Project REACH
CALABARZON

ONLINE REVIEW

CHEMISTRY

OUTLINE

GENERAL CHEMISTRY

- Classification and Properties of Matter
- Electron Configuration
- Expression of Chemical Formula
- Stoichiometry
    - Mole Concept
    - Atomic and Molecular Weight
    - Types of Chemical Reactions
- Empirical and Molecular Formula

OUTLINE

INORGANIC CHEMISTRY

- Electron Pair & Molecular Geometry
- Periodic Trends
- Chemical Bonding
    - Intramolecular & Intermolecular Forces

ORGANIC CHEMISTRY

- The Carbon Atom
- Hybridization
- Classes of Functional Groups

OUTLINE

ANALYTICAL CHEMISTRY

- Dimensional Analysis
  - Accuracy, Trueness, Precision
  - Unit Conversion
- Concentration Expressions
  - Molarity & Molality
  - Mole Fraction
  - %w/w and %v/v
- Good Laboratory Practices
  - Safety Data Sheets
  - Chemical Safety (GHS Classifications)

OUTLINE

BIOCHEMISTRY

- Biomolecular Substances
- Photosynthesis and Respiration
- pH, pOH, and Acid-Base Equilibria

PHYSICAL CHEMISTRY

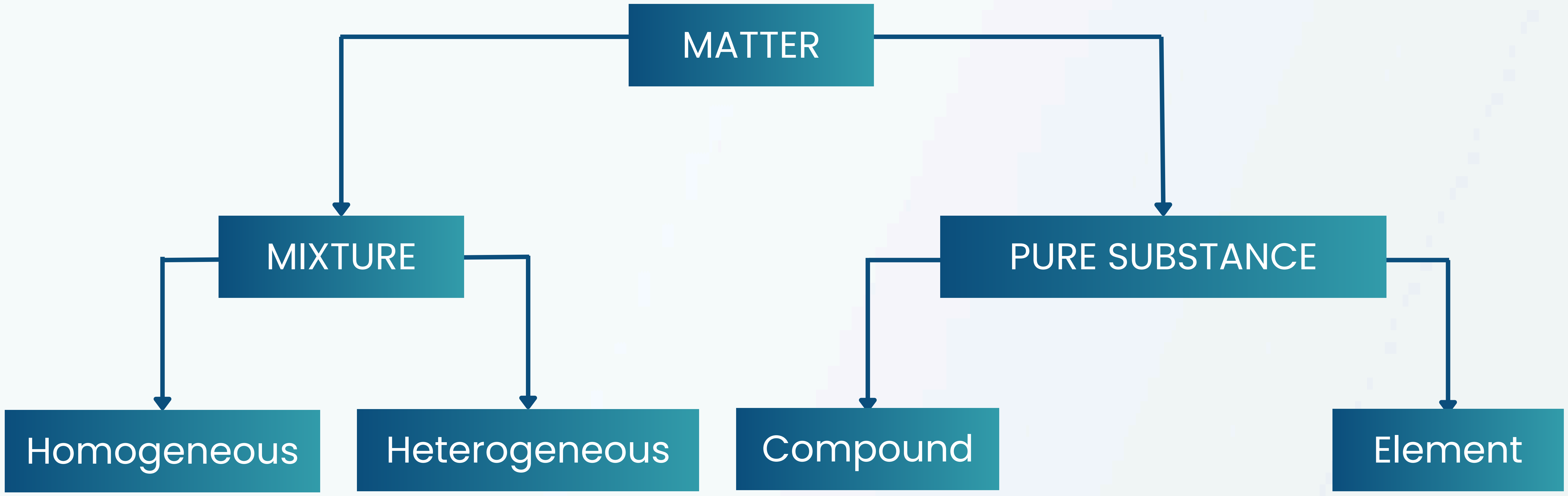
- Gas Laws
- Kinetic Molecular Theory
- Phase Changes

CHEMISTRY

THE CENTRAL SCIENCE

CLASSIFICATION AND PROPERTIES OF MATTER

Matter is defined as anything that occupies space and has volume.



CLASSIFICATION AND PROPERTIES OF MATTER

- **Physical Properties**

They can be observed without having to change the identity and/or composition of a particular substance.

Examples: color, odor, hardness, density, boiling & melting point

- **Chemical Properties**

They can be observed by means of performing chemical reactions, thus changing the identity of the substance.

Examples: flammability, toxicity, solubility

CLASSIFICATION AND PROPERTIES OF MATTER

- **Intensive Properties**

They are properties that are not dependent on the amount of sample or system being examined.

Examples: color, molecular weight, temperature

- **Extensive Properties**

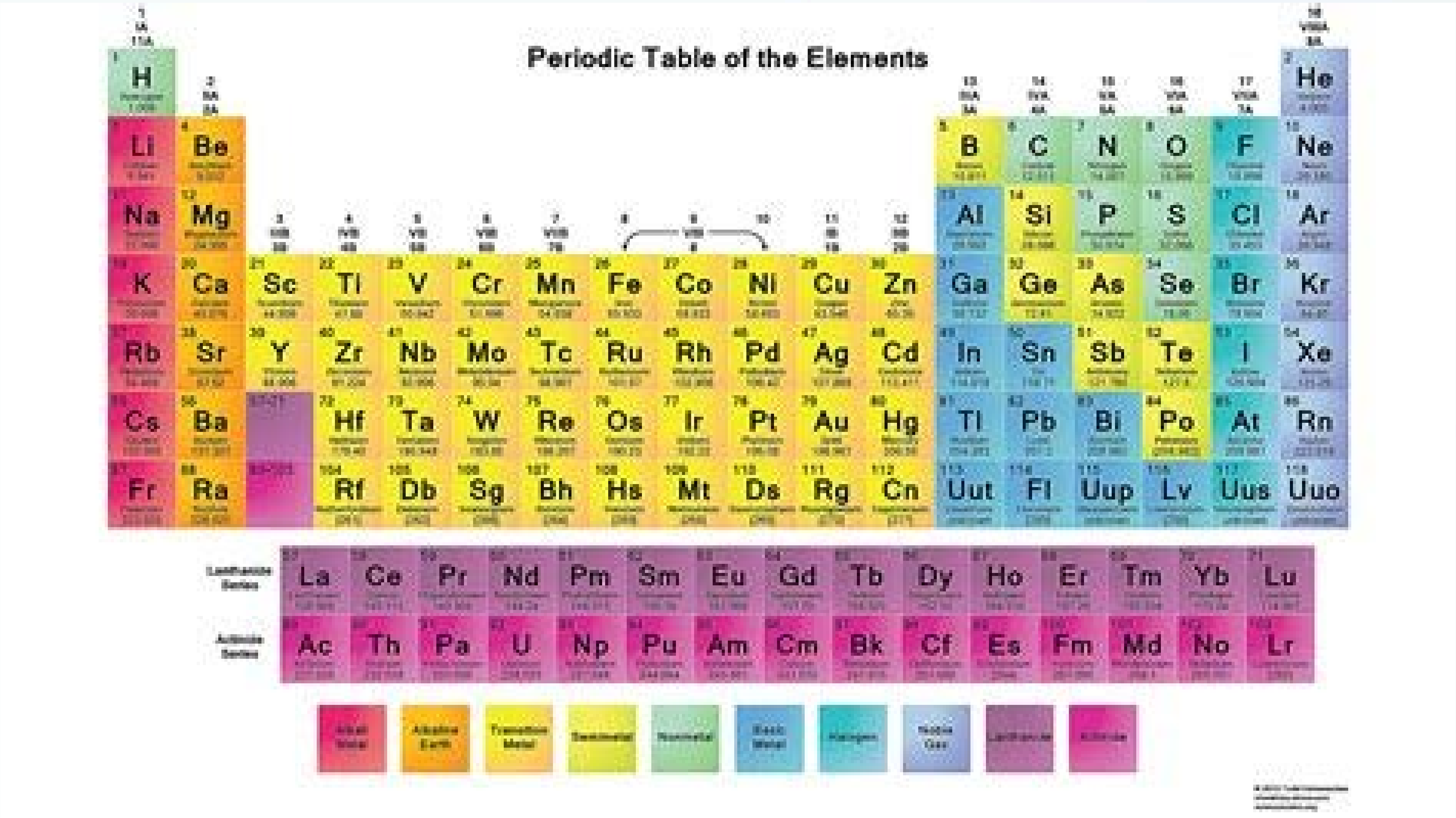
They are properties that are dependent on the amount of sample or system being examined.

Examples: mass, volume

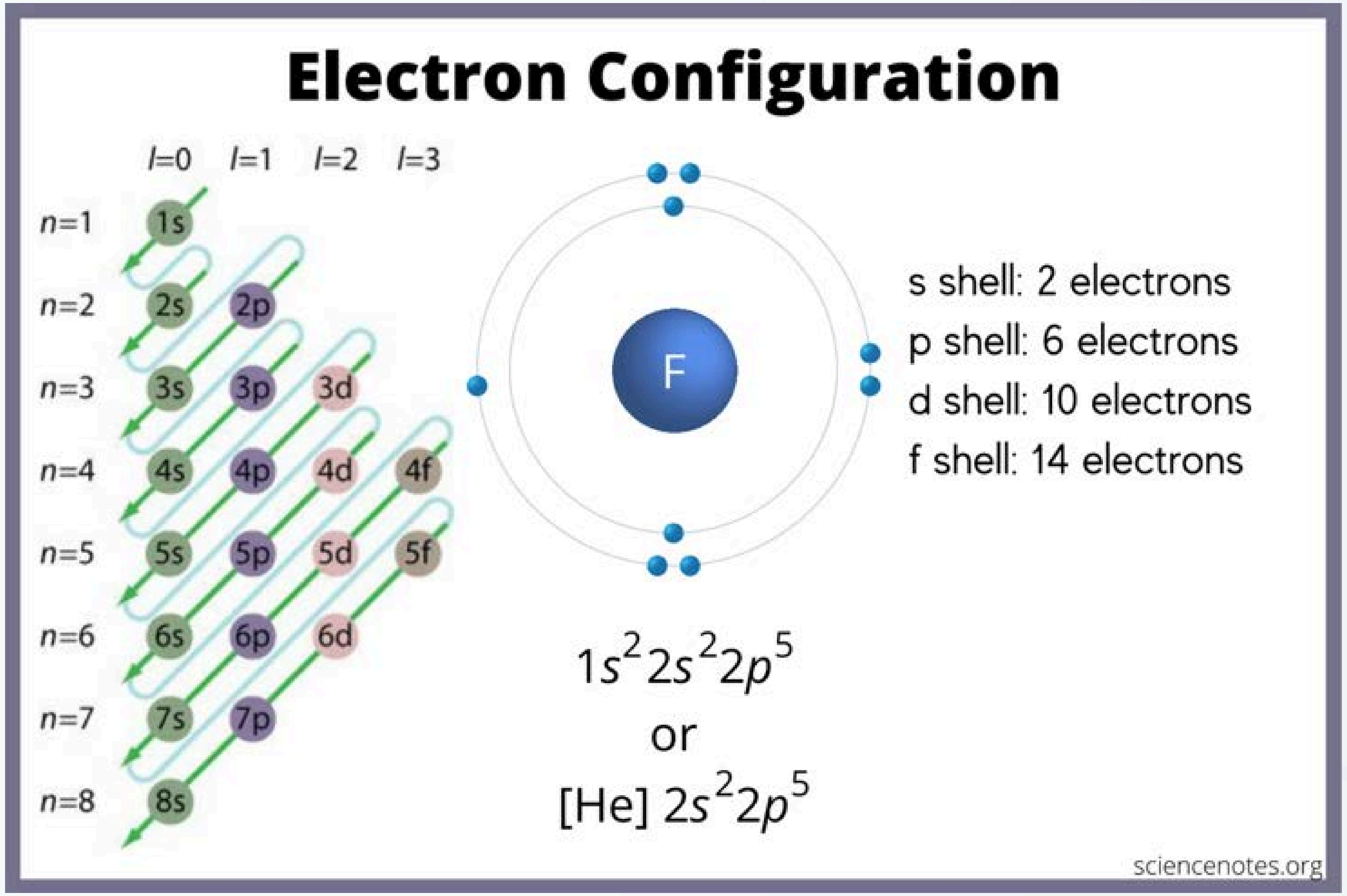
REVIEW: PROTONS, ELECTRONS, AND NEUTRONS

- Atoms are composed of extremely small particles called **protons**, **neutrons**, and **electrons**.
- In the center of the atom, there are **protons** and **neutrons** (nucleons) making up the nucleus. **Electrons**, meanwhile, surround the nucleus.
- **Protons** have a (**+**) charge, while **electrons** have a (**-**) charge. **Neutrons** have **no charge**.
- As opposite charges attract, **protons and electrons attract each other**.
- The **mass number** is expressed as the total number of protons and neutrons, while the **atomic number** is expressed as the number of protons in an element.

PERIODIC TABLE OF ELEMENTS



REVIEW: ELECTRON CONFIGURATION



CHEMICAL FORMULA

A **chemical formula** is defined as the representation of a molecule by means of chemical symbols.

In expressing the chemical formula of a substance,

- Identify the elements or ions for which the formula has to be written;
- Write down the chemical symbols for the identified elements or ions, as well as their respective charges;
- Cross over the absolute value of the valencies of each element or ion with the other; and
- Write the ratios in the form of subscripts.

