{(0.73)(-65.6)} = 57 \text{ g}$$

## 9.4 Strength of ionic and Covalent Bonds



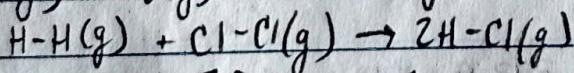
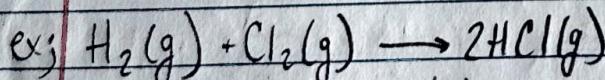
average C-H bond energy  $\rightarrow \frac{1660}{4} = 415 \text{ kJ/mol}$

$$D_{\text{C-H}}$$

bond energy = energy minimum - energy of separated atoms  
 energy released when bond formed = energy required to break

$\sigma$  bond energy >  $\pi$  bond energy

$$\Delta H = \sum D_{\text{bonds broken}} - \sum D_{\text{bonds formed}}$$



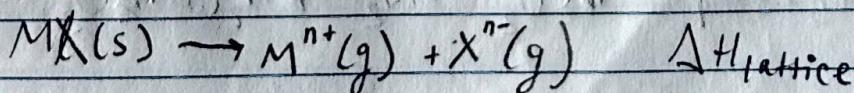
$$\Delta H = \sum D_{\text{broken}} - \sum D_{\text{formed}}$$

$$= [D_{\text{H-H}} + D_{\text{Cl-Cl}}] - 2D_{\text{H-Cl}}$$

$$= [436 + 243] - 2(432) = -165 \text{ kJ} \quad (\text{released as heat})$$

Ionic Bond Strength  $\propto$  Lattice Energy:

Lattice energy  $\rightarrow$  measure of strength between ions



$$\Delta H_{\text{lattice}} = C(Z^+)(Z^-)$$

C  $\rightarrow$  constant

$Z^{+-}$   $\rightarrow$  charges

$R_0$   $\rightarrow$  interatomic distance

\* Born-Haber cycle? \*

## 10.1 Intermolecular Forces (IMFs)

Increase KE

(s) (l) (g)

Increase IMF

We can also apply pressure to make (l) or (s)

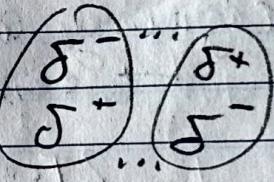
intramolecular force — in the same atom (strong)

London Dispersion Forces

↳ due to ~~possibly~~ distribution of electrons

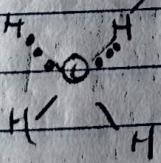
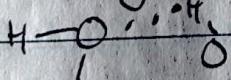
↳ larger contact area = greater force

Dipole-Dipole Attraction

↳ Partial - → Partial + 

Hydrogen Bonding (not real bond)

↳ very concentrated partial charge



## 10.2 Properties of liquids

Viscosity - measure of resistance to flow  
temp, visc

cohesive forces → various IMFs between identical molecules  
↳ causes spherical droplets

Surface tension - energy required to increase surface area of a liquid

Adhesive forces - IMFs between two different molecules

capillary action - liquid flows in porous material  
↳ can happen with up tubes

$$h = \frac{2T \cos \theta}{r \rho g}$$

T - Surface tension

r - radius of tube

$\rho$  - density

g - acceleration grav.

## 10.3 Phase Transition

rate of condensation = rate of vaporization

boiling point  $\rightarrow$  vapor pressure = pressure of surrounding  
normal boiling point  $\rightarrow$  at 1 atm (760 torr)

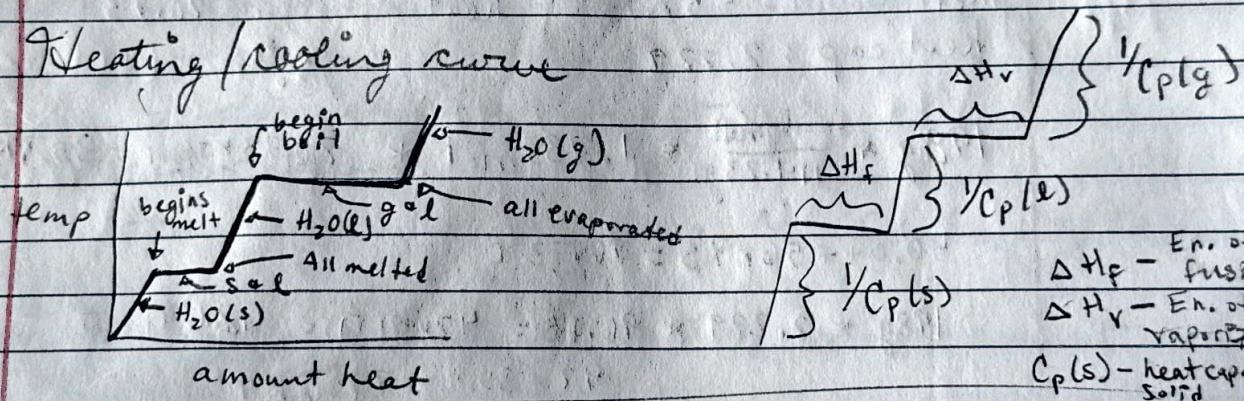
Enthalpy of Vaporization (endothermic)

