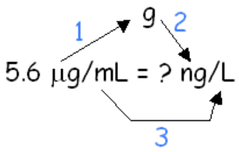
Chemistry 11
Some Study Materials for the Final Exam

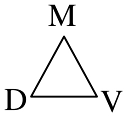
Prefix	Abbreviation	Exponent
giga	**G**	10^9
mega	**M**	10^6
kilo	**k**	10^3
hecto	**h**	10^2
deca	**da**	10^1
deci	**d**	10^{-1}
centi	**c**	10^{-2}
milli	**m**	10^{-3}
micro	**µ**	10^{-6}
nano	**n**	10^{-9}
pico	**p**	10^{-12}

Complex Unit Conversion



$$5.6 \times 10^0 \frac{\cancel{\mu g}}{\cancel{mL}} \times \frac{10^{-6}\cancel{g}}{1\cancel{\mu g}} \times \frac{1\ ng}{10^{-9}\cancel{g}} \times \frac{1\ \cancel{mL}}{10^{-3}\ L} = 5.6 \times 10^6 \frac{ng}{L}$$

Density



Precision

-The number of significant digits to which a value has been reliably measured.
-The more decimal places, the more precise the measurement.
-The greater the precision, the less the uncertainty.

The accuracy of a measurement is how close the measurement is to an *accepted standard*.

Significant Digits Rules:

1. **All non-zero digits are significant**
2. **Zero's between non-zero digits are significant**
3. **All zero's to the LEFT of the 1st non-zero digit are NOT significant. (called leading zero's)**
4. **Zero's to the RIGHT of the last non-zero digit ARE significant IF the decimal point is SHOWN.**
5. **Zero's to the RIGHT of the last non-zero digit (trailing zero's) ARE NOT significant if there is an UNDERSTOOD decimal point.**
6. **In Scientific Notation, the exponent part of the number is NOT significant.**

For Multiplication or Division:

Answer is rounded to the LOWEST # OF SD'S in the data.

For Addition or Subtraction:

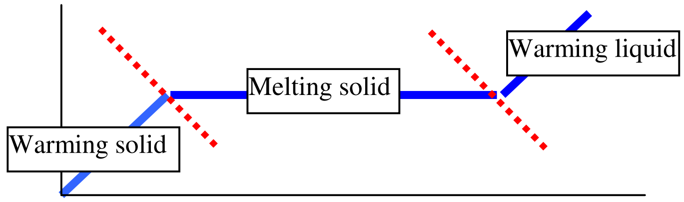
Answer is rounded to the LOWEST # OF DECIMAL PLACES in the data.

Some Terms in Unit 3: Observation, Interpretation, Qualitative, Quantitative, Data, Experiment, Hypothesis, Theory, Laws, Matter, Chemistry, Physical and Chemical Properties, Malleability, Ductility, Lustre, Viscosity and Diffusion. Review the Phases of Matter. Define: Observation, Interpretation, Qualitative, Quantitative, Data, Experiment, Hypothesis, Theory, Laws, Matter, Chemistry, Physical and Chemical Properties, Malleability, Ductility, Lustre, Viscosity and Diffusion. Review the Phases of Matter.

The Methods of Separation of Mixtures:

1. **Filtration**
2. **Distillation**
3. **Solvent Extraction**
4. **Recrystallization**
5. **Gravity Separation**
6. **Paper Chromatography**

Temperature – Time Graph



5 common acids

Name	Formula
hydrochloric acid	HCl
nitric acid	HNO_3
sulphuric acid	H_2SO_4
phosphoric acid	H_3PO_4
acetic acid	CH_3COOH

Prefixes

1	mono	6	hexa
2	di	7	hepta
3	tri	8	octa
4	tetra	9	nona
5	penta	10	deca

Covalent names and Formulas

- use only Prefixes

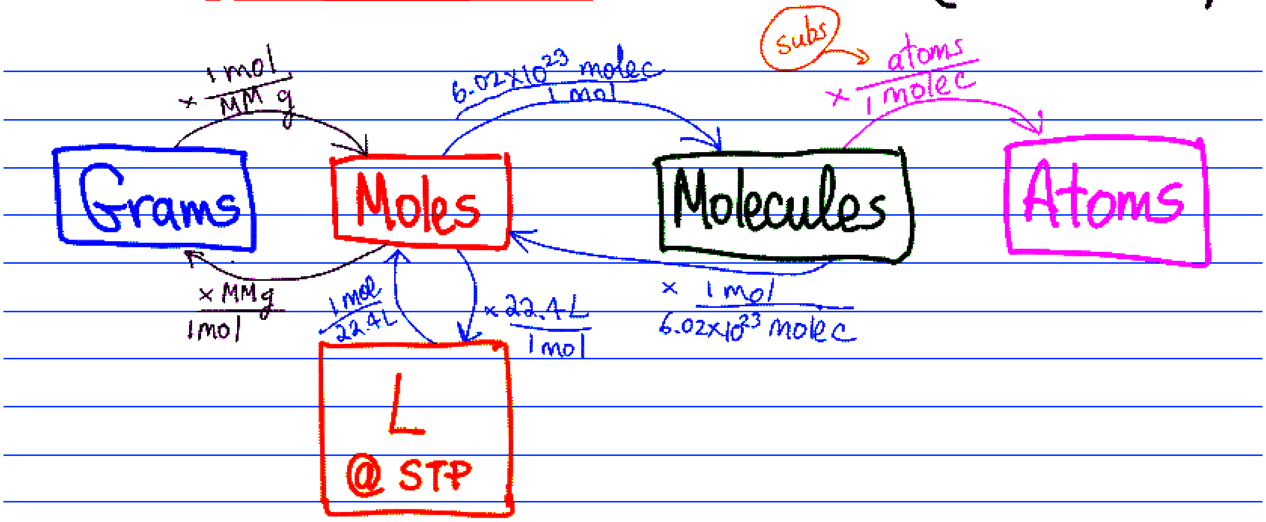
#	prefix	Example
1	mono	CO carbon monoxide
2	di	CO_2 carbon dioxide
3	tri	SO_3 sulphur trioxide
4	tetra	CCl_4 carbon tetrachloride
5	penta	PCl_5 phosphorus pentachloride
6	hexa	XeF_6 xenon hexafluoride

