CHEMISTRY 100 LECTURE

Unit II

Part 1 ATOMIC STRUCTURE

Subatomic Particles:

Particle Name	Symbol	Charge	Location	Mass

The Nucleus

The nucleus contains practically all of the mass of the atom. The protons and neutrons are in the nucleus.

The radius of the nucleus is extremely small in relation to the radius of the entire atom

The atomic number equals the number of protons which equals the number of electrons

Like charges repel. Opposite charges attract

III. ISOTOPES

Isotopes are atoms of the same element that have a different number of neutrons. Isotopes exist for every known element.

$_{Z}E^{A}$

1. Atomic number, $\mathbb{Z}$,, equals the number of protons

2. Mass number, $\mathbb{A}$, equals the sum of protons and neutron (nucleons)

3. Electrons, e^-, equals the number of protons in a neutral atom

4. Subatomic Particles = e^- , p^+ , n

Summary:

Remember: opposites attract

B. Atomic Isotopes - Atoms with the same atomic number (# p^+), but different number of neutrons
→ Different mass

Examples:

Isotope	Symbol	Mass #, A	Atomic #, Z	# p^+	# n	% natural abundance
N-14	$_7N^{14}$					
N-12	$_7N^{12}$					
N-13	$_7N^{13}$					

Isotope	Symbol	Mass #, A	Atomic #, Z	# p^+	# n	% natural abundance
	$_6C^{12}$					99.9
Carbon-13						1.11
Carbon-14						Very little

C. IONS-Ions are atoms with a charge

IONS

ANIONS CATIONS

Ion-Problem

1. a. Calculate the number of protons, electrons and neutrons of an N-14 atom that has a -3 charge.

b. How many subatomic particles does this ion have?

IV. Electronic Arrangement in Atoms

A. Background:

Electrons

How are electrons arranged in the atom and why is it important?

Location of the electron

Energy levels

Number of electrons on each shell or energy level

Valence Shell

Using the periodic table to determine the shell

What is the maximum number of electrons on the valence shell?

Determining the electron arrangement in the atom

How many electrons does the atom have?

How many shells are in the atom?

How many electrons are in each shell?

First put the correct number of electrons in the valence shell

Put the correct number of electrons in the rest of the shells starting with the first shell

Atomic Diagrams

$_{1}H^{2}$	$_{12}Mg^{24}$	$_{48}Cd^{113}$
$_{4}Be^{10}$	$_{16}S^{33}$	$_{35}Br^{80}$
$_{6}C^{12}$	$_{26}Fe^{56}$	$_{30}Zn^{66}$

The valence (outermost shell) is most important since that is where atoms form chemical bonds.
With the exception of H and He elements in periods are most stable when they have 8 valence electrons.