CHEMICAL FORMULA

Sample Problem

What is the chemical formula for aluminum sulfate?

Identify the elements or ions for which the formula has to be written.

- **Aluminium ion**
- **Sulfate ion**

Write down the chemical symbols for the identified elements or ions, as well as their respective charges.

- Aluminium ion: $\mathbf{Al^{3+}}$
- Sulfate ion: $\mathbf{SO_4^{2-}}$

CHEMICAL FORMULA

What is the chemical formula for aluminum sulfate?

Cross over the absolute value of the valencies of each element or ion with the other.

$$Al^{3+} \times SO_4^{2-}$$

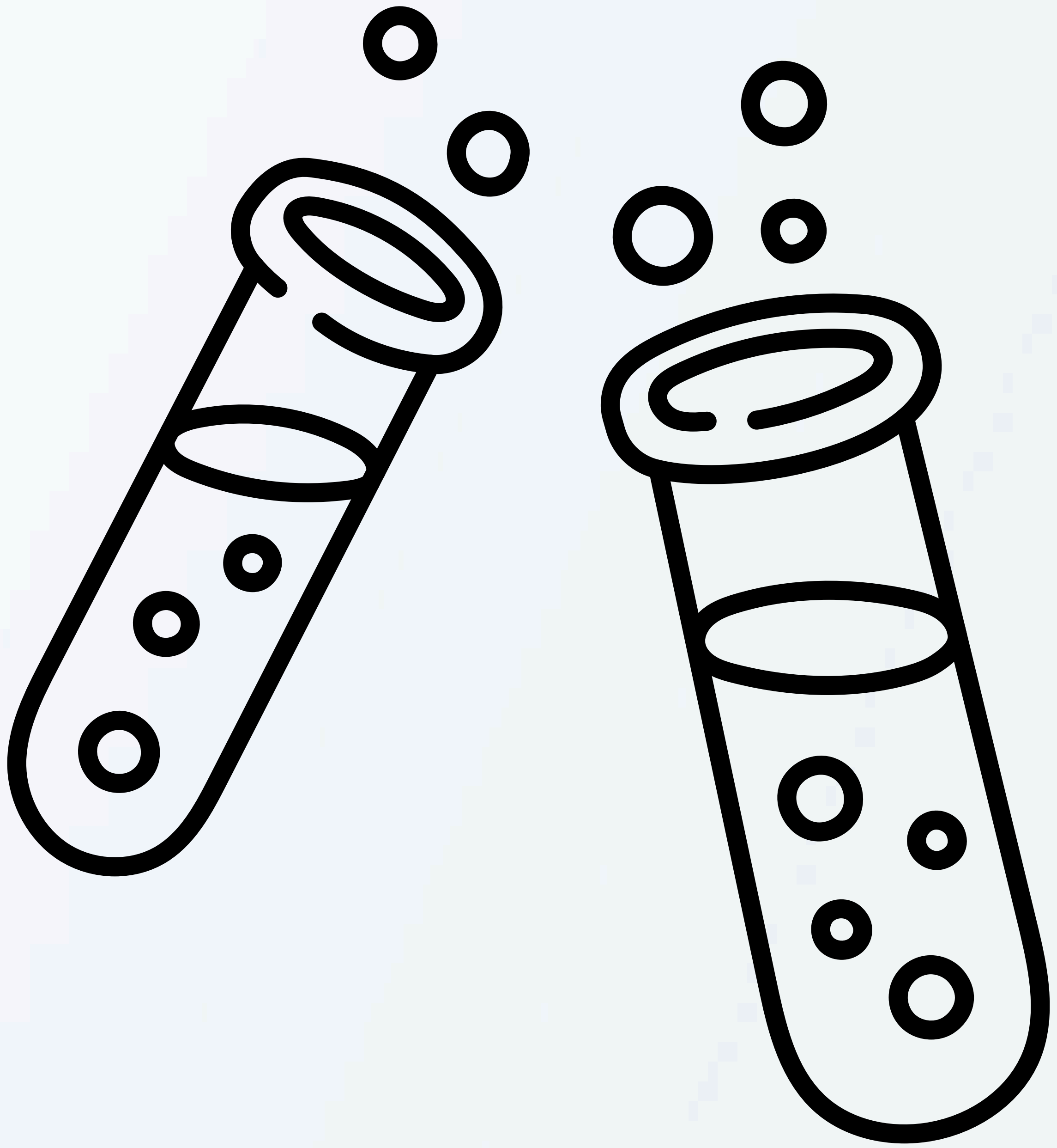
Write the ratios in the form of subscripts.

$$Al_2(SO_4)_3$$

STOICHIOMETRY

Stoichiometry denotes the relationship of the quantities of substances in chemical reactions.

It involves the concepts of **balancing of chemical equations** and **mole ratio.**



REVIEW: MOLE CONCEPT

A **mole** is a quantity of matter containing the Avogadro's number.

$$1\ \textbf{mole} = 6.0221 \times 10^{23}\ \textbf{particles}^{*}$$

*can either be **atoms**, **molecules**, or **ions**

This quantity is used to conveniently express a substance being weighed in a laboratory.

REVIEW: ATOMIC & MOLECULAR WEIGHT

- **Atomic weight**

This refers to the mass of an atom of an element located in the Periodic Table.

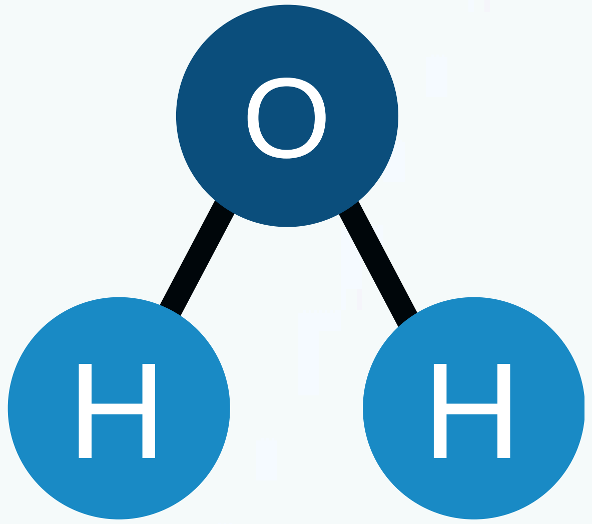
- **Molecular weight**

This is a combination of all atomic weights of each element in a compound.

Both quantities can be expressed in terms of ***grams per mole*** *(g/mol).*

REVIEW: ATOMIC & MOLECULAR WEIGHT

atomic weight



$AW_O = 16\ g/mol$

$AW_H = 1\ g/mol$

$$MW_{H_2O} = (AW_H \times 2) + (AW_O)$$
$$= (1\ g/mol \times 2) + (16\ g/mol)$$
$$MW_{H_2O} = 18\ g/mol$$

molecular weight

REVIEW: CHEMICAL REACTIONS

Types of Chemical Reactions

- **Synthesis or Combination**

$$A + B \rightarrow AB$$

$$MgO + CO_2 \rightarrow MgCO$$

- **Decomposition**

$$AB \rightarrow A + B$$

$$MgCO_3 \rightarrow MgO + CO$$

STOICHIOMETRY

Types of Chemical Reactions

- **Single Replacement (Substitution)**

$$AB + C \rightarrow CB + A$$

$$Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$$

- **Double Replacement (Exchange)**

$$AB + CD \rightarrow AD + CB$$

$$BaCl_2 + MgSO_4 \rightarrow BaSO_4 + MgCl_2$$

STOICHIOMETRY

Types of Chemical Reactions

- **Neutralization (Acid-Base)**

$$\text{acid} + \text{base} \rightarrow \text{salt} + \text{water}$$

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

- **Combustion**

$$\text{substance} + O_2 \rightarrow CO_2 + H_2O$$

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

STOICHIOMETRY

In **balancing chemical equations**, the number of atoms for each element present on both reactant and product sides must be **equal**.

Take the combustion of methane as an example.

$$CH_4 + O_2 \rightarrow CO_2 + H_2O$$

The balanced equation for this reaction is,

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Element/Number of Atoms	Reactant	Product
C	1	1
H	4	2
O	2	3

STOICHIOMETRY: Mole Ratio

The **mole ratio** is a ratio between species present in a chemical reaction, which comes from their respective coefficients.

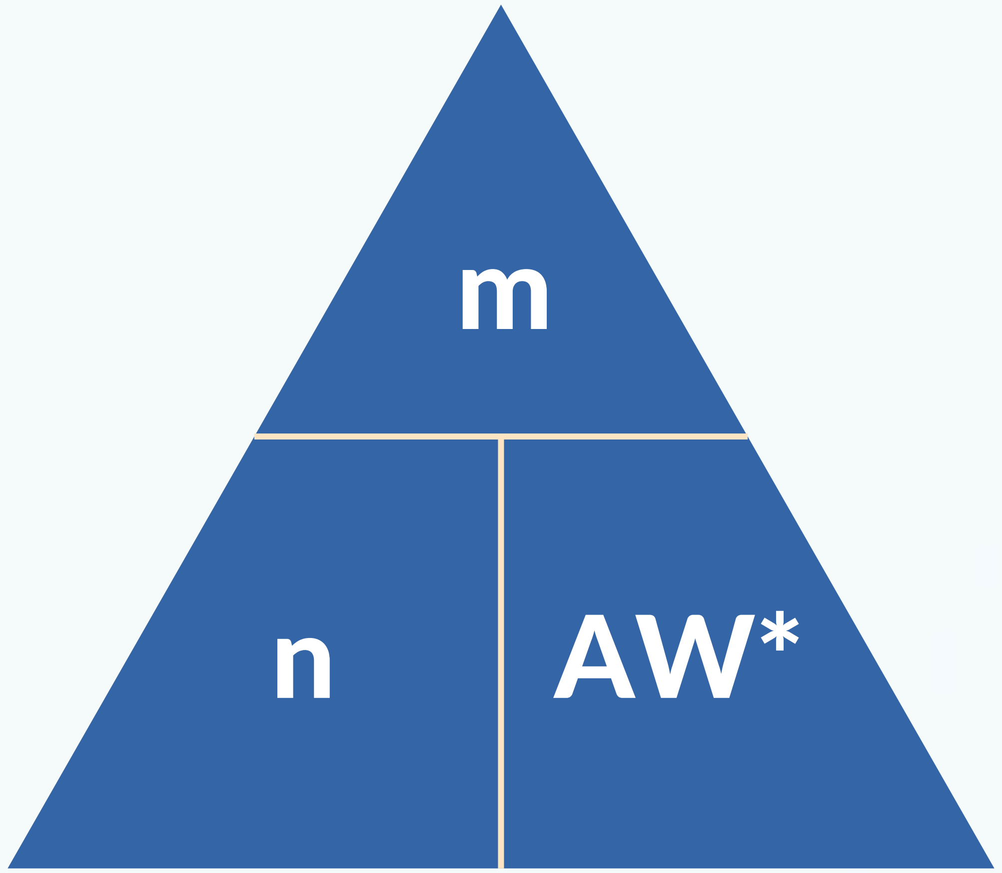
$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

In the combustion of methane above, the mole ratio of CH to H O can be denoted below:

$$\frac{\text{1 mole of } CH_4}{\text{2 moles of } H_2O}$$

REVIEW: Mass and Mole Conversions

Take note of this tool for derivations:



**can also be MW*

where,
m = mass (g)
n = number of moles (mol)
AW or **MW** = atomic/molecular weight (g/mol)

Approach to Stoichiometry Problems

Given the combustion of methane,

The **general formula** for a stoichiometry problem is denoted below:

$$\frac{\text{(unknown) } \mathbf{n \text{ moles of desired substance}}}{\mathbf{n \text{ moles of given substance}}} = \frac{\text{(theoretical) } \mathbf{n \text{ moles of desired substance}}}{\text{(theoretical) } \mathbf{n \text{ moles of given substance}}}$$

The **theoretical mole ratio** comes from the **balanced chemical equation**.

STOICHIOMETRY: Example

Given the combustion of methane,

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

How many moles of water can be produced by burning 5 moles of methane?

STOICHIOMETRY: Example

Given the combustion of methane,

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

How many moles of water can be produced by burning 5 moles of methane?

Given: **5 moles of methane (CH_4)**

Find: **n moles of water (H_2O)**

STOICHIOMETRY: Example

Given the combustion of methane,

Given: **5 moles of methane (CH_4)**

Find (desired): **n moles of water (H_2O)**

Ratio of desired to given substance: **2:1**

Formula:

$$\frac{\text{(unknown) } \mathbf{n\ moles\ of\ desired\ substance}}{\mathbf{n\ moles\ of\ given\ substance}} = \frac{\text{(theoretical) } \mathbf{n\ moles\ of\ desired\ substance}}{\text{(theoretical) } \mathbf{n\ moles\ of\ given\ substance}}$$

STOICHIOMETRY: Example

Given the combustion of methane,

Solution:

$$\frac{n \text{ moles } H_2O}{5 \text{ moles } CH_4} = \frac{2 \text{ moles } H_2O}{1 \text{ mole } CH_4}$$

$$n \text{ moles } H_2O = \frac{2 \text{ moles } H_2O \quad (5 \text{ moles } CH_4)}{1 \text{ mole } CH_4}$$

$$\mathbf{n = 10 \text{ moles}}$$

*If the **mass** is required, *multiply the obtained value of n to the molecular weight of water.*

EMPIRICAL AND MOLECULAR FORMULA

- **Empirical Formula** – shows the simplest whole number ratio of atoms present in a compound
- **Molecular Formula** – shows the actual representation of the compound's elemental composition

To determine the empirical formula of a compound,

- Know the number of moles of each element present;
- Divide all molar amounts by the smallest number of moles present; and/or
- Obtain whole numbers by multiplying the values by integers, if deemed necessary.