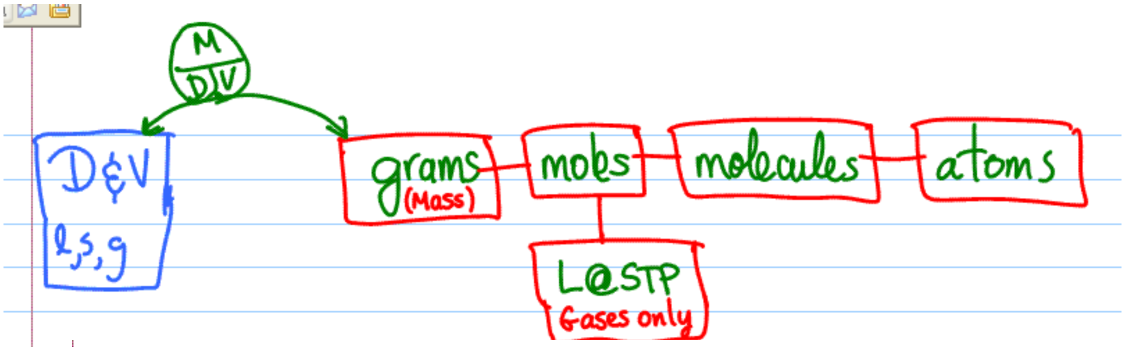
→ diatomic (2 atoms/molecule)

H_2 O_2 N_2 F_2 Cl_2 Br_2 I_2 At_2

Harry Often Needs Halogens

THE MOLE DIAGRAM (MOLE MAP)





Density of Gases @ STP

$$D = \frac{\text{mass of 1 mol}}{\text{volume of 1 mol}}$$

$$\boxed{D_{STP} = \frac{MM}{22.4}}$$

$$\boxed{MM = D_{STP} \times 22.4}$$

Percent Composition

$K_2Cr_2O_7$

$2(39.1) + 2(52.0) + 7(16.0)$

$78.2 + 104.0 + 112.0 = \underline{294.2}$

$\%K = \frac{78.2}{294.2} \times 100 = \boxed{26.6\%}$

$\%\text{"O"} = \frac{112.0}{294.2} \times 100 = \boxed{38.1\%}$

$\%Cr = \frac{104.0}{294.2} \times 100 = \boxed{35.4\%}$

Finding Empirical Formula

– given masses of elements

eg) A sample of an unknown compd was analyzed and found to contain 8.4 g of C, 2.1 g of "H" & 5.6 g of "O"
Find the empirical formula

Element	Mass (g)	Atomic Mass	Moles $\frac{\text{mass}}{\text{atomic mass}}$	$\frac{\text{moles}}{\text{smallest moles}}$	Simplest Ratio (SR)
C	8.4	12.0	$\frac{8.4}{12.0} = 0.70$	$\frac{0.70}{0.35} = 2.0$	2
H	2.1	1.0	$\frac{2.1}{1.0} = 2.1$	$\frac{2.1}{0.35} = 6.0$	6
O	5.6	16.0	$\frac{5.6}{16.0} = 0.35$	$\frac{0.35}{0.35} = 1.0$	1

Empirical Formula C_2H_6O

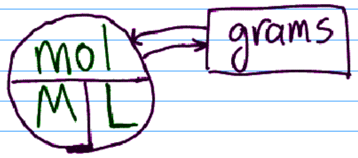
When $\frac{\text{moles}}{\text{s.moles}}$ is NOT A WHOLE NUMBER

When $\frac{\text{moles}}{\text{s.moles}}$ ends in the decimal	Multiply ALL #'s By...
~ 0.5	× 2
~0.33 or ~0.66	× 3
~ 0.25 or 0.75	× 4
~0.2, 0.4, 0.6, 0.8	× 5

FINDING MOLECULAR FORMULA GIVEN EMPIRICAL FORMULA AND MOLAR MASS

eg) The empirical formula for a compound is CH_2O and the molar mass (molecular mass) is 60.0 g/mol. Find the molecular formula

	empirical	molecular
formula	$CH_2O \xrightarrow{\times 2}$	$C_2H_4O_2$?
mass	$12.0 + 2(1.0) + 16.0 = 30.0 \xrightarrow{\times 2}$	60.0



[NaOH] → means "the molar concentration of NaOH".