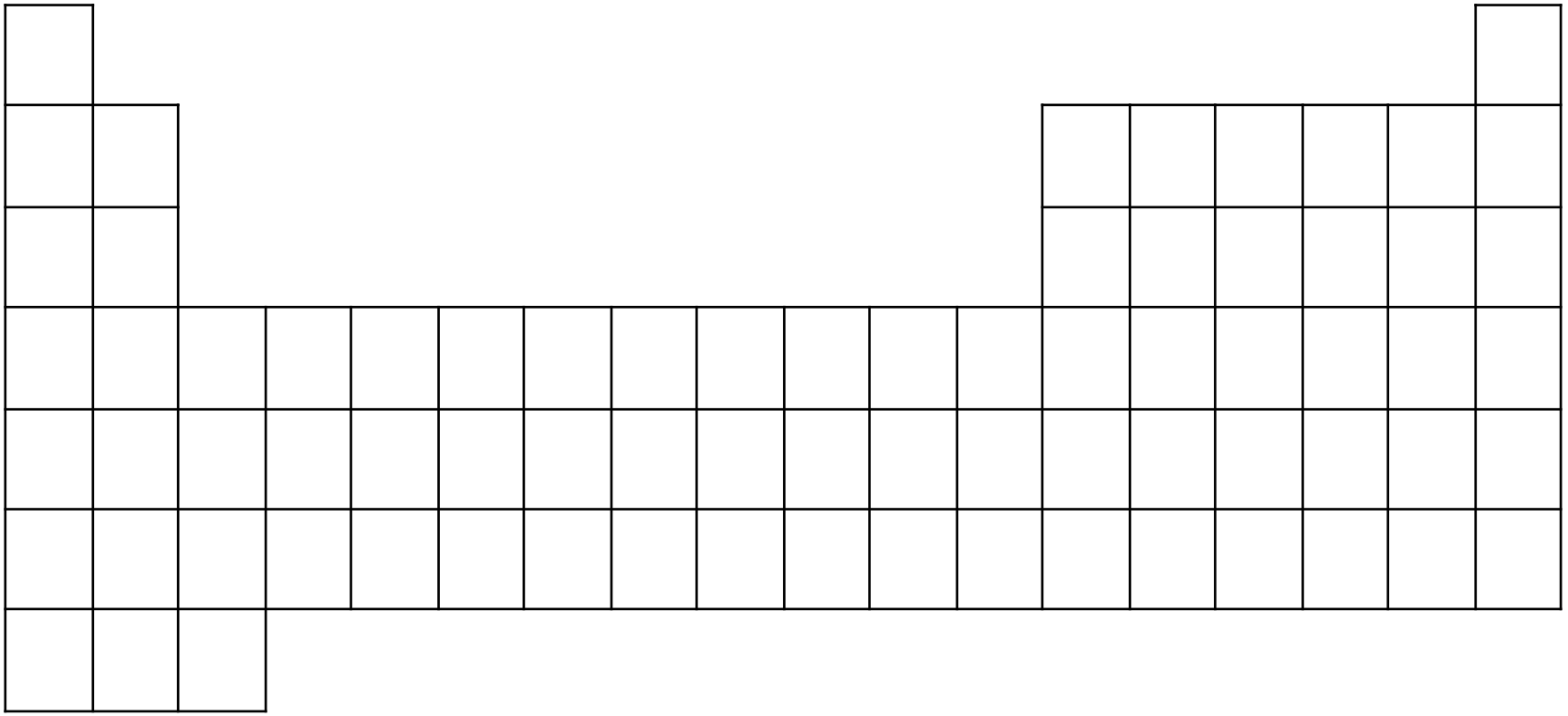
Lewis electron dot symbols:

These models are a simplified diagram showing only the valence electrons. These models help us very quickly determine how an atom will form a bond.

Write the symbol
Imagine the diagram as having 4 sides like a box around the symbol
Instead of four sides the element gets up to 8 dots.
Use the family number on the periodic table to determine the number of valence electrons (dots).
Place the dots one at a time on the left side, top, right side, and bottom.
Make sure there is one dot on each of the four sides before doubling up.

Na Mg Al C N O F

Ne



PERIODIC TABLE IA

Part 2 CHEMICAL BONDS

Atoms form bonds with other atoms in order to achieve stability, 8 valence electrons. This is the Octet rule.

Types of bonds

There are 2 ways that atoms form bonds.

Sharing electrons : Covalent Bonds

Transferring electrons : Ionic Bonds

Covalent Bonds:

When 2 nonmetal atoms share at least one pair of electrons a covalent bond is formed

Lewis dot diagrams of diatomic elements:

Hydrogen

Chlorine

Oxygen

Nitrogen

HONC Rule

The most bonds between any two atoms is:

Lewis dot diagrams of diatomic some simple compounds:

Water

Carbon dioxide

Ammonia

Methane

Carbon tetrachloride

Carbon monoxide

Ionic Bonds:

When a metal atom and a nonmetal atom react they form a bond in which the metal atom loses one or more electrons and the nonmetal atom gains one or more electrons. The bond is the attraction between a negative ion and a positive ion.