EMPIRICAL AND MOLECULAR FORMULA

Sample Problem

In a 0.5022 g of sample, there are 21.21% nitrogen, 6.10% hydrogen, 36.36% carbon, and 36.33% oxygen. Determine the empirical formula of the sample.

EMPIRICAL AND MOLECULAR FORMULA

In a 0.5022 g of sample, there are 21.21% nitrogen, 6.10% hydrogen, 36.36% carbon, and 36.33% oxygen. Determine the empirical formula of the sample.

Given:

- Weight of sample: 0.5022 g
- Percent N: 21.21%
- Percent H: 6.10%
- Percent C: 36.36%
- Percent O: 36.33%

Find: Empirical formula

EMPIRICAL AND MOLECULAR FORMULA

In a 0.5022 g of sample, there are 21.21% nitrogen, 6.10% hydrogen, 36.36% carbon, and 36.33% oxygen. Determine the empirical formula of the sample.

Solution:

- Determine the masses of compound present.

mass N: 0.5022 g (0.2121) = 0.10651662 g
mass H: 0.5022 g (0.0610) = 0.0306342 g
mass C: 0.5022 g (0.3636) = 0.18259992 g
mass O: 0.5022 g (0.3633) = 0.18244926 g

EMPIRICAL AND MOLECULAR FORMULA

In a 0.5022 g of sample, there are 21.21% nitrogen, 6.10% hydrogen, 36.36% carbon, and 36.33% oxygen. Determine the empirical formula of the sample.

Solution:

- Know the number of moles of each element present.

moles N: $0.10651662 \text{ g} \times \dfrac{1 \text{ mol N}}{14.01 \text{ g}}$

$= 0.0076028993576017 \text{ mol}$

EMPIRICAL AND MOLECULAR FORMULA

In a 0.5022 g of sample, there are 21.21% nitrogen, 6.10% hydrogen, 36.36% carbon, and 36.33% oxygen. Determine the empirical formula of the sample.

Solution:

- Know the number of moles of each element present.

moles N = 0.0076028993576017 mol
moles H = 0.0303910714285714 mol
moles C = 0.0152039900083264 mol
moles O = 0.01140307875 mol

What element has the smallest number of moles present in the sample?

EMPIRICAL AND MOLECULAR FORMULA

In a 0.5022 g of sample, there are 21.21% nitrogen, 6.10% hydrogen, 36.36% carbon, and 36.33% oxygen. Determine the empirical formula of the sample.

Solution:

- Divide all molar amounts by the smallest number of moles present.

$$\textbf{ratio for O} = \frac{0.01140307875 \text{ mol}}{0.0076028993576017 \text{ mol}}$$

$= 1.499832920792082$

≈ 1.5

EMPIRICAL AND MOLECULAR FORMULA

In a 0.5022 g of sample, there are 21.21% nitrogen, 6.10% hydrogen, 36.36% carbon, and 36.33% oxygen. Determine the empirical formula of the sample.

Solution:

- Divide all molar amounts by the smallest number of moles present.

ratio for N = 1
ratio for H = 3.997300240228108 ≈ 4
ratio for C = 1.999762103009401 ≈ 2
ratio for O = 1.499832920792082 ≈ 1.5

What do we do when there is a non-whole number in our obtained ratios?

EMPIRICAL AND MOLECULAR FORMULA

In a 0.5022 g of sample, there are 21.21% nitrogen, 6.10% hydrogen, 36.36% carbon, and 36.33% oxygen. Determine the empirical formula of the sample.

Solution:

- Obtain whole numbers by multiplying the values by integers, if deemed necessary.

ratio for N $= 1 \times 2 = 2$
ratio for H $\approx 4 \times 2 = 8$
ratio for C $\approx 2 \times 2 = 4$
ratio for O $\approx 1.5 \times 2 = 3$

Hence, the empirical formula of the sample is $\mathbf{C_4H_8N_2O_3}$.

ELECTRON PAIR AND MOLECULAR GEOMETRY

Number of Electron Dense Areas	Electron-Pair Geometry	Molecular Geometry				
		No Lone Pairs	1 lone Pair	2 lone Pairs	3 lone Pairs	4 lone Pairs
2	Linear	Linear				
3	Trigonal planar	Trigonal planar	Bent			
4	Tetrahedral	Tetrahedral	Trigonal pyramidal	Bent		
5	Trigonal bipyramidal	Trigonal bipyramidal	Sawhorse	T-shaped	Linear	
6	Octahedral	Octahedral	Square pyramidal	Square planar	T-shaped	Linear

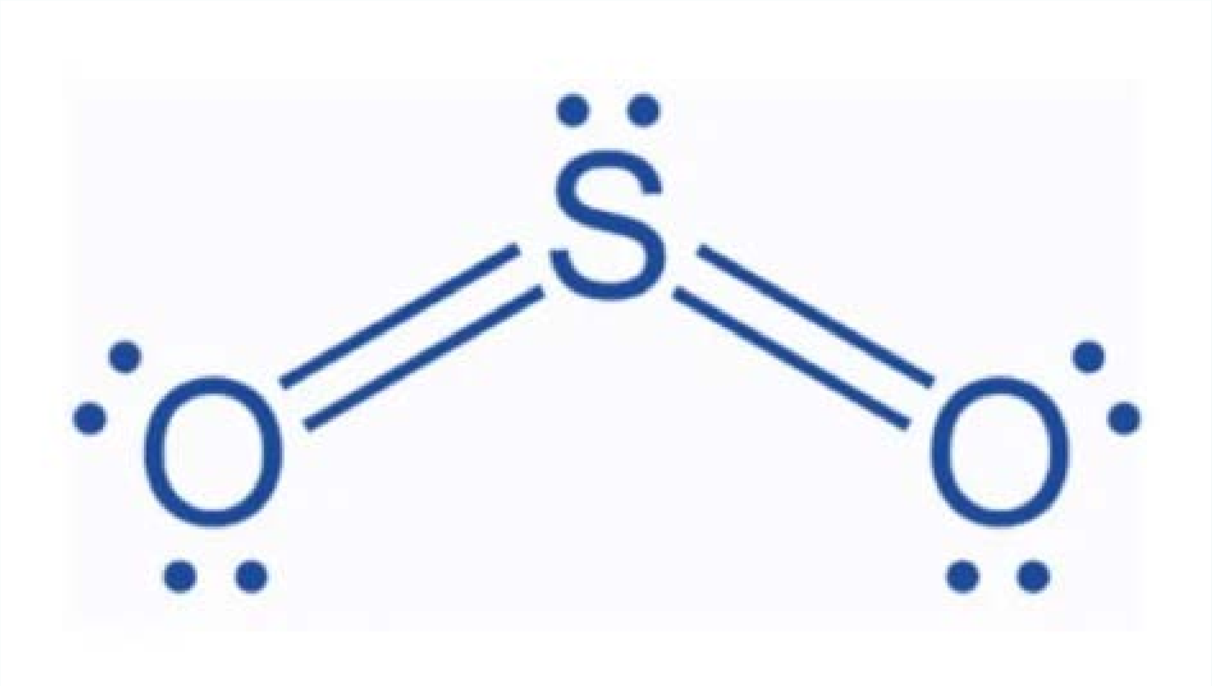
- **Electron Pair Geometry** – takes account of all the electron pairs in a compound
- **Molecular Geometry** – is dependent on the number of bonding pairs

One may use the **AXE** method in determining the molecular geometry of substances.

ELECTRON PAIR AND MOLECULAR GEOMETRY

Sample Problem

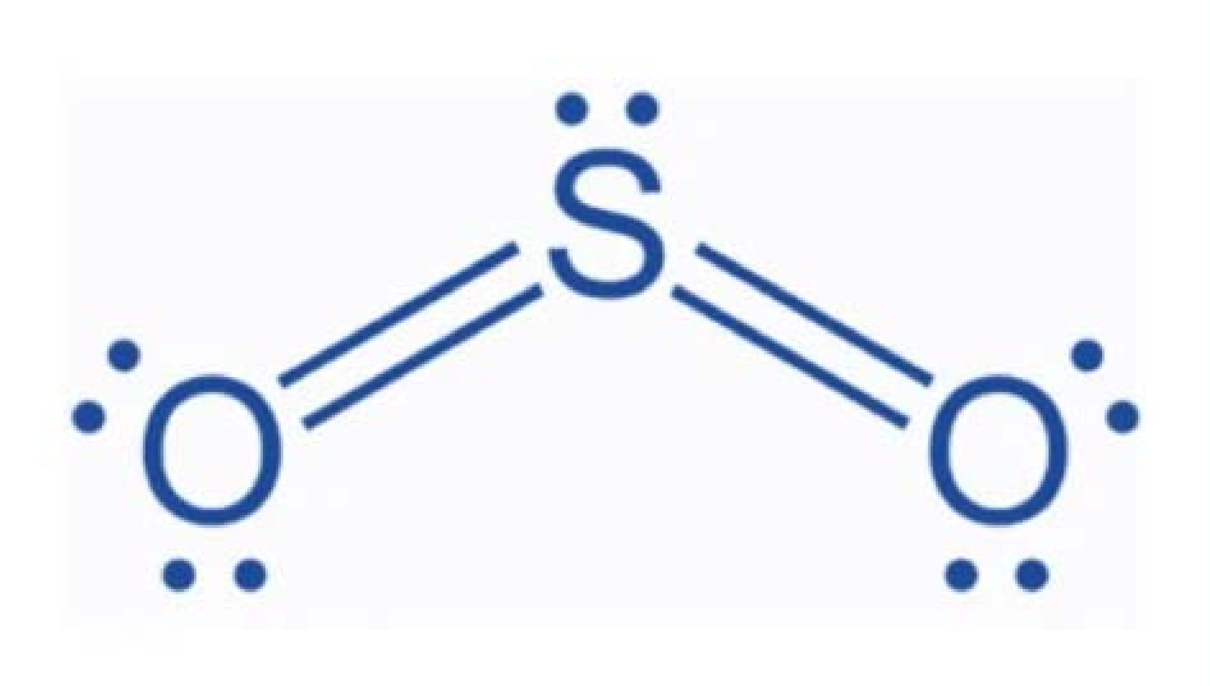
Determine the electron pair and molecular geometry of SO_2.



What is the central atom in this compound?

ELECTRON PAIR AND MOLECULAR GEOMETRY

Determine the electron pair and molecular geometry of SO_2.

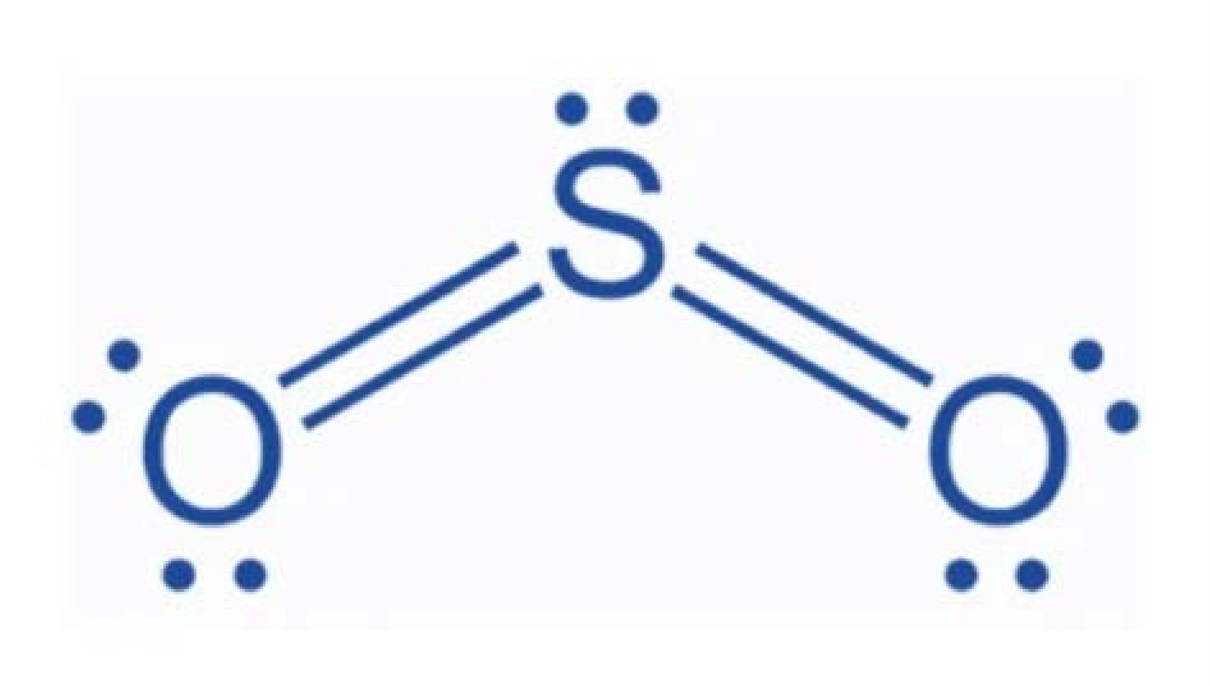


- To determine **EPG**, obtain the sum of the number of atoms attached to the central atom, as well as the lone pairs of the central atom.

no. of atoms attached to S: **2**
no. of lone pairs of S: **1**
It has **3** electron pairs; thus, its EPG is **trigonal planar**.