Dilutions of Solutions

The dilution formula

$$FC \times FV = IC \times IV$$

C = concentration
V = volume
I = initial
F = final

Another form

$$\boxed{FC = IC \times \frac{IV}{FV}}$$

Calculating Water Added

$$FV = IV + WA$$

$$WA = FV - IV$$

WA = water added

Types of Reactions

1. Synthesis (Combination)

$$A + B \rightarrow AB$$

-usually: elements → a compound

eg) $2Al + 3F_2 \rightarrow 2AlF_3$ ← a compd

elements

RU-diatomic?

Al^{3+} F^-

2. Decomposition

$$AB \rightarrow A + B$$

Often: compound → its elements

NOTE: Unless otherwise told break a compd all the way down to its elements (Even break up PAI's!)

$$2H_3PO_4 \rightarrow 3H_2 + 2P + 4O_2 \quad \text{(dec)}$$

$$Ca(C_2O_4)_2 \rightarrow Ca + 4C + 4O_2 \quad \text{(dec)}$$

$$C_{12}H_{22}O_{11} \rightarrow 12C + 11H_2 + \tfrac{11}{2}O_2$$

3. Single Replacement

$$\underset{\substack{\uparrow\\ \text{an element}}}{A} + \underset{\substack{\uparrow\\ \text{a compd}}}{BC} \rightarrow \underset{\substack{\uparrow\\ \text{new}\\ \text{element}\\ \text{(RU diatomic?)}}}{B} + \underset{\substack{\nwarrow\\ \text{new}\\ \text{compd.}}}{AC}$$

Two types

1. Metal SR (single replacement)
2. Non-metal SR

1. Some metal SR's

$Ca^{2+}\ Cl^{-}$

$$\underset{\substack{\uparrow\\ \text{single}\\ \text{metal}}}{Ca} + \underset{\substack{\uparrow\\ \text{combined}\\ \text{metal}}}{2KCl} \rightarrow \underset{\substack{\uparrow\\ \text{single}\\ \text{metal}}}{2K} + CaCl_2$$

2. Non-Metal SR's

Li^+ Cl^-

eg) $Cl_2 + 2LiBr \rightarrow Br_2 + 2LiCl$

a single non-metal

combined non-metal

metal written first

4. Double Replacement

$AB + CD \rightarrow AD + CB$

M NM M NM

- can also have PAI's

don't break apart

eg) $MgCl_2 + K_2SO_4 \rightarrow MgSO_4 + 2KCl$

DR

LEUDMEU!

Look 'em up
DON'T
make 'em up!

$Mg^{2+} \times K^+$
$Cl^- \quad SO_4^{2-}$

an "X box"

5. Neutralization

an acid + a base → water + a salt

eg) $HCl + NaOH \rightarrow H_2O + NaCl$

can also be called DR

$3Ca(OH)_2 + 2H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6H_2O$

neutralization

$Ca^{2+} \times H^+$
$OH^- \quad PO_4^{3-}$

6. Combustion (Burning Stuff)

2 Types: 1. Combustion of Hydrocarbons
(H, C & sometimes O
N, S)

2. Combustion of Metals

1. Hydrocarbons

ASSUME: The Products are Always $CO_2 + H_2O$

In Combustion

O_2 is always a reactant.

combustion of butanol (C_4H_9OH)

$$C_4H_9OH + 6O_2 \rightarrow 4CO_2 + 5H_2O$$

combustion

Combustion of Metals

needs O_2

Mg^{2+} O^{2-}

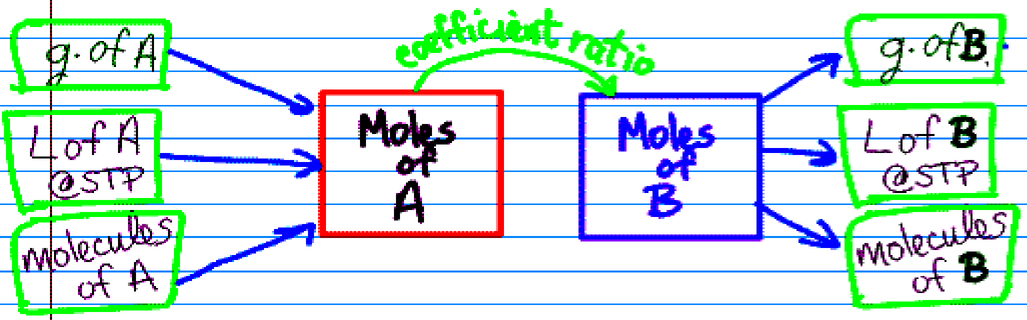
$$2Mg + O_2 \rightarrow 2MgO$$

combustion

But wait...

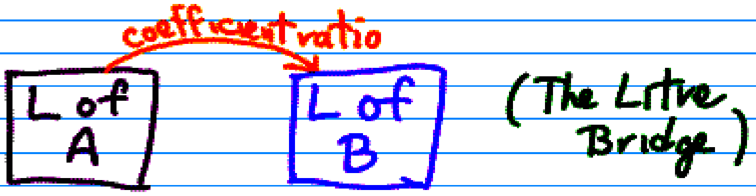
also called synthesis

THE MOLE BRIDGE

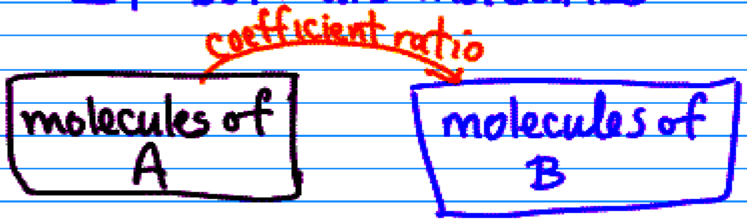


A couple of Shortcuts

- If both are Litres



- If both are molecules



Given:

$H_3PO_4 + 3KOH \rightarrow 3H_2O + K_3PO_4$

What mass of KOH is required to react with 250.0 mL of 0.250 M H_3PO_4?