Ion an atom or molecule that has a charge due to gaining or losing an electron

Cations: Positively charged ions. Atoms that have lost an electron leaving more protons in the nucleus than there are electrons

Anions: Negatively charged ions. Atoms that have gained an electron leaving more electrons than protons in the nucleus.

Examples

Sodium chloride

Magnesium oxide

Calcium bromide

Electronegativity: how attracted an atom is towards the electrons in a bond

Patterns of electronegativity on the periodic table

High electronegativity elements

Low electronegativity elements

Electronegativty and chemical bonds

Ionic bonds

Covalent bonds

Polar covalent

Nonpolar covalent

<u>Types of Molecules</u>

Just as bonds can be polar or nonpolar, molecules can also be polar or nonpolar. This polarity significantly affects the properties of the molecule.

Nonpolar molecules:

Polar Molecules:

Intermolecular bonds:

Bonds can form between atoms *of different* molecules or molecules and ions. These bonds are not as strong as the covalent and ionic bonds.

Ion-dipole attractions between an ion and the partially charged part of a polar molecule

Hydrogen bond A hydrogen bond is a relatively strong dipole-dipole attractive force between a hydrogen atom and a pair of nonbonding electrons on a F,O, or N atom

Dipole-dipole interactions are electrostatic attractions between polar molecules

London Forces London forces are very weak electrostatic forces of attraction between molecules with "temporary" dipoles.

Part 3 Energy in Reactions

I. CHANGES IN TEMPERATURE AS A SUBSTANCE IS HEATED [Energy Added]

As a substance absorbs heat, the temperature rises. Different substances can absorb and store more heat than others.

A. HEAT CAPACITY [Specific heat]

The amount of heat required to raise the temperature of 1 g of a substance exactly $1^{o}C$.

Substance	Specific Heat (cal/g-C)
Water	1.00
Aluminum	0.215
Iron	0.108
Gold	.031

Example: How many degrees Celsius will the temperature rise if 25 g ether absorbs 160. cal of energy.

$$\text{Specific heat}_{\text{ether}} = \frac{0.529 \text{ cal}}{\text{g } ^{\circ}\text{C}}$$

B. ENERGY AND CHANGE OF STATE

Energy (as heat) is either lost or absorbed when a substance changes its state

Solid → Liquid

Liquid → Gas

Gas → liquid

C. HEAT OF VAPORIZATION- The quantity of heat needed to convert a liquid at its boiling point to the gaseous state.

Prob: Who much heat is needed to convert 155 g water to steam at it's B.P.?
ΔH_{vap} = 540 cal/ gram

D. HEAT OF FUSION- The quantity of heat needed to convert a solid at its melting point to the liquid state.

Prob: Who much energy is needed to convert 35 g of ice to water at it's M.P.? ΔH_{fus} = 80 cal/gram

E. CHANGES IN TEMPERATURE AND PHYSICAL STATE

Summary of T^{o} & State changes when Energy [heat] is added:

Specific Heat = $\frac{J}{g\ ^{\circ}C}$ or $\frac{cal}{g\ ^{\circ}C}$ ...etc.

Heat of Fusion = $\frac{KJ}{g}$ or $\frac{KJ}{mole}$ or $\frac{Kcal}{g}$ ...etc.

Heat of Vaporization = $\frac{KJ}{g}$ or $\frac{KJ}{mole}$ or $\frac{Kcal}{g}$ ...etc.

Problem. How much energy [Heat in kilojoules] is needed to convert 500.0 g of ice at -15.0°C to steam at 105.0 °C?