ELECTRON PAIR AND MOLECULAR GEOMETRY

Determine the electron pair and molecular geometry of SO_2.



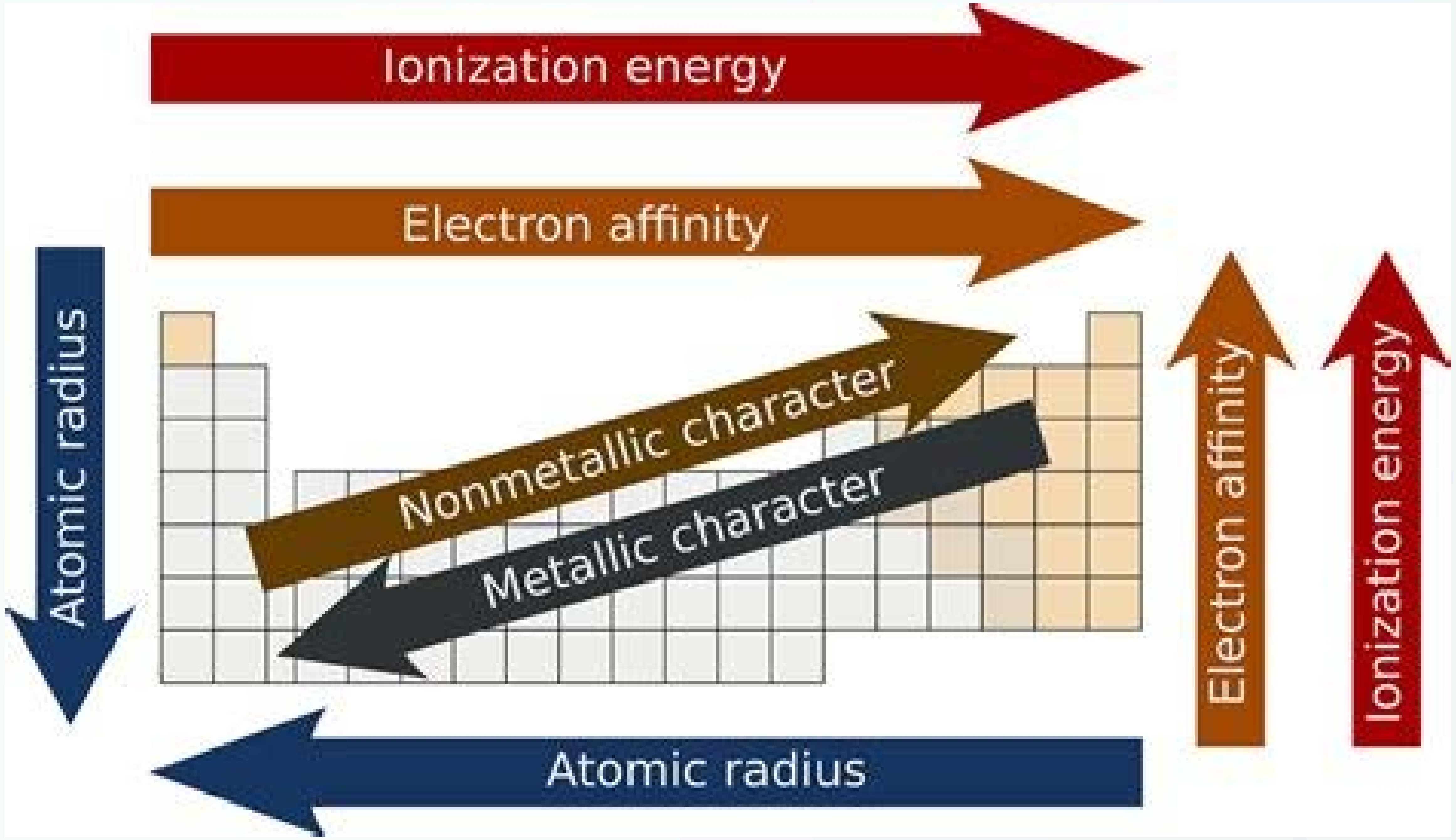
- To determine **MG**, utilize the AXE method.

$$\mathbf{AX_mE_n}$$

m = no. of atoms attached to central atom
n = no. of lone pairs of central atoms

no. of atoms attached to S = m = **2**
no. of lone pairs of S = n = **1**
Its formula shall be **AX_2E**; thus, its MG is **bent.**

PERIODIC TRENDS



PERIODIC TRENDS

Decreasing from top to bottom, increasing from left to right:

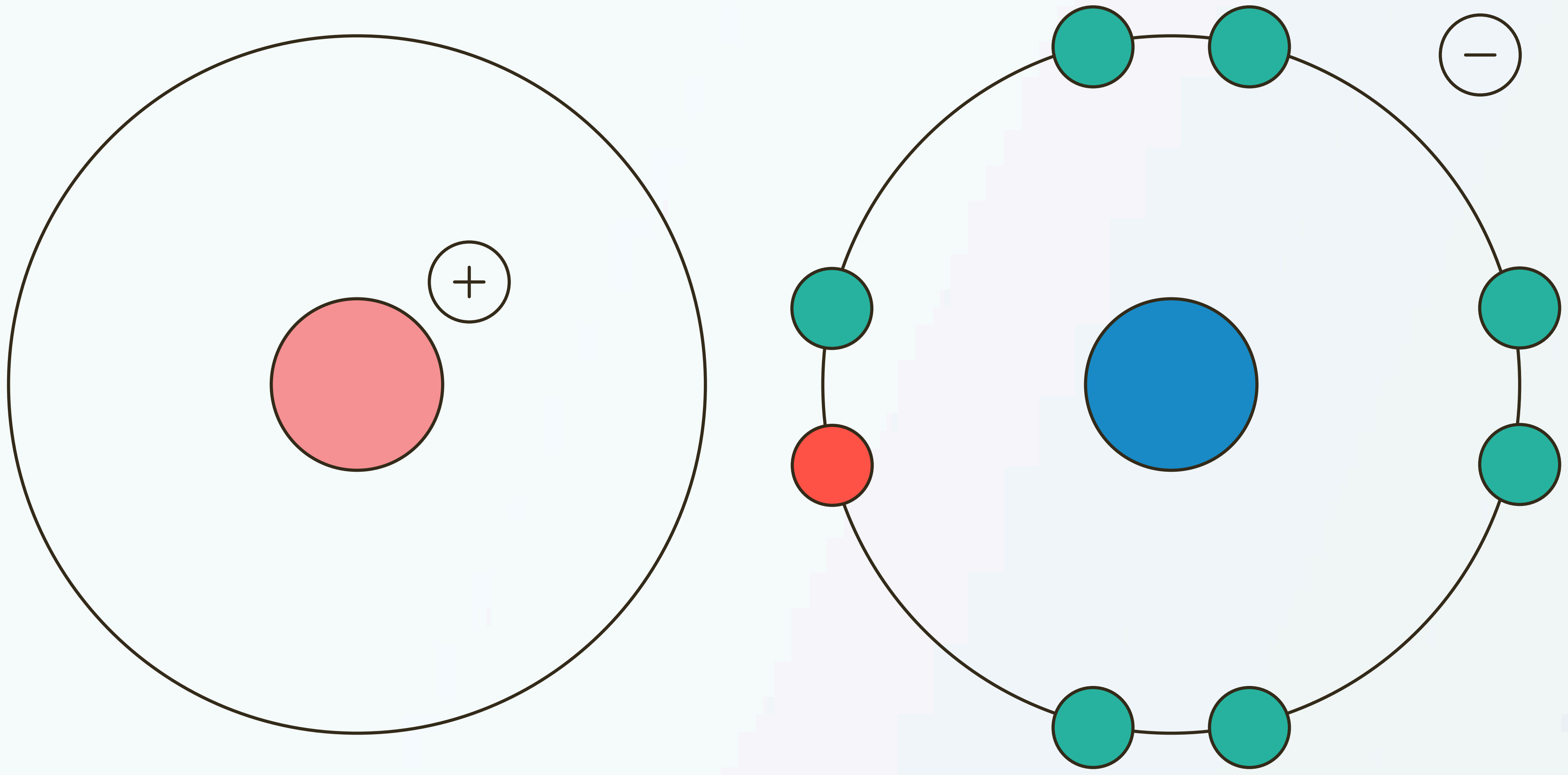
- **Electronegativity** — tendency of an atom to attract shared electrons
- **Electron Affinity** — ability of an atom to accept an electron
- **Ionization Energy** — energy required to remove an electron from a neutral atom
- **Nonmetallic Character** — readiness of an atom to gain an electron (or the ability of an atom to become an anion)

Increasing from top to bottom, decreasing from left to right:

- **Atomic Radius** — measure of the distance from the nuclei to the outermost isolated electron
- **Metallic Character** — readiness of an atom to lose an electron (or the ability of an atom to become a cation)

CHEMICAL BONDING

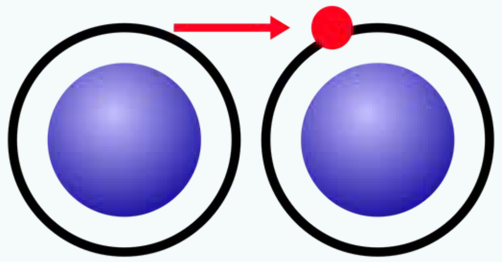
This refers to the formation of chemical bonds between atoms, molecules, and ions to form new compounds.



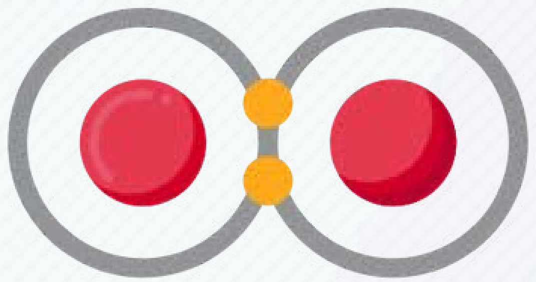
INTRAMOLECULAR FORCES OF ATTRACTION

The **intramolecular forces** are chemical bonds holding atoms together in the molecules. Major types of these are as follows:

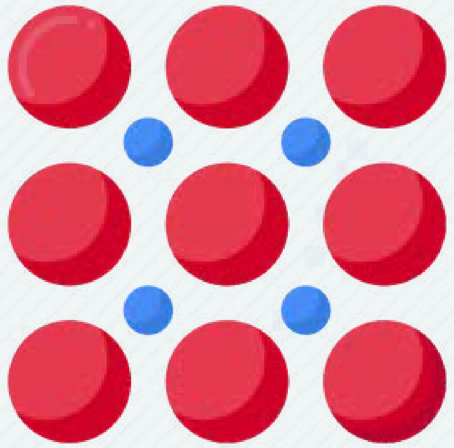
Ionic Bond
transfer of electrons



Covalent Bond
sharing of electrons



Metallic Bond
bonding in metals

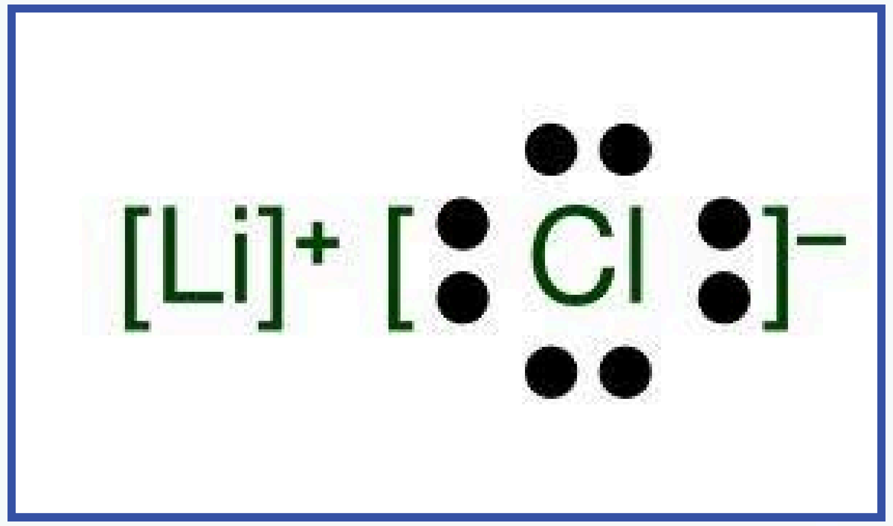


INTRAMOLECULAR FORCES OF ATTRACTION

The conventional Lewis structures for the chemical bonds are as follows:

Ionic Bond

transfer of electrons



Covalent Bond

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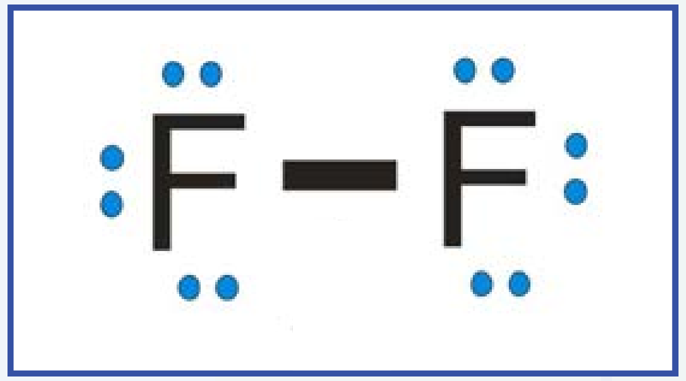
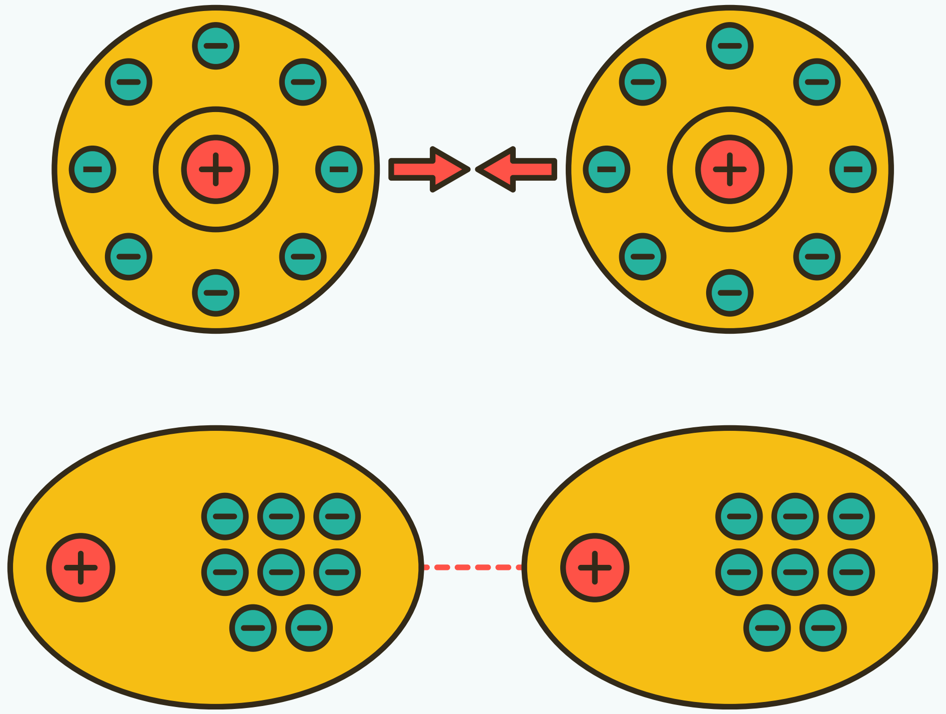


INTERMOLECULAR FORCES OF ATTRACTION



The **intermolecular forces** are electrostatic interactions between molecules. They may be weaker than the intramolecular forces, but they play a big role in identifying the properties of various compounds.

Major types of intermolecular forces are,

- **London Dispersion Forces**
- **Dipole-Dipole Interactions**
- **Hydrogen Bonding**

INTERMOLECULAR FORCES OF ATTRACTION

- **London Dispersion Forces**

They are considered as the weakest among all the intermolecular forces. The temporary dipole moment they create is deemed present in all substances regardless of polarity.

- **Dipole-Dipole Interactions**

These forces are present in polar molecules as they possess permanent dipoles (where one end is δ+ and another is δ-).

- **Hydrogen Bonding**

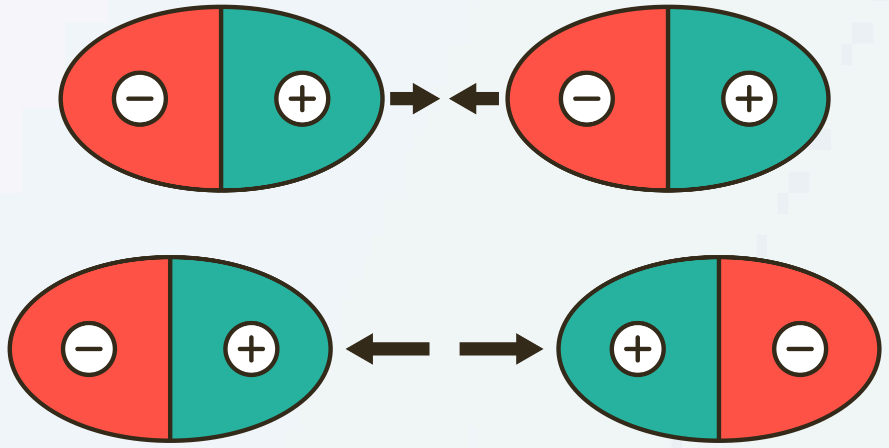
This is a special type of dipole-dipole interaction occurring between a hydrogen atom and a highly electronegative atom (N, O, F). It is deemed the strongest intermolecular force as well.

INTERMOLECULAR FORCES OF ATTRACTION

What are the implications of a high IMFA?

It means that the forces controlling bonds are **stronger** (or harder to break), which leads to,

- higher boiling point
- higher melting point
- higher surface tension
- higher latent heat of fusion, vaporization, and sublimation



INTERMOLECULAR FORCES OF ATTRACTION

Sample Problem

What is the strongest intermolecular force in 1-butanol ($CH_3CH_2CH_2CH_2OH$)?

A. London Disperson Forces
B. Hydrogen Bonding
C. Dipole-Dipole Interaction
D. Ion-Dipole Interaction

INTERMOLECULAR FORCES OF ATTRACTION

What is the strongest intermolecular force in 1-butanol ($CH_3CH_2CH_2CH_2OH$)?

A. London Disperson Forces
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C. Dipole-Dipole Interaction
D. Ion-Dipole Interaction

*Shown above is the structure of **1-butanol**. It is then safe to assume that it is relatively **polar**, due to the presence of the -OH bond. Based on the discussion, it can exhibit all the intermolecular forces. However, we only look for the strongest IMFA, thus we shall select **hydrogen bonding**.*

THE CARBON ATOM

The **carbon** atom has the symbol C and atomic number 6 in the Periodic Table of Elements.

It is considered to be **nonmetallic** and **tetravalent**, hence it can have a maximum of **four covalent bonds.**

HYBRIDIZATION

Hybridization is defined as the concept of combining pure atomic orbitals on atoms with about the same energy to form a new set of orbitals.

In organic chemistry, there is a trick to easily determine the hybridization of orbitals.

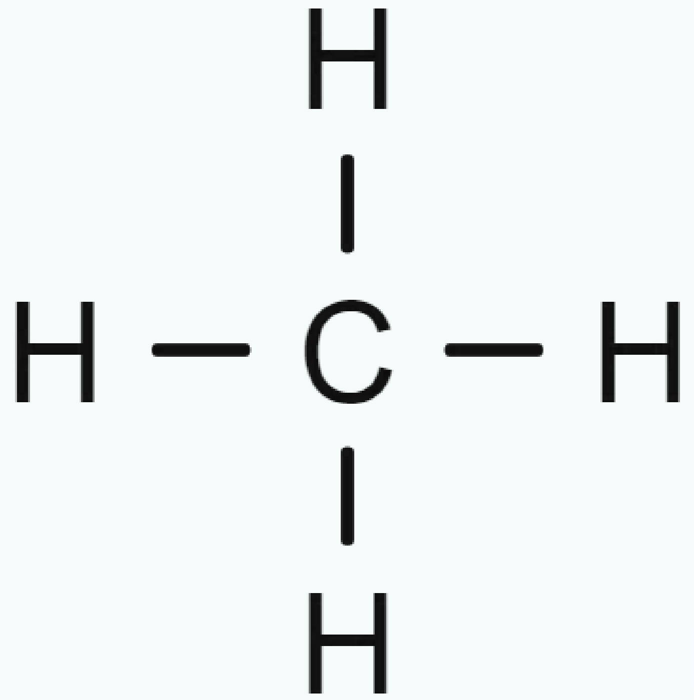
n	**hybridization**	**electron-pair geometry**
4	sp	tetrahedral
3	sp	trigonal planar
2	sp	linear

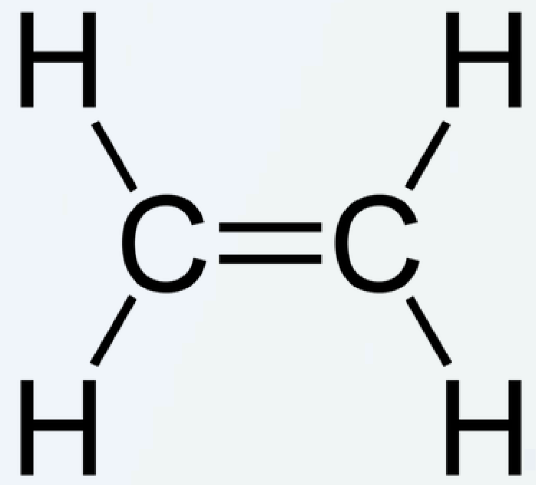
where n = coordination # + # lone pairs

HYBRIDIZATION

Sample Problem

Consider the structures of methane and ethylene.





HYBRIDIZATION

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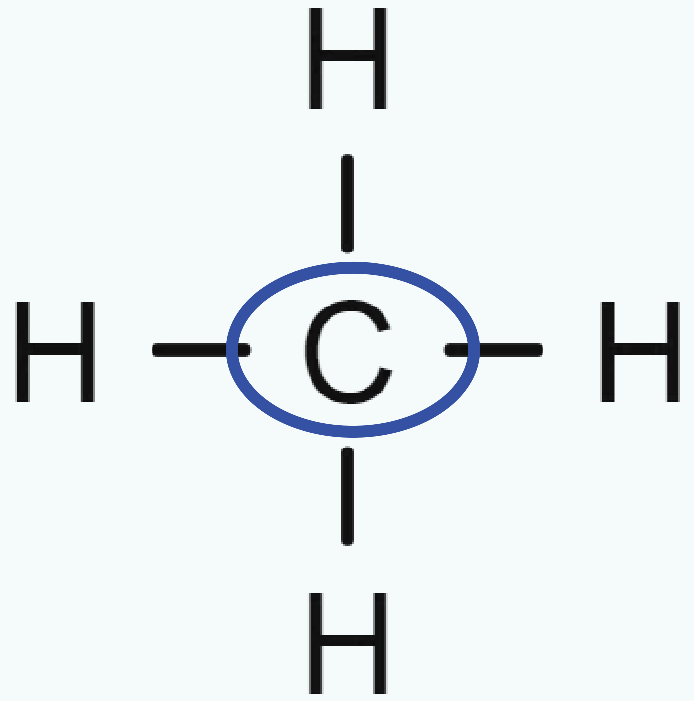

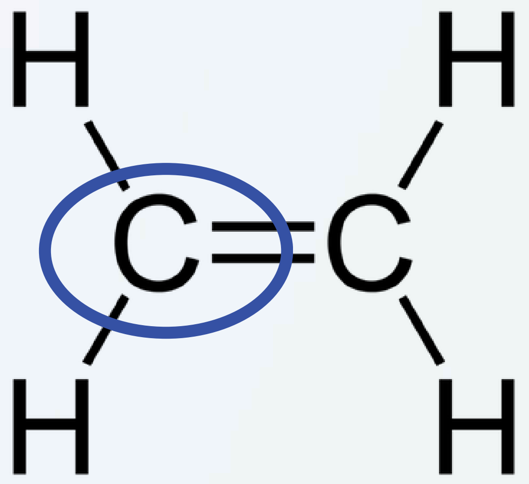

HYBRIDIZATION

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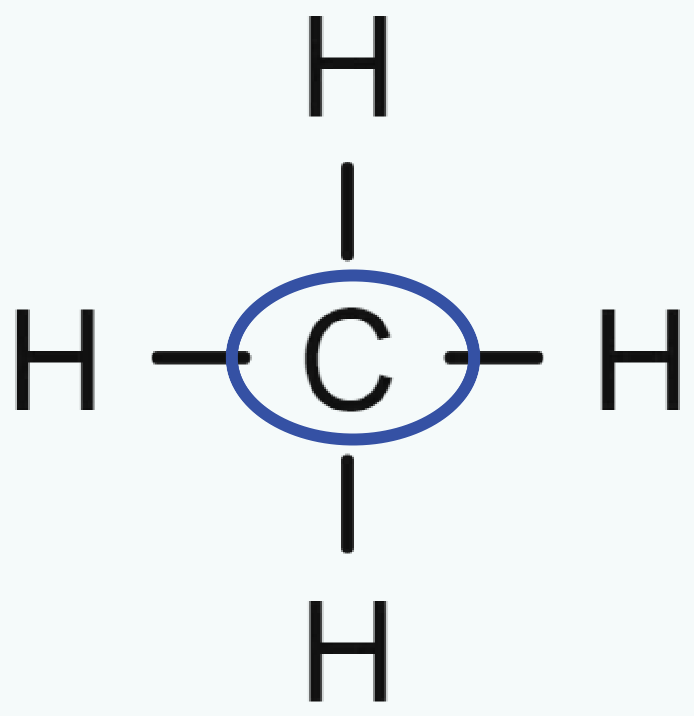
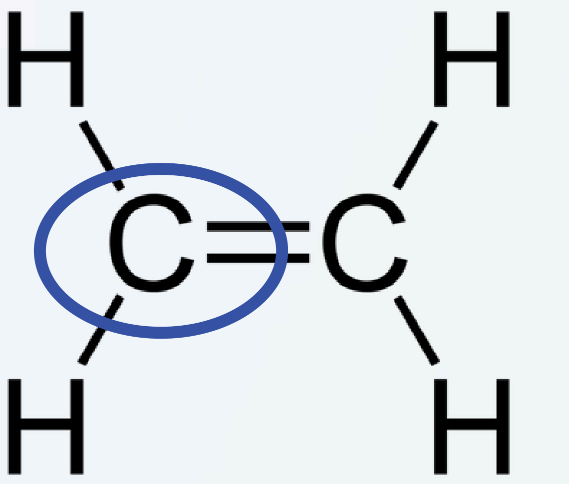




