CHEMICAL NOMENCLATURE & TYPES OF CHEMICAL REACTIONS

* Relate names to formulas of molecular compounds and vice versa
* Relate names to formulas and charges of simple ions and vice versa
* Combine simple ions to write formulas and names of some ionic compounds
* Balance chemical equations
* Recognise and describe different types of chemical reactions

[NOMENCLATURE]

the process of naming chemicals — standardised by IUPAC!

1 Ionic compound

metal cation (+ve ion) + non-metal anion (-ve ion) — electrostatic attraction

2 Covalent compound

non-metal + non-metal — sharing of valence electrons (outermost)

3 Binary compound

element A + element B (two elements only)

Binary Ionic Compounds

Type I

(for metal cations that have only one possible charge)

Sodium chloride, NaCl (Na^+, Cl^-)

simple anions end with suffix -ide — VS — complex ions

charge of cation & anion cancel out

Li^+ O^{2-} → Li_2O (subscript)

Type II

(for metal cations that have more than 1 possible charge) — transition elements

Fe^{2+} → Iron (II) — capital roman numeral

complex ions
- charged molecule (two/more atoms bonded together)
- mostly anions

POLYATOMIC IONS

add H^+

$S^{2-} \rightarrow HS^-$

$SO_4^{2-} \rightarrow HSO_4^-$

increasing number of oxygen atoms:

ClO_4^- perchlorate

ClO_3^- chlorate

ClO_2^- chlorite

ClO^- hypochlorite

Binary Covalent Compounds

(no ions involved)

prefixes indicate number of atoms

1 mono — never used for 1st element
2 di
3 tri
4 tetra
5 penta
6 hexa
7 hepta
8 octa
9 nona
10 deca

ie. CO_2

✗ monocarbon dioxide

✓ carbon dioxide

P_4O_{10} — omit "a"

✗ tetraphosphorus decaoxide

✓ tetraphosphorus decoxide

Binary Acids

Acids — substance that produces H^+ ions in water

hydro____ic acid

hydrochloric acid

hydrobromic acid

Oxy-acids

"ate"	"ite"
NO_3^- nitrate	NO_2^- nitrite
____ ic acid	____ ous acid
nitric acid	nitrous acid

CHEMICAL NOMENCLATURE & TYPES OF CHEMICAL REACTIONS

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CHEMICAL EQUATION

conditions of reaction
heating, catalyst
(Δ) (Pt)

Reactants Products

$$2H_2(g) + O_2(g) \xrightarrow{\Delta} 2H_2O(l)$$

coefficient
relative number of molecules

state of substance
gas (g) liquid (l)
solid (s) aqueous (aq)

Balanced equations

atoms cannot be gained / lost / changed
number of atoms in reactants = products

Types of Chemical Reactions

A Combination

$A + B \rightarrow AB$

B Decomposition

$AB \rightarrow A + B$

C Single Replacement

$AB + C \rightarrow A + BC$

D Double Replacement

$AB + CD \rightarrow AD + CB$

E Combustion

$AH_4 + 2O_2 \rightarrow AO_2 + 2H_2O$
$B + O_2 \rightarrow BO_2$

reaction with oxygen
usually products: an oxide, water, heat, energy

incomplete combustion = carbon monoxide

CALCULATIONS WITH CHEMICAL FORMULAS AND EQUATIONS

- Calculate molecular weight and formula weight
- Know the mole concept and Avogadro's number
- Find molar mass of elements and compounds
- Convert between mass and moles
- Calculate number of particles
- Calculate mass and mass percentage of elements
- Find empirical formula from mass percentage
- Obtain molecular formula from molar mass
- Interpret chemical equation at molecular, molar and mass level
- Calculate mole, mass, number of molecules / atoms based on given chemical equation and based on the limiting reagent determined
- Find theoretical, actual and percentage yield

Molecular weight – molecular substance
Formula weight – ionic substance

} sum of all atomic weight (amu) – from PTE; atomic mass unit

Mole (mol)
└ the amount of matter that contains as many entities (atoms, molecules, ions) as the number of atoms in 12g of carbon

Mass of ^{12}C = 12 amu

1 amu = $\frac{1}{12}$ mass of ^{12}C

Avogadro's number, N_A
6.02×10^{23} = 1 mol

$$\boxed{\text{No of mol (mol)} = \frac{\text{No of particles}}{\text{Avogadro's number (mol}^{-1})}}$$