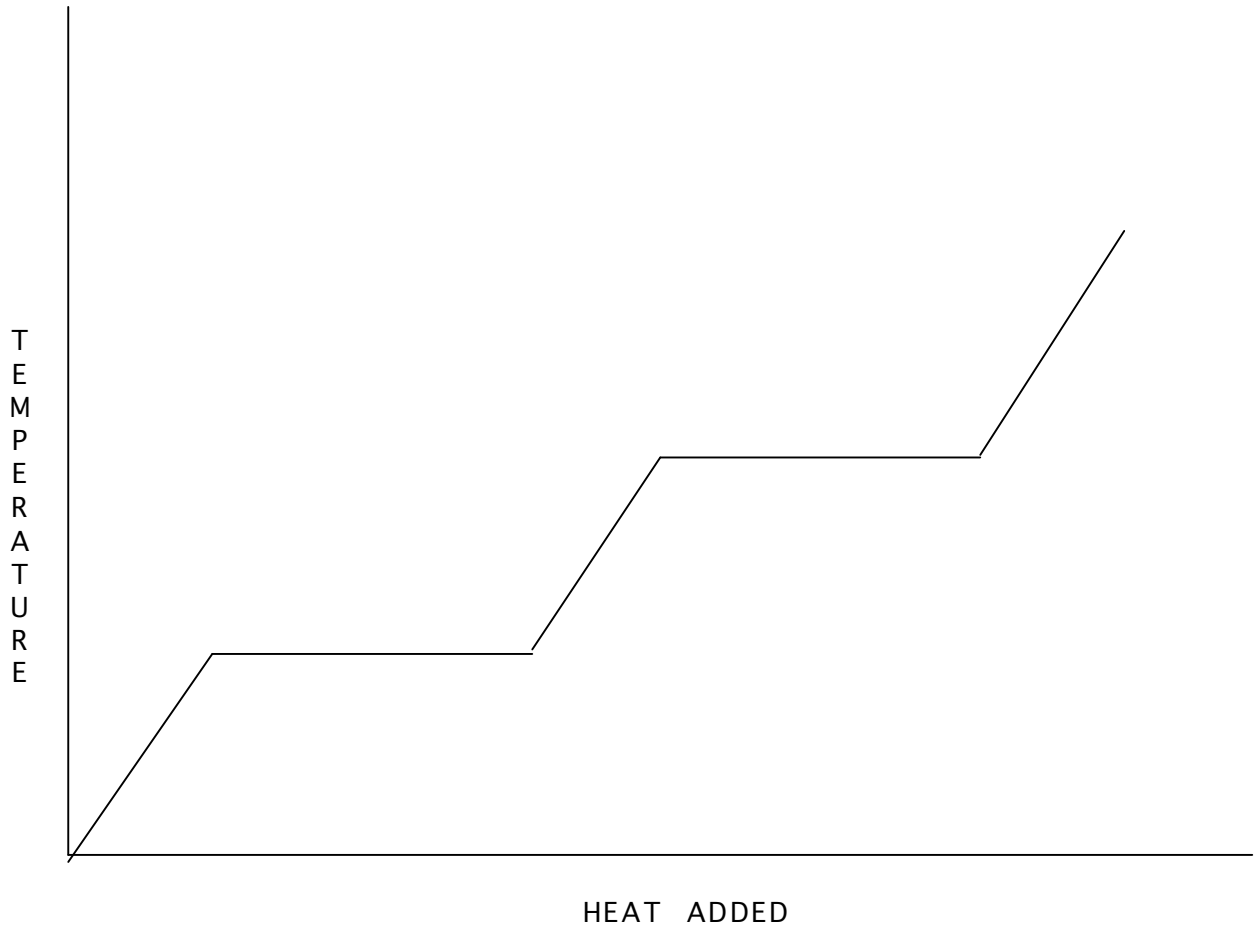
H_{fusion}= 80 cal/gram H_{vap} = 540 cal/ gram

Specific heat of ice = $\frac{.50 \text{ cal}}{\text{g } ^{o}\text{C}}$

Specific heat of water = $\frac{1.00 \text{ cal}}{\text{g } ^{o}\text{C}}$

Specific heat of steam = $\frac{.48 \text{ cal}}{\text{g } ^{o}\text{C}}$

GRAPH:



TOTAL HEAT ADDED

Problems:

1. Calculate the number of calories required to convert 58.9 g of ice at 0^{o}C to water at 81 ^{o}C

2. Given a sample of 30.0 g of water at 37 ^{o}C, calculate the quantity of heat in calories that would be required to convert it to 90^{o}C.