$\rightarrow$ 0.250 L

Plan: M & L of $H_3PO_4 \rightarrow$ mol $H_3PO_4 \rightarrow$ mol KOH $\rightarrow$ g KOH

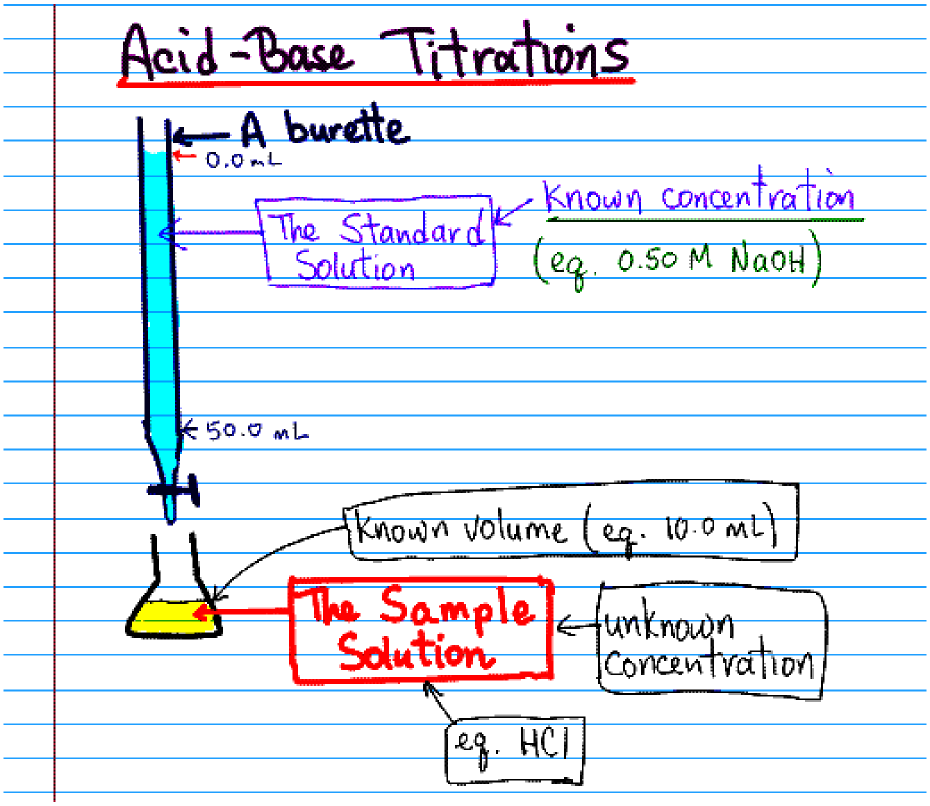
mol H_3PO_4 = 0.250M × 0.250 L = 0.0625 mol H_3PO_4

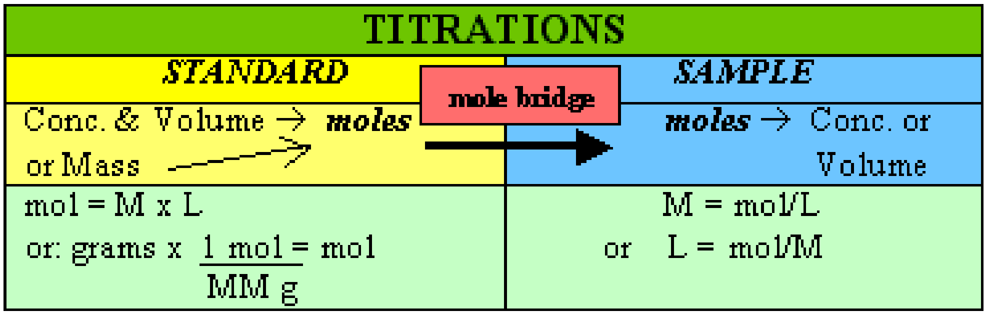
$$0.0625\,\cancel{mol\ H_3PO_4} \times \frac{3\,\cancel{mol\ KOH}}{1\,\cancel{mol\ H_3PO_4}} \times \frac{56.1\ g\ KOH}{1\,\cancel{mol\ KOH}}$$

39.1+16.0+1.0

= 10.5 g KOH

Acid-Base Titrations





TITRATIONS		
STANDARD		***SAMPLE***
Conc. & Volume → ***moles*** or Mass →	**mole bridge** →	***moles*** → Conc. or Volume
mol = M x L or: grams x $\frac{1\ \text{mol}}{\text{MM g}}$ = mol		M = mol/L or L = mol/M

Excess and Limiting Reactant Problems

Question

Given: $2Al + 3Cl_2 \rightarrow 2AlCl_3$

If 108.0 g Al is mixed with 400.0 g Cl_2, which reactant is in excess.

Directions:

① Pick a product (eg. $AlCl_3$) (read ahead for a product you are asked for mass)

② Calculate the mass of this product starting with each reactant.

(one from 108.0 g Al)

(one from 400.0 g Cl_2)

③ Whichever reactant gives you the larger mass of product (eg $AlCl_3$) is the Excess reactant.