melting point = freezing point

sublimation  $\rightarrow$  solid to gas

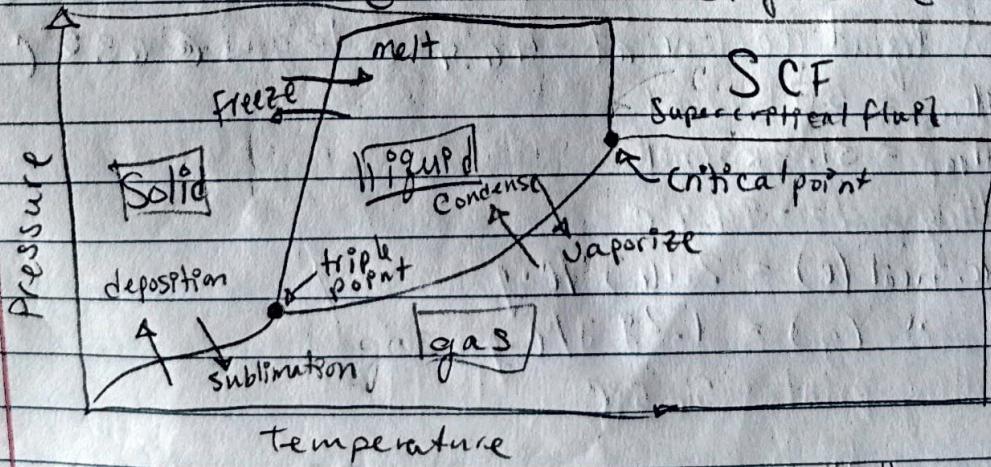
$\hookrightarrow$  reverse is deposition

Heating / cooling curve



## 10.4 Phase Diagram

$\hookrightarrow$  Pressure vs. temperature



SCF - density  $>$  typical gas

$\hookrightarrow$  low surface tension

$\hookrightarrow$  low viscosity

## 10.5 The Solid State of Matter

Crystalline - orderly pattern

Amorphous - not arranged

↳ (larger molecules)

- Polycrystalline  
(continuous)

### Ionic Solid

↳ high melting point

↳ brittle but strong

↳ don't conduct electricity till melted

### Metallic Solid

↳ held by metallic bonding

↳ thermal/electrical conductivity

↳ metallic luster, malleability

### Covalent Network Solid

↳ diamond (Carbon)

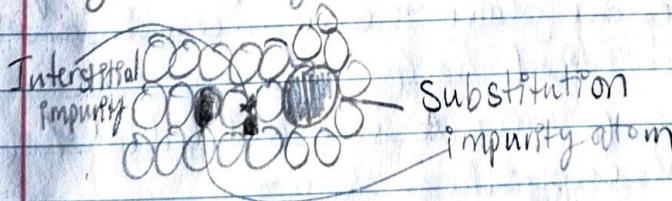
↳ other covalent bonds

### Molecular Solid

↳ neutral molecule ( $H_2$ ,  $N_2$ ,  $O_2$ ,  $F_2$ ,  $CO_2$ , etc.)

\* allotropes - different structure, same element  
(Diamond, graphite)

### Crystal Defects



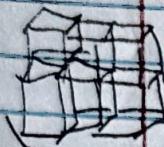
10.6

## Lattice Structures in Crystalline Solids

lattice points



unit cell



Simple cubic unit cell



Coordination number - # of particles each particle

Contacts

(6)

Body-centered cubic → (BCC)

↳ (Simple cubic w/ one in the middle)

Face-centered cubic → (FCC or CCP)

most metals

↳ simple cubic w/ extra on sides

↳ also called "cubic closest packing (CCP)"

Hexagonal closest packing (HCP)

↳ similar to FCC, but off-centered

Structures of ionic Crystals

↳ more complex b/c ions are different sizes

↳ 3 anions of one plane + one anion in another

forms a tetrahedral hole

↳ center of 6 anions is a octahedral hole

↳ cations occupy these holes

\* The closer molecules are, the stronger their lattice energy

$$F = K \frac{18+1}{r^2}$$