Part 4 NOMEMCLATURE

I. COMPOUNDS - Two or more elements chemically combined in definite proportions.

COMPOUNDS

IONIC COMPOUNDS	MOLECULAR COMPOUNDS
Metal - Nonmetal	Nonmetal-Nonmetal

II. Ionic compounds

Formation of ions:

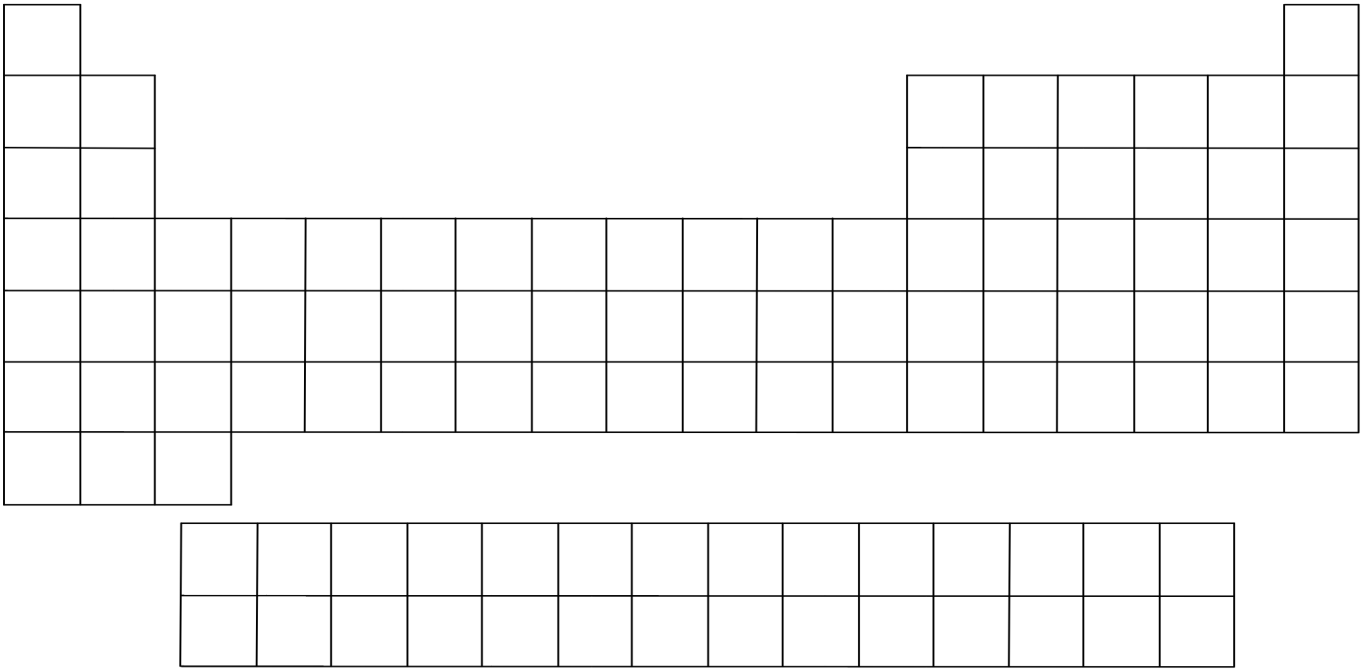
Metals form cations (+) ions:

Nonmetals form Anions (-) ions:

III. Cation and Anions

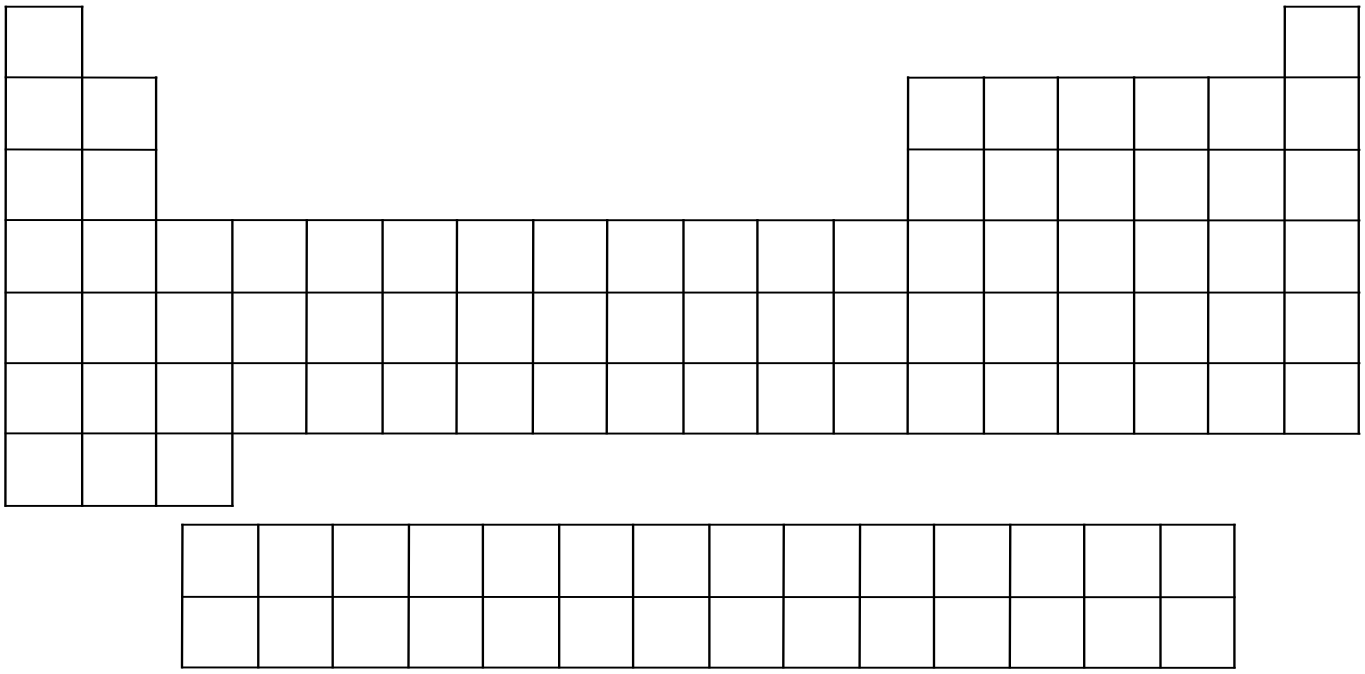
A. Metallic Cations - (+ charge)