n = coordination # + # lone pairs

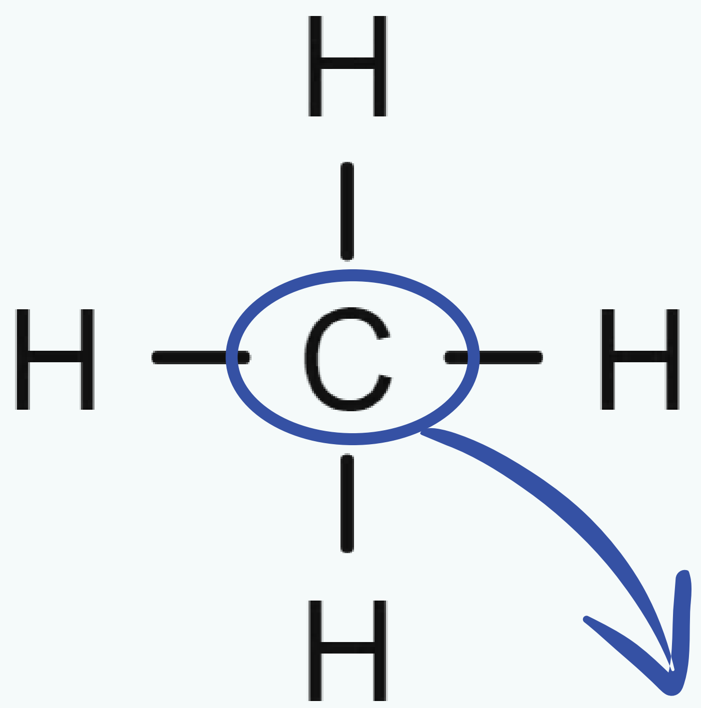
n = 4 + 0 = 4

n = coordination # + # lone pairs

n = 3 + 0 = 3

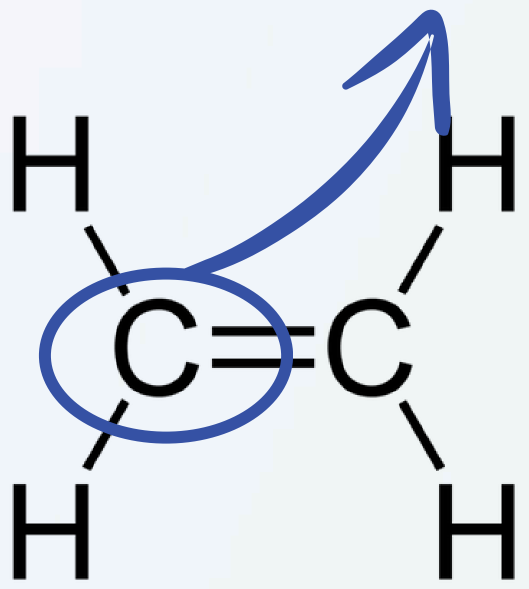
HYBRIDIZATION

Consider the structures of methane and ethylene.



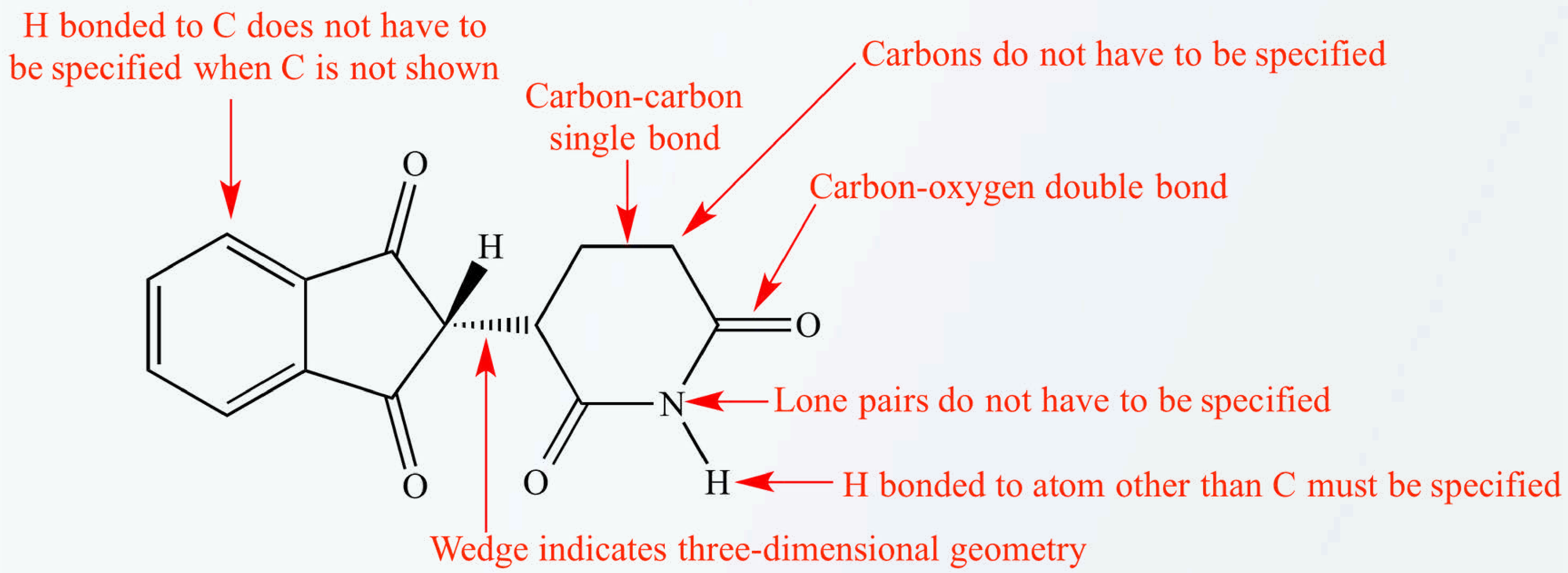
sp^3 hybridized

sp^2 hybridized

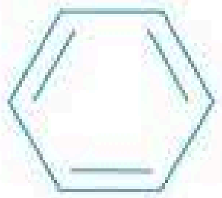


ORGANIC CHEMISTRY

Organic chemistry is the branch of chemistry dealing with most carbon containing compounds.

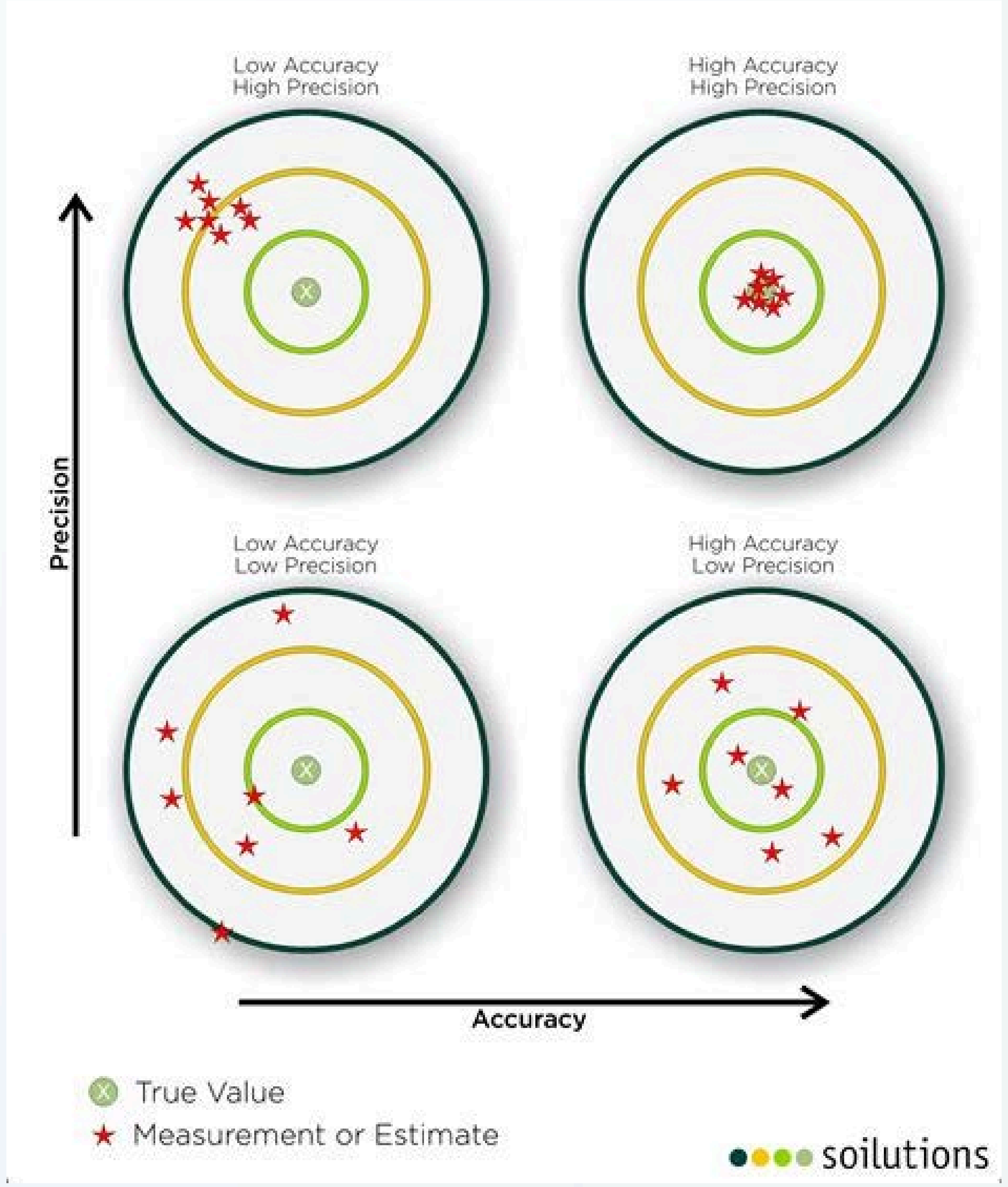


FUNCTIONAL GROUPS IN ORGANIC CHEMISTRY

Class	General Formula	Example	Common Name (Systematic Name)	Common Suffix/Prefix (Systematic)
		Hydrocarbons		
Alkanes	RH	CH_3CH_3	ethane	-ane
Alkenes	$RR'C{=}CR''R'''$	$H_2C{=}CH_2$	ethylene (ethene)	-ene
Alkynes	$RC{\equiv}CR'$	$HC{\equiv}CH$	acetylene (ethyne)	(-yne)
Arenes	ArH[a]		benzene	-ene

ACCURACY, TRUENESS, AND PRECISION

- **Accuracy** — refers to the closeness of individual values to a known quantity
- **Trueness** — refers to the closeness of mean value (after several replications) to a known quantity
- **Precision** — refers to the closeness of individual values with each other



UNIT CONVERSION

Mass & Weight
1Kg = 1000g = 2.205 pounds
1 gram = 1000 mg
1 pound = 453.59 grams
1 amu = 1.6606 X10^{-24} grams
1 gram = 6.022 X 10^{23} amu
1 ton = 2000 pounds
16 ounces = 1 pound

Length
1 inch = 2.54cm
1 meter = 100 cm = 39.7 inches
1 yard = 0.9144 meters
1 mile = 1.6093 kilometers
1 kilometer = 1000 meters = 0.621371 miles
1 Angstrom = 1.0 X10-10 meters = 1.0X10^{-8} cm
1 troy ounce = 31.3 g

1 foot = 12 inches

Volume
1 liter = 0.001 cubic meters (M^3)
1 liter = 1000 cm^3 = 1000 mL
1 liter = 1.056 quarts
1 quart = .94631 liter
1 mL = 0.001 liters = 1 cm^3
1 ft^3 = 7.475 gallons = 28.316 liters
1 cup = 8 ounces
1 quarts = 4 cups = 2 pints
4 quarts = 1 gallon
1 ounce = 29.57cm^3 or mL

Metric Conversions		
Unit	Abbr.	Meaning (Example: 1 gram = 10^{-3} kg)
Mega-	M	10^6
kilo-	k	10^3
hecto-	h	10^2
deca-	dk	10^1
deci-	d	10^{-1}
centi-	c	10^{-2}
milli-	m	10^{-3}
micro-	μ	10^{-6}
nano-	n	10^{-9}

UNIT CONVERSION

- Celsius to Fahrenheit: $°F = (9/5 * °C) + 32$

  $°C \rightarrow °F$
- Fahrenheit to Celsius: $°C = (5/9) * (°F - 32)$

  $°F \rightarrow °C$
- Celsius to Kelvin: $K = °C + 273$

  $°C \rightarrow K$
- Kelvin to Celsius: $°C = K - 273$

  $K \rightarrow °C$

DIMENSIONAL ANALYSIS

Dimensional analysis refers to the study of the relationship between known physical quantities and various measurement units in accord to their base quantities.