④ The reactant which is not in excess is the limiting reactant

ALWAYS use the LIMITING REACTANT to determine other amounts of products formed or reactants used.

Theoretical Yield (Predicted) (TY) - The mass of product calculated using stoichiometry

Actual Yield (AY) - The mass of a product we ACTUALLY get. (Sometimes AY < TY)

Percent(age) Yield

$$\boxed{\% \text{ Yield} = \frac{AY}{TY} \times 100\%}$$

$$\boxed{AY = \frac{\% \text{ Yield}}{100} \times TY}$$

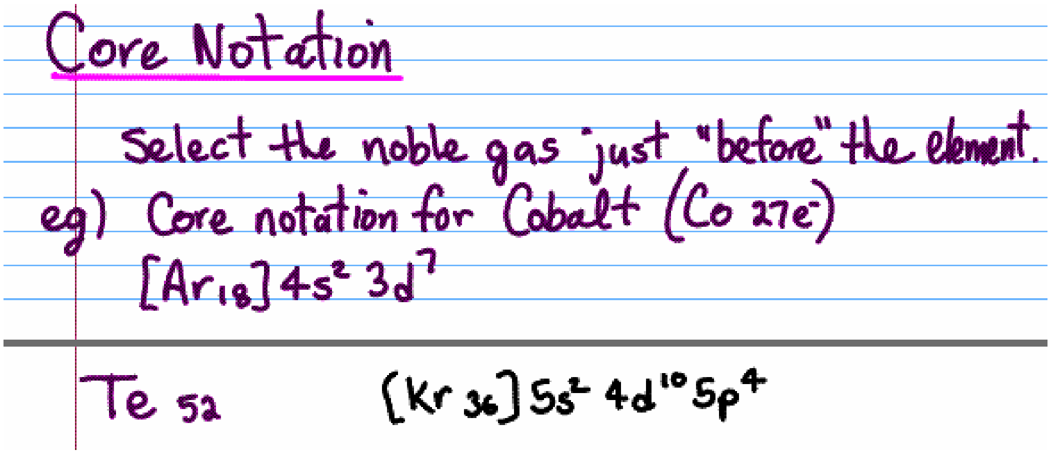
Isotope Abundances and Atomic Mass

Atomic Mass - The weighted average of the mass numbers of the naturally occuring isotopes of an element.

b) "Short-cut" 60% ^{69}Ga
40% ^{71}Ga

Average Atomic Mass

$$0.60(69) + 0.40(71) = \underline{69.8}$$



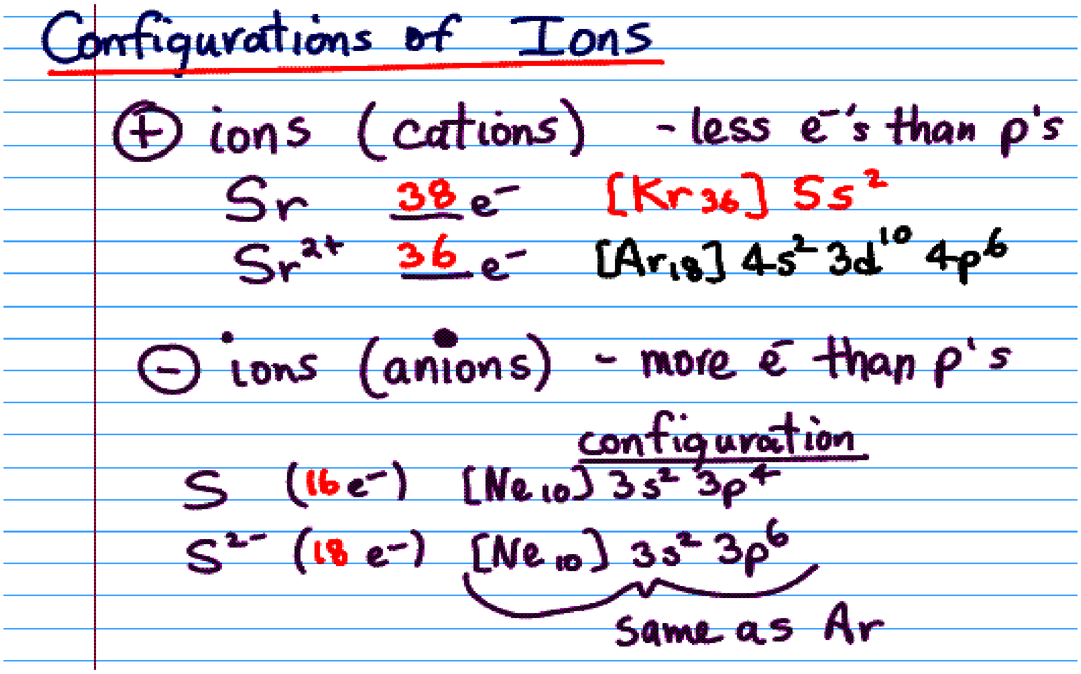
Core Notation

Select the noble gas "just "before" the element.

eg) Core notation for Cobalt (Co $27e^-$)