1. Fixed Charged cations are those metals that form only one type of ion.



PERIODIC TABLE IA

2. Variable charged cations are those metals that form more than one type of ion.



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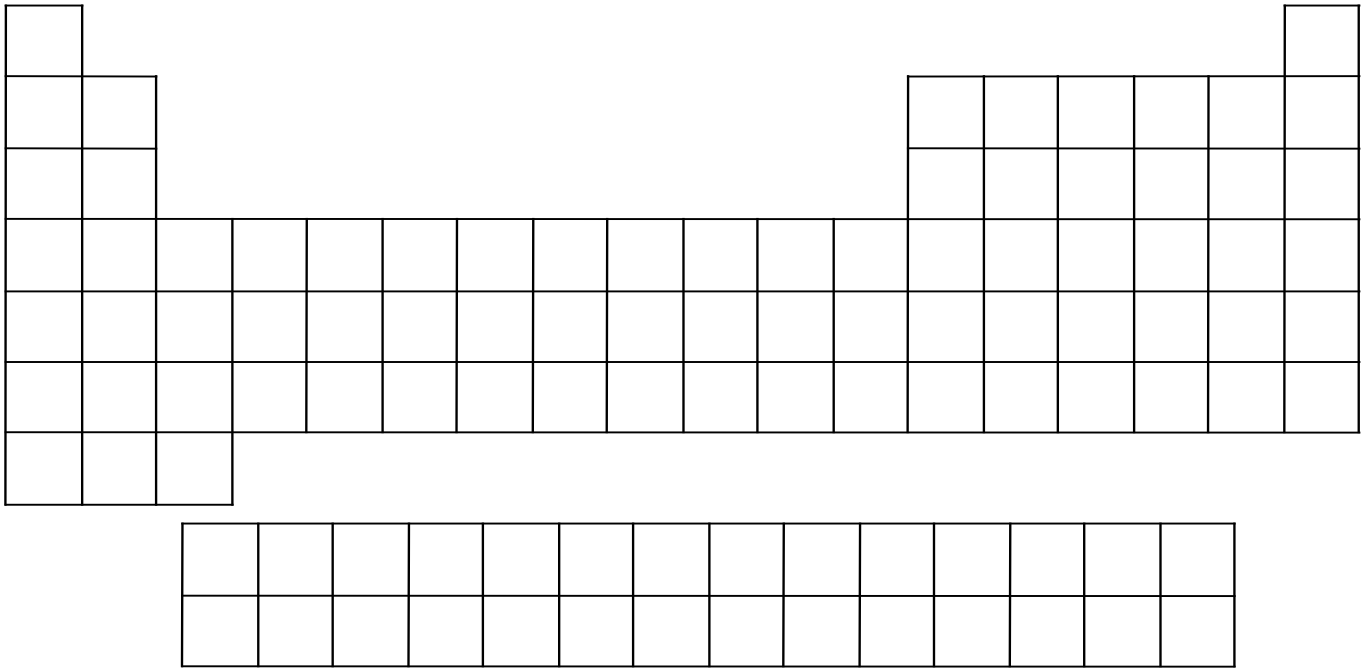
B. Nonmetal Anions (-) charge



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IV. Naming Ionic Compounds

1. Fixed metal → name as is

2. Variable charged metal- remember the (roman numeral) or use the classical "common" name.

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V. Polyatomic Ions

A group of atoms bonded together to form an ion

N	S	P	C
NO_2^{1-} Nitrite	SO_3^{2-} Sulfite	PO_3^{3-} Phosphite	
NO_3^{1-} Nitrate	SO_4^{2-} Sulfate	PO_4^{3-} Phosphate	CO_3^{2-} Carbonate

VI. Naming compounds with polyatomic ions

VII. Chemical Formulas

Key: Compounds are neutral → no net charge

VIII. Molecular compounds

Nonmetal - Nonmetal

Variable combinations

Ex.

1. Know prefixes:

Prefix	Number
Mono-	1
Di-	2
Tri-	3
Tetra-	4
Penta-	5
Hexa-	6
Hepta-	7
Octa-	8
Ennea- /Nona-	9
Deca-	10

2. Naming formula:

Prefix element #1 + prefix stem of element #2 + ide

Ex.