To approach conversion problems via dimensional analysis,

- Start with the number and unit that was provided;
- Cancel out the unit by placing it to the denominator of the supposed multiplier.
- Fill in with the appropriate conversion factor and simplify.

DIMENSIONAL ANALYSIS

Sample Problem

Convert 144 inches to feet.

Length
1 inch = 2.54cm
1 meter = 100 cm = 39.7 inches
1 yard = 0.9144 meters
1 mile = 1.6093 kilometers
1 kilometer = 1000 meters = 0.621371 miles
1 Angstrom = 1.0 X10-10 meters = 1.0X10^{-8} cm
1 troy ounce = 31.3 g
1 foot = 12 inches

$$144 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}} = \mathbf{12\ ft}$$

EXPRESSION OF CONCENTRATION

Concentration is defined as quantity of a solute that is contained in a particular quantity of solvent or solution. There are different means to express concentration which are as follows:

- **Molarity (M)**, number of moles (n) per liter of solution

$$\textbf{Molarity}\ (\mathrm{M}) = \frac{\textbf{moles of solute}}{\textbf{liters of solution}}$$

EXPRESSION OF CONCENTRATION

- **Molality (m)**, number of moles (n) per kilograms of solvent

$$\textbf{Molality } (m) = \frac{\textbf{moles of solute}}{\textbf{kilograms of solvent}}$$

- **Mole fraction (χ)**, moles of component per total moles of all components

$$\textbf{Mole fraction } (\chi) = \frac{\textbf{moles of component}}{\textbf{total moles of all components}}$$

EXPRESSION OF CONCENTRATION

- **Percent by mass (%w/w)**, mass of a component of a solution per total mass of solution

$$\textbf{percent by mass } (\%w/w) = \frac{\textbf{mass of component}}{\textbf{total mass of solution}}$$

- **Percent by volume (%v/v)**, volume of a component of a solution per total volume of solution

$$\textbf{percent by volume } (\%v/v) = \frac{\textbf{volume of component}}{\textbf{total volume of solution}}$$

CHEMICAL HANDLING AND SAFETY

- **Good Measurement Practices (GMP)**

These are practices for maintaining, calibrating, and utilizing equipment and instrumentation.

- **Standard Operations Procedure (SOP)**

These are directions for analyzing a specific sample such as its processing in the laboratory as well as standardization and data analysis.

- **Protocol for Specific Purpose (PSP)**

This contains the most detailed descriptions on the ideal laboratory proceedings thus needing to be validated by an esteemed agency sponsoring a particular analysis.

CHEMICAL HANDLING AND SAFETY

- **Good Laboratory Practices (GLP)**

These practices describe the general laboratory operatioms that one must adhere to in any analysis, including,

  - Recording of data and maintaining records;
  - Using chain-of-custody forms for samples;
  - Specifying and/or purifying chemical reagents;
  - Preparing commonly used reagents;
  - Cleaning and calibrating glassware;
  - Training laboratory personnel; and
  - Maintaining laboratory facilities and equipment

CHEMICAL HANDLING AND SAFETY

Safety Data Sheets (SDS)

It refers to a document containing information related to occupational safety in terms of usage of various substances in the laboratory. This looks like a catalogue with necessary details about a chemical species including its properties, hazards, and precautions.

MATERIAL SAFETY DATA SHEET
ETHYLENE DICHLORIDE

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT IDENTIFIER: **ETHYLENE DICHLORIDE**
RECOMMENDED USAGE: Cracking to produce Vinyl Chlorine Monomer

MANUFACTURER:
PT ASAHIMAS CHEMICAL
Ds Gunung Sugih, Jalan Raya Anyer Km-122
Cilegon 42447 Banten - Indonesia
Tel: +62 254 601252
Fax: +62 254 602027
Contact Department: CVT Department
EMERGENCY PHONE NUMBER: +62 254 601252

SECTION 2 HAZARDS IDENTIFICATION

GHS Classification:

Health	Environmental	Physical
Acute Toxicity - Category 3 Eye Corrosion - Category 2A Skin Corrosion - Category 2 Skin Sensitization - Category 1 Mutagenicity - Category 2 Carcinogenicity - Category 2 Reproductive/Developmental - Category 2 Target Organ Toxicity (Repeated) - Category 1	Aquatic Toxicity: • Acute Category 4 • Chronic Category 4	Substance explosive- Category 1 Flammable liquid, Category 2

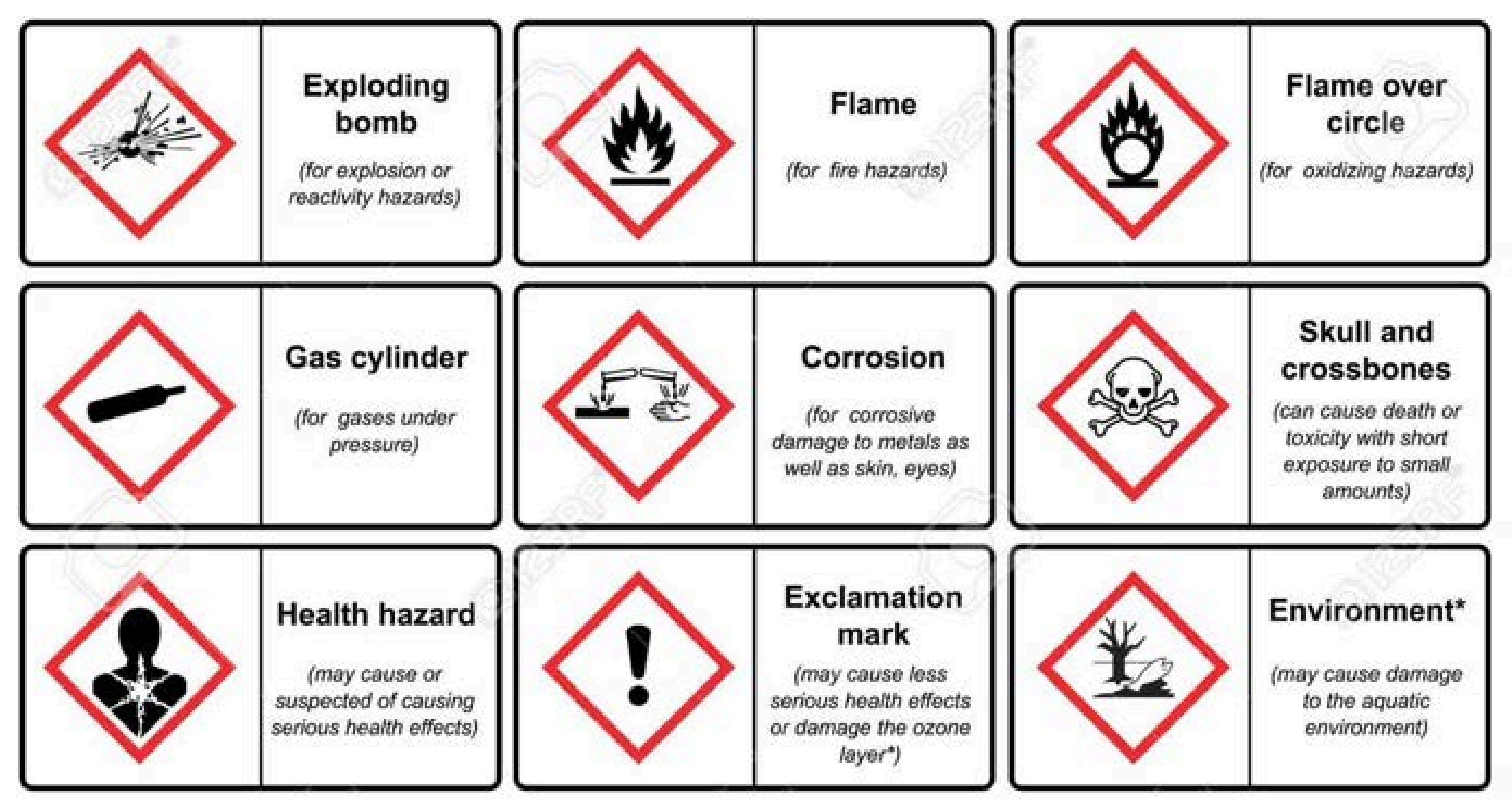
GHS Label:
Symbols: Flammable liquid, skull and crossbones, and health hazard

Hazard Statements	*Precautionary Statements*
DANGER! FLAMMABLE LIQUID Fatal if inhaled. Avoid to be swallowed. Causes severe skin burns and eye damage. Can cause blindness, permanent scarring and death. Toxic if swallowed and in contact with skin Suspected of damaging the unborn child. Suspected of causing genetic defects. May cause damage to cardiovascular, respiratory, nervous, and gastrointestinal systems and liver and blood through prolonged or repeated exposure. Harmful to aquatic life.	Do not breathe mist/vapors. Keep container tightly closed. Wear protective gloves and eye/face protection. Store container tightly closed in cool/ well-ventilated place. Wash thoroughly after handling.

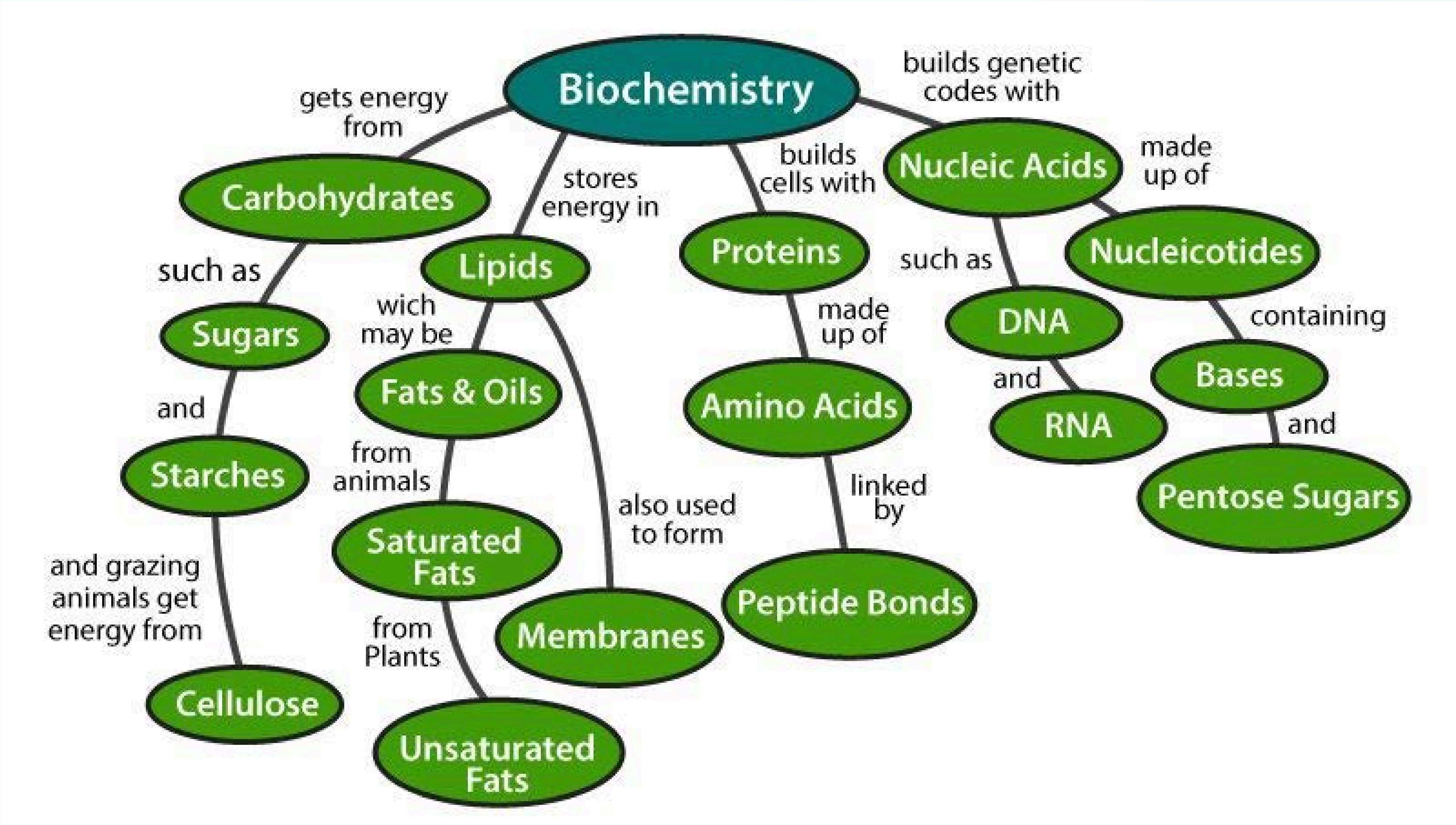
CHEMICAL HANDLING AND SAFETY

GHS Classifications

The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) can classify chemicals by types of hazards.