$[Ar_{18}]\ 4s^2\ 3d^7$

Te $_{52}$ $[Kr_{36}]\ 5s^2\ 4d^{10}\ 5p^4$



Configurations of Ions

⊕ ions (cations) - less e^-'s than p's

Sr $38\ e^-$ $[Kr_{36}]\ 5s^2$

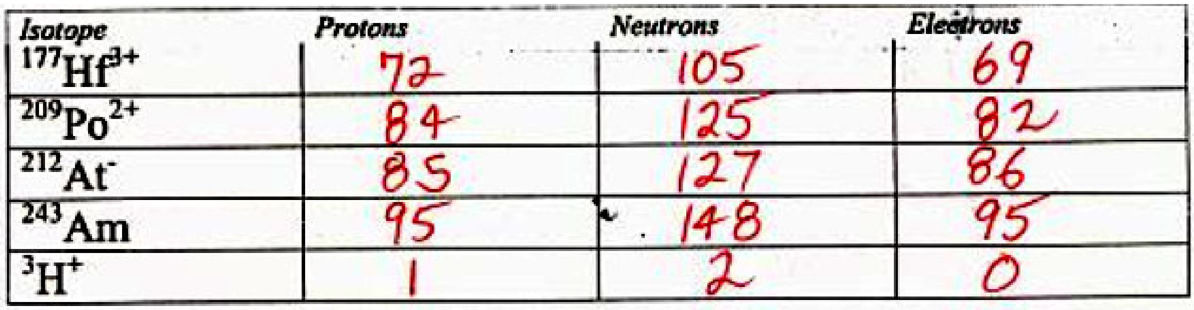
Sr^{2+} $36\ e^-$ $[Ar_{18}]\ 4s^2\ 3d^{10}\ 4p^6$

⊖ ions (anions) - more e^- than p's

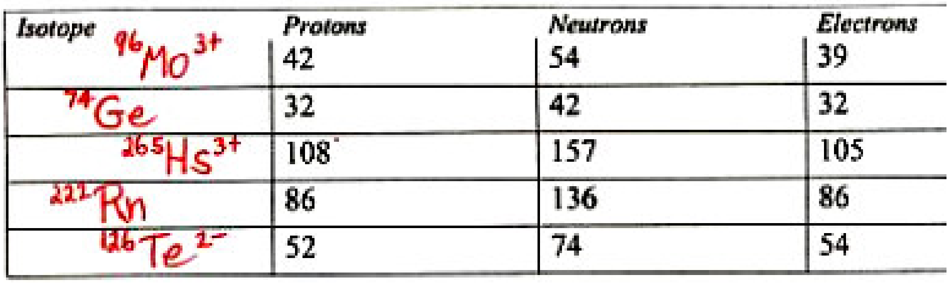
configuration

S ($16e^-$) $[Ne_{10}]\ 3s^2\ 3p^4$

S^{2-} ($18\ e^-$) $\underbrace{[Ne_{10}]\ 3s^2\ 3p^6}_{\text{same as Ar}}$



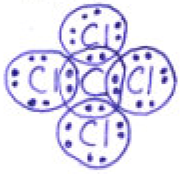
Isotope	Protons	Neutrons	Electrons
$^{177}Hf^{3+}$	72	105	69
$^{209}Po^{2+}$	84	125	82
$^{212}At^{-}$	85	127	86
^{243}Am	95	148	95
$^{3}H^{+}$	1	2	0



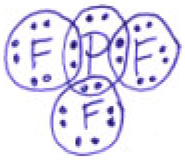
Isotope	Protons	Neutrons	Electrons
$^{96}Mo^{3+}$	42	54	39
^{74}Ge	32	42	32
$^{265}Hs^{3+}$	108	157	105
^{222}Rn	86	136	86
$^{126}Te^{2-}$	52	74	54

Electron-Dot Formulas

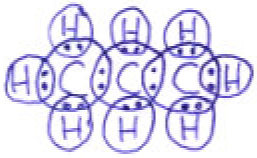
c) CCl_4



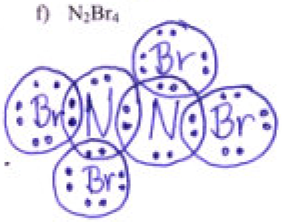
d) PF_3



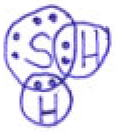
e) $CH_3CH_2CH_3$



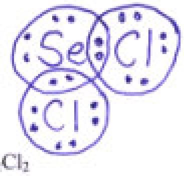
f) N_2Br_4



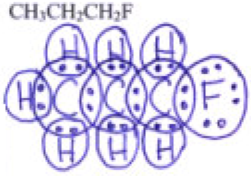
g) H_2S



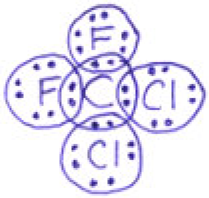
h) $SeCl_2$



i) $CH_3CH_2CH_2F$



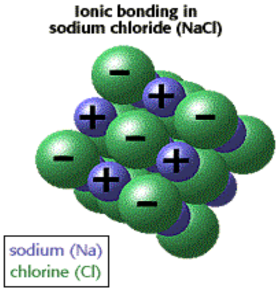
j) CF_2Cl_2



Electronegativity **– the tendency of an atom to attract electrons from a neighbouring atom.**

When the electronegativities of two atoms are quite different from each other:
One atom loses an electron (or electrons) The other atom gains an electron (or electrons)
This results in an *Ionic Bond*.

Crystal Lattice

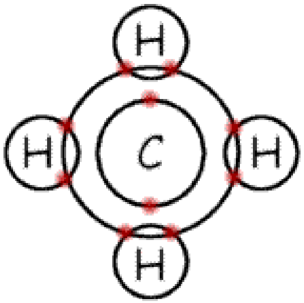


When Electronegativities of bonding atoms are the same (as they are in diatomic molecules) or close to the same, they SHARE electrons.