KEY: Recognize the ion part of the Acid

ACID	ION

NOMENCLATURE

Formula starts with an "H" + (aq)
(Water is excluded)

ACID

- oxyacid — contains oxygen
  - EXAMPLES: HClO — hypochlorous acid
- binary acid — does not contain oxygen
  - EXAMPLES: HCl — hydrochloric acid

Metal-Nonmetal

IONIC COMPOUND

- Fixed charged metal — Group IA, IIA, Al, Ga, Cd, Zn, or Ag --> name as is
  - EXAMPLES: KBr — Potassium bromide
- Variable charged metal — All other metals --> place charge in ( ) as roman numerals/ know classical names
  - EXAMPLES: CuOH — Copper (I) hydroxide

Nonmetal-Nonmetal

MOLECULAR COMPOUND

When naming, use prefixes (mono, di tri...etc.)

- EXAMPLES: CO — Carbon monoxide

HYDRATES: CONTAINS H_2O in the chemical formula - use prefix + Hydrate

$CuSO_4 \cdot 5H_2O$ -Copper (II)) sulfate pentahydrate

Nomenclature Examples

Part 5 CHEMICAL FORMULA CALCULATIONS

I. FORMULA WEIGHTS = $\sum$ Mass of all atoms

Atomic level

one formula unit of Al_2O_3 =

II. THE MOLE

1 mole of particles = 6.02 x 10^{23} particles

Avogadro's number → memorize!!

Conversions

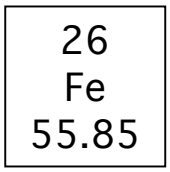
$$\frac{\text{1 mole H atoms}}{6.02 \times 10^{23} \text{ atoms}} \quad \text{or} \quad \frac{6.02 \times 10^{23} \text{ H atoms}}{\text{1 mole atoms}}$$

Problem: How many Cu atoms in 6.0 mol Cu?

Know: 1 mol Cu = 6.02 x 10^{23} atoms Cu

III. MOLAR MASS (molecular wt.)

1 mole = AMU weight numerically in grams



Atomic wt.
55.85 AMU
{1 atom}

Molar mass
55.85 g
= 1mole of Fe atoms
= 6.02×10^{23} Fe atoms

Conversion factors:

Problems:

1a. How many moles of Fe in 33.0 g of Fe?

b. How many atoms is this?

IV. MOLECULAR COMPOUNDS AND IONIC COMPOUNDS

V. MOLES AND CHEMICAL FORMULAS

N_2O_5

2 atoms N	2 mole N
5 atoms O	5 moles O
= 1 molecule N_2O_5	= 1 mole of N_2O_5

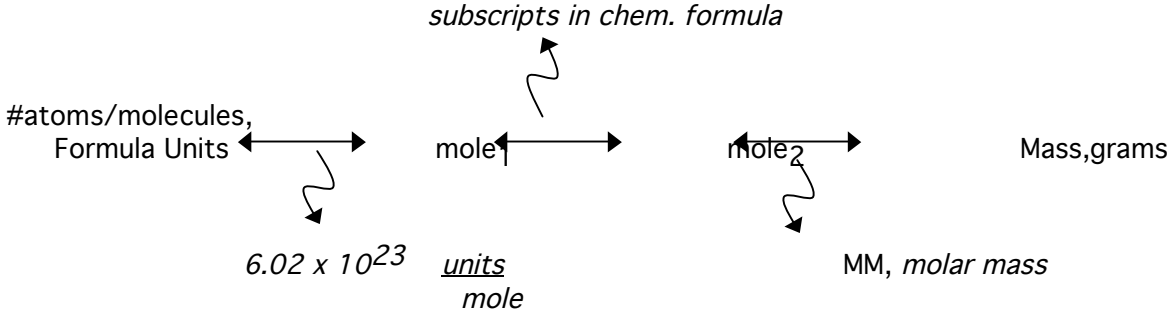
Ratios:

Problems:

1. How many moles of N in 13.5 moles of N_2O_5?

2. How many moles of O in 13.5 moles of N_2O_5?

VI. MOLES AND CHEMICAL CALCULATIONS:



Problems:

1. How many atoms in 13.4 g of S?

2. How many K atoms in 3.0 g K_3P?