Molar mass ($g\ mol^{-1}$)
└ mass of one mole of substance
= atomic, molecular, formula weight (amu)

$$\boxed{\text{No of mol (mol)} = \frac{\text{Mass (g)}}{\text{Molar mass (g mol}^{-1})}}$$

[PERCENT COMPOSITION] – percentage by mass of of each element

$$\boxed{\text{Mass\% of A} = \frac{\text{mass of A}}{\text{mass of compound}} \times 100\%}$$

[EMPIRICAL FORMULA] – the simplest formula of a compound written with smallest integer subscripts

Molecular formula = (Empirical formula)$_n$

$n = \frac{\text{molecular weight}}{\text{empirical weight}}$

* Ascorbic acid (Vitamin C)

40.92% C
4.58% H
54.50% O
} assume 100g

Empirical formula: $C_3H_4O_3$

Element	C	H	O
Mass by percentage	40.92	4.58	54.50
No of mol	$\frac{40.92}{12.01} = 3.407$	$\frac{4.58}{1.008} = 4.58$	$\frac{54.50}{16.00} = 3.406$
Ratio	$\frac{3.407}{3.406} = 1$	$\frac{4.58}{3.406} = 1.33$	$\frac{3.406}{3.406} = 1$
Simplest ratio	1 × 3 = 3	1.33 × 3 = 4	1 × 3 = 3

CALCULATIONS WITH CHEMICAL FORMULAS AND EQUATIONS

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Interpreting Chemical Equations

$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

(Haber process)

Mass: 28.0g of N_2 reacts with 3 × 2.02g (6.06g) of H_2 to produce 2 × 17.0g (34.0g) of NH_3.

Molecular: one N_2 molecule reacts with three H_2 molecules to produce two NH_3 molecules

Molar: one mole of N_2 reacts with three moles of H_2 to produce two moles of NH_3

Ratio!

$1 \text{ mol } N_2 = 2 \text{ mol } NH_3$

$4 \text{ mol } N_2 = 8 \text{ mol } NH_3$

Theoretical yield

L amount of product calculated with the assumption that the reaction proceeded to completion // when all limiting reactant has reacted

Actual yield

L Experimentally measured yield of the product of a reaction. often less than the theoretical yield

Percent yield

$$\frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100\%$$

Limiting Reactant (entirely consumed in a reaction)

Excess Reactant (not completely consumed)

Given:
10.0g H_2
10.0g N_2

1 Write a balanced equation

$N_2 + 3H_2 \longrightarrow 2NH_3$

2 Convert mass to moles

$$\left.\begin{aligned} \frac{10.0g\ N_2}{(14.0g)(2)} &= 0.357 \text{ mol of } N_2 \\ \frac{10.0g\ H_2}{(1.01g)(2)} &= 4.95 \text{ mol of } H_2 \end{aligned}\right\} \text{amount HAVE}$$

3 Calculate number of moles used

$$\frac{4.95 \text{ mol } H_2}{3 \text{ mol } H_2} \times 1 \text{ mol } N_2 = 1.65 \text{ mol of } N_2$$

amount NEEDED

$$\frac{0.357 \text{ mol } N_2}{1 \text{ mol } N_2} \times 3 \text{ mol } H_2 = 1.07 \text{ mol of } H_2$$

4 Compare "moles have" with "moles needed"

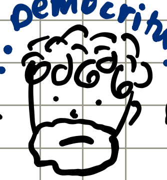
N_2 have < N_2 needed ⇒ limiting

H_2 have > H_2 needed ⇒ excess

THE STRUCTURE OF ATOMS I: SUBATOMIC PARTICLES

HISTORY!

1. Democritus



ATOMOS (greek for indivisible)

smallest piece = ATOM!

matter cannot be broken down at some point

2. John Dalton

Father of Atomic Theory (the indivisible spheres)

- invisible
- indivisible
- solid

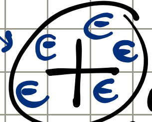
} sphere

1. all matter is made up of indivisible and indestructible atoms
2. all atoms of an element have the same mass and physical properties
3. different elements = different physical & chemical properties
4. atoms combine in simple whole-number ratios to form compounds
5. chemical reactions
   - L combination
   - L separation
   - L rearrangement