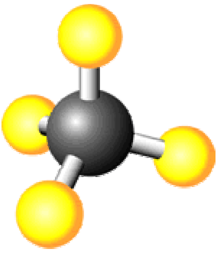
Bonds formed when atoms share electrons are called Covalent Bonds.

In diatomic molecules (like H_2 or Cl_2), the electronegativities of both atoms are exactly the same so electrons are shared equally!

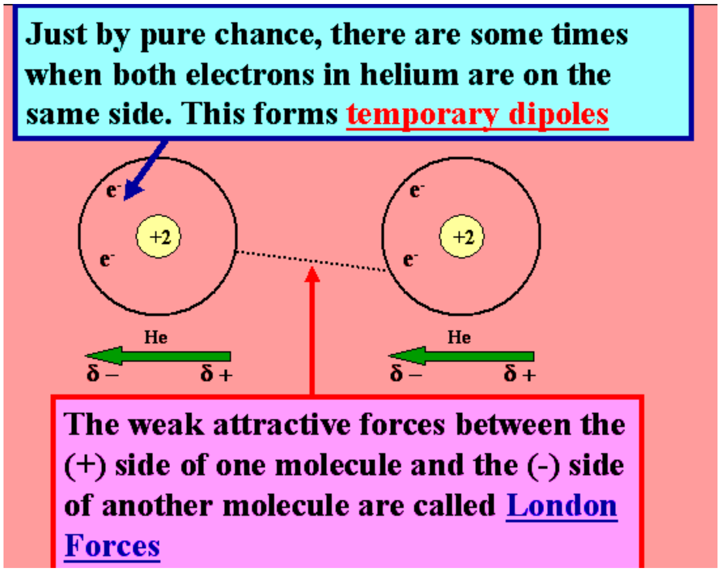
Bonds <u>within</u> molecules that hold the atoms of a molecule together are called *<u>intramolecular bonds</u>*. They are strong covalent bonds.



Covalent Bonds



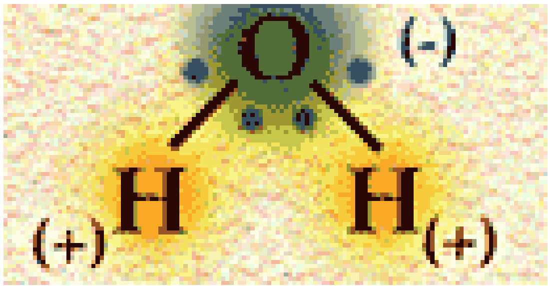
A *<u>dipole</u>* is a partial separation of charge which exists when one end of a molecule has a slight positive charge and the other end has a slight negative charge



Just by pure chance, there are some times when both electrons in helium are on the same side. This forms <u>temporary dipoles</u>

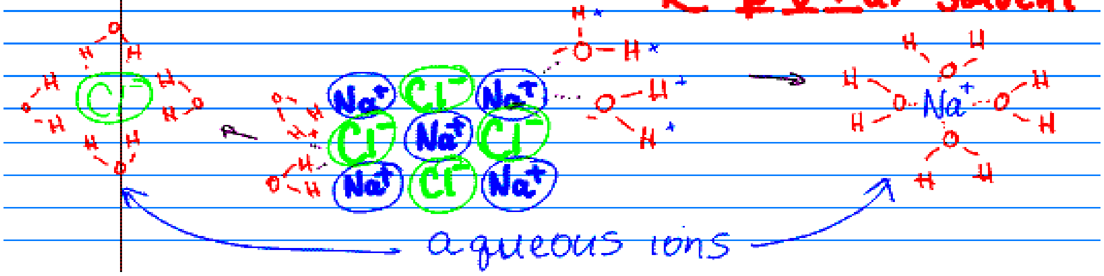
The weak attractive forces between the (+) side of one molecule and the (-) side of another molecule are called <u>London Forces</u>

When electrons are shared *<u>unequally</u>* between two atoms, the bond is called <u>Polar Covalent</u>.



<u>Dissociation</u>

<u>Ionic Compounds in water</u> ← <u>polar solvent</u>



Dissociation Equations (in water)

eg) $NaCl_{(s)} \rightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$

↑ ↑ dissolved in water

(in dissociation PAI's are not broken up)

$CaCl_{2\,(s)} \rightarrow Ca^{2+}_{(aq)} + 2Cl^{-}_{(aq)}$

not part of a PAI

$Al_2(SO_4)_{3\,(s)} \rightarrow 2Al^{3+}_{(aq)} + 3SO_4^{2-}{}_{(aq)}$

part of the PAI

Question

What mass of $AlBr_3$ must be dissolved in 500.0 mL of solution to give a $[Br^-] = 4.50\ M$?

Plan: $[Br^-] \rightarrow \underset{M}{[AlBr_3]} \rightarrow mol \rightarrow g$

$$\overset{1.50M}{\_AlBr_3} \xleftarrow{1/3} \rightarrow Al^{3+} + \overset{4.50M}{\underline{3}Br^-}$$

$[AlBr_3] = 1.50\ M$

$mol = M \times L$
$= 1.50\ M \times 0.5000\ L = 0.750\ mol$

$$0.750\ mol\ AlBr_3 \times \frac{266.7\ g\ AlBr_3}{1\ mol\ AlBr_3} = \underline{200.0\ g}$$

Mixtures with Common Ions

eg) 30.0 mL of 0.60 M Na_2SO_4 is mixed with 45.0 mL of 0.30 M Na_3PO_4. Find the final conc. of all 3 ions.