BIOMOLECULAR SUBSTANCES



PHOTOSYNTHESIS AND RESPIRATION

Photosynthesis

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

Respiration

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

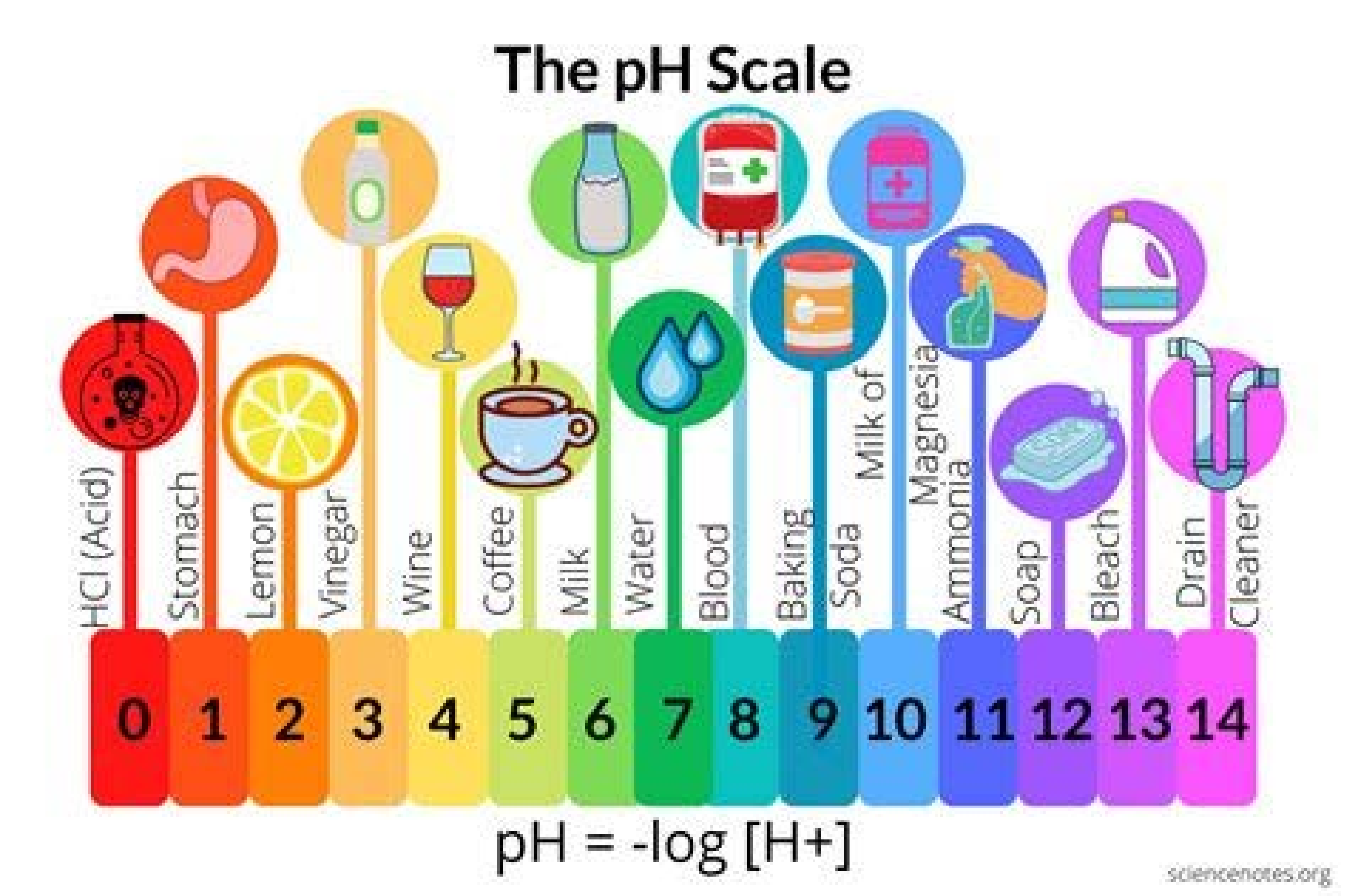
ACID AND BASE STRENGTH

Different chemical species have assigned pH and pOH values, and said quantities are being utilized due to the small hydronium and hydroxide ion concentration values being recorded in solutions.

pH refers to the measurement of acidity of a solution, while in reverse comes **pOH** or the measurement of a solution's basicity.

If **pH + pOH = 14** based on the scale, one may calculate for either pH or pOH of a compound given pertinent information.

ACID AND BASE STRENGTH



ACID AND BASE STRENGTH

6 Strong Acids		6 Strong Bases	
$HClO_4$	perchloric acid	$LiOH$	lithium hydroxide
HCl	hydrochloric acid	$NaOH$	sodium hydroxide
HBr	hydrobromic acid	KOH	potassium hydroxide
HI	hydroiodic acid	$Ca(OH)_2$	calcium hydroxide
HNO_3	nitric acid	$Sr(OH)_2$	strontium hydroxide
H_2SO_4	sulfuric acid	$Ba(OH)_2$	barium hydroxide

ACID-BASE EQUILIBRIA

Chemical equilibria is defined as a state where the concentration of reactants and products remains unchanged. This can also be described as a phenomena where the forward and backward reactions are of equal rates (as expressed by a double-headed, reversible arrow, $\rightleftharpoons$).

Acid-base equilibria, as its name suggests, is a study on the equilibrium of acid-base reactions, in which protons are exchanged between <u>donors (acids)</u> and <u>acceptors (bases)</u>.

A conjugate acid-base pair, meanwhile, is composed of two species in an acid-base equilibrium, with a difference of only one proton count.

ACID-BASE EQUILIBRIA

For the reaction below,

$$NH_3\,(aq) + H_2O\,(l) \rightleftharpoons NH_4^+\,(aq) + {}^-OH\,(aq)$$

Ammonia, as a base, accepts an H^+ from H_2O, which acted as an acid. This led to the formation of NH_4^+ and ^-OH.

The conjugate acid-base pairs are as follows:

- **H_2O** (acid) — **^-OH** (conjugate base)
- **NH_3** (base) — **NH_4^+** (conjugate acid)

ACID-BASE EQUILIBRIA

For the reaction below,

$$NH_3\ (aq) + H_2O\ (l) \rightleftharpoons NH_4^+\ (aq) + {}^-OH\ (aq)$$

Meanwhile, the expression for the equilibrium reaction can be written as,

$$K_b = \frac{[NH_4^+]\ [{}^-OH]}{[NH_3]}$$

In writing equilibrium reactions, consider the following: **acid/base strength**, and **phases of the chemical species** (solid/liquid species shall not be included in the expression)

GAS LAWS

Boyle's Law
($V \propto 1/P$)

$$P_1V_1 = P_2V_2$$

Charles' Law
($V \propto T$)

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Gay-Lussac's Law ($P \propto T$)

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

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

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

GAS LAWS

Ideal Gas Law

$$PV = nRT$$

where,

P = pressure (atm)

V = volume (L)

n = number of moles (mol)

R = ideal gas constant = 0.082056 L·atm/mol·K

T = temperature (K)

GAS LAWS: Example

A 10.0 L cylinder contains 500 g of methane. Calculate its pressure at 27°C using ideal gas equation.

Given:

- **volume** = 10.0 L
- **mass of CH_4** = 500 g
- **temperature** = 27°C + 273.15 = 300.15 K
- **ideal gas constant (R)** = 0.082056 L·atm/mol·K
- **a** = 2.273 L^2·atm/mol^2
- **b** = 0.0430 L/mol

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$$500 \text{ g } CH_4 \times \frac{1 \text{ mol } CH_4}{16 \text{ g } CH_4}$$

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Convert 500 g of methane into n moles first (MW of CH ≈ 16 g/mol).

$$500 \text{ g } CH_4 \times \frac{1 \text{ mol } CH_4}{16 \text{ g } CH_4} = \mathbf{31.25\ moles}$$

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From **PV = nRT**,

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From **PV = nRT**,

$$P = \frac{nRT}{V}$$

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A 10.0 L cylinder contains 500 g of methane. Calculate its pressure at 27°C using ideal gas equation.

From **PV = nRT**,

$$P = \frac{nRT}{V} = \frac{(31.25\ \text{mol})\ (0.082056\ \text{L·atm/mol·K})\ (300.15\ \text{K})}{(10.0\ \text{L})}$$

GAS LAWS: Example

A 10.0 L cylinder contains 500 g of methane. Calculate its pressure at 27°C using ideal gas equation.

From **PV = nRT**,

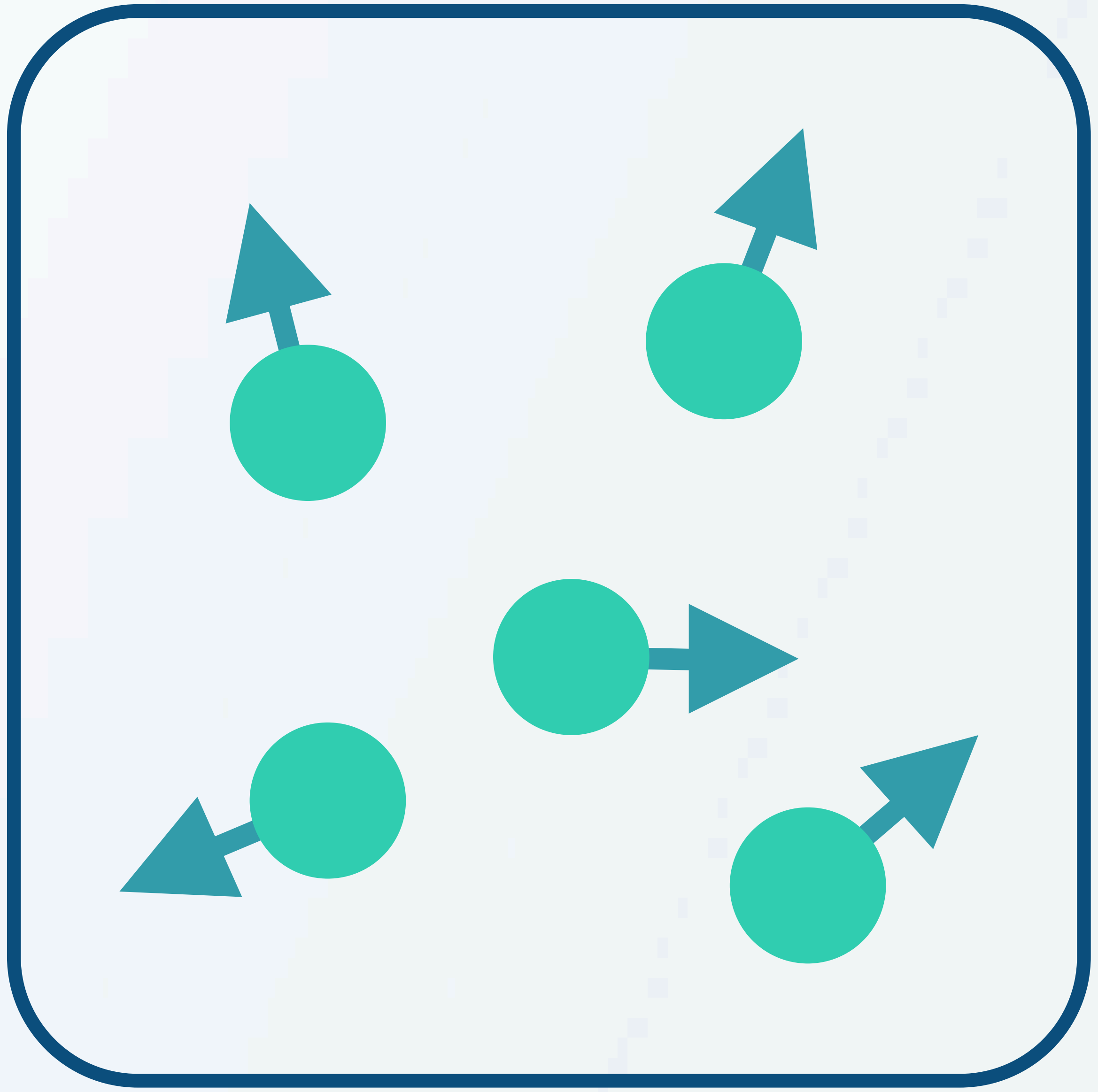
$$P = \frac{nRT}{V} = \frac{(31.25\ \text{mol})\ (0.082056\ \text{L·atm/mol·K})\ (300.15\ \text{K})}{(10.0\ \text{L})}$$

$$\mathbf{P = 76.96596375\ atm \approx 77\ atm}$$

KINETIC MOLECULAR THEORY

The **Kinetic Molecular Theory** states that,

- Gas molecules are widely separated in space;
- Gas molecules are in constant, rapid, and straight-line motion;
- Gas molecules' kinetic energy is directly proportional to temperature; and
- Attractive forces between gas molecules are insignificant.



PHASE CHANGES