Final $[Na_2SO_4]$

$$= 0.60\,M \times \frac{30.0\,mL}{75.0\,mL} = \underline{0.24\,M}$$

$$0.24\,M \xrightarrow{2/1} 0.48\,M \qquad 0.24\,M \xrightarrow{1/1} 0.24\,M$$

$$Na_2SO_{4(s)} \rightarrow 2Na^+_{(aq)} + SO_{4(aq)}^{2-}$$

Final $[Na_3PO_4] = 0.30\,M \times \frac{45.0\,mL}{75.0\,mL} = \underline{0.18\,M}$

$$0.18\,M \xrightarrow{3/1} 0.54\,M \qquad 0.18\,M \xrightarrow{1/1} 0.18\,M$$

$$Na_3PO_{4(s)} \rightarrow 3Na^+_{(aq)} + PO_{4(aq)}^{3-}$$

Final $[Na^+] = \underset{\text{from } Na_2SO_4}{0.48\,M} + \underset{\text{from } Na_3PO_4}{0.54\,M} = \underline{1.02\,M}$

$[SO_4^{2-}] = 0.24\,M$

$[PO_4^{3-}] = 0.18\,M$

Equations for Precipitation (pptn) Reactions

Formula Equation (Don't dissociate)

$$2AgNO_{3(aq)} + K_2CrO_{4(aq)} \longrightarrow Ag_2CrO_{4(s)} + 2KNO_{3(aq)}$$

$$\boxed{\begin{array}{ccc} Ag^+ & \times & K^+ \\ NO_3^- & & CrO_4^{2-} \end{array}}$$

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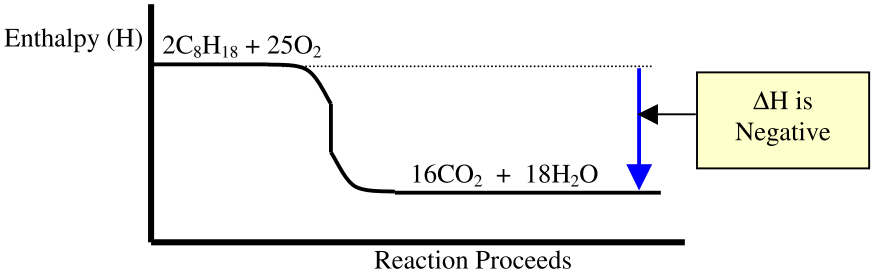
Complete Ionic Equation

$$2Ag^+_{(aq)} + 2NO^-_{3(aq)} + 2K^+_{(aq)} + CrO^{2-}_{4(aq)} \rightarrow Ag_2CrO_{4(s)} + 2K^+_{(aq)} + 2NO^-_{3(aq)}$$

Net-Ionic Equation (leave out spectator ions eg K^+ NO_3^-)

$$2Ag^+_{(aq)} + CrO^{2-}_{4(aq)} \rightarrow Ag_2CrO_{4(s)}$$

An enthalpy diagram for an **exothermic** reaction:



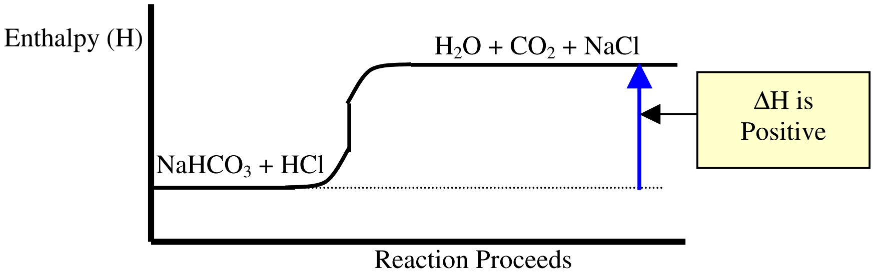
So, to summarize, in an **exothermic** reaction:

- ΔH is negative
- Products are **lower** than Reactants on the Enthalpy Diagram

Heat is released to the surroundings

In an **endothermic** reaction: Heat is **absorbed** from the surroundings and converted into **enthalpy**.

Here is an enthalpy graph for an **endothermic** reaction:



Heat and Moles in Equations

Find the amount of heat released during the formation of 14.6 moles of NH_3, given the reaction:

$N_2 + \mathbf{3H_2} \rightarrow \mathbf{2NH_3} + \mathbf{46.2\ kJ}$

Solution:

$$14.6 \text{ mol } NH_3 \text{ x } \frac{46.2kJ}{2molNH_3} = \mathbf{337\ kJ}$$

Calorimetry:

Example: Given that the heat capacity of water: C_{H_2O} = 4180 J/kg · °C

Calculate the heat required to warm 400.0 g of water from 20 °C to 50 °C.

Solution:

First we have to change 400.0 g to 0.4000 kg and calculate the temperature change (Δt)

50 °C - 20 °C = 30 °C

Next, we write the equation:

$$\text{Heat} = m \cdot C \cdot \Delta t$$

Then we plug in the data:

Heat (J) = 0.4000 kg x 4180 J/kg · °C x 30 °C = **50 160 J**