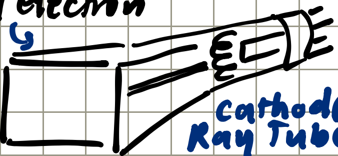
3. J.J. Thomson

ELECTRONS

- plum-pudding model
- negatively-charged electron
- isotope

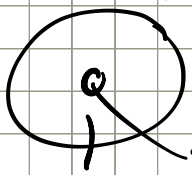


electrons spread out



4. Rutherford

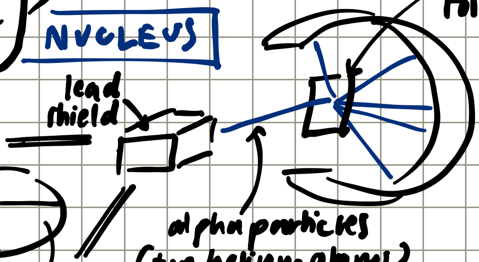
NUCLEUS



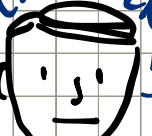
atoms are mostly empty space

-ve electrons + protons!

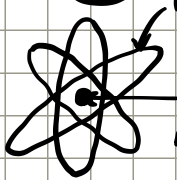
+ve nucleus (dense, 99.9% of mass)



5. Chadwick



NEUTRON



ATOMS — protons, neutrons, electrons } subatomic particles

L smallest unit of an element

Z ATOMIC NUMBER (proton number)

L integer equal to the number of protons in the nucleus of an atom

A MASS NUMBER (nucleon number)

L integer equal to the sum of the number of protons and neutrons in the nucleus

NUCLEAR SYMBOL

$^{A}_{Z}X$

IONS

- L anion (-ve) — add e^-
  - electron > proton
- L cation (+ve) — remove e^-
  - proton > electron

ISOTOPES

L atoms of the same element with the same number of protons but different number of neutrons

ISOTOPIC ABUNDANCE

% L percentage of that isotope found in the sample of element

$^{35}Cl : ^{37}Cl$

3 : 1

75% 25%

RADIOISOTOPES

high energy

- cobalt-60 (treat cancer)
- plutonium-238 (heart pacemaker)
- carbon-14 (radiochemical dating)

- Describe the history of an atom
- Describe Dalton's theory of atoms
- Describe J.J. Thomson's experimental evidence for the existence of electrons
- Describe Rutherford's scattering experiments and show how the results of the experiments imply the existence of atomic nuclei
- State the definitions of an atom, subatomic particles, and isotopes
- Give appropriate info of atomic number, number of protons, number of electrons, number of neutrons, and mass number of an atom/ion
- Calculation of atomic weight
- Understanding of mass spectrometry

	Symbol	Charge	Relative mass
Proton (in nucleus)	$^{1}_{1}H/p$	+1	1
Neutron (in nucleus)	$^{1}_{0}n/n$	0	1
Electron	$^{0}_{-1}e/e^-$	-1	0

same chemical properties (electrons)

diff. physical properties (mass)

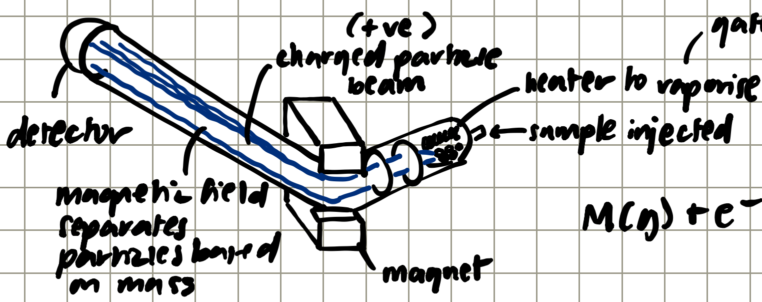
THE STRUCTURE OF ATOMS I: SUBATOMIC PARTICLES

Atomic MASS	Atomic WEIGHT
mass of 1 atom / isotope	average weight of an element (incl. isotopes & abundance)
mass of neutrons + protons	relative mass x fractional abundance

Br-79	Br-81
51%	49%
78.92 amu	80.92 amu

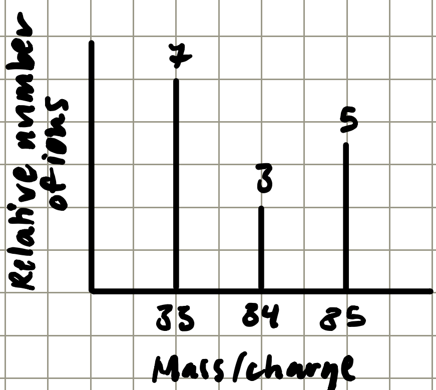
Atomic weight
$= 78.92(0.51) + 80.92(0.49)$
$= 79.9$

MASS SPECTROSCOPY



always positive!

$M(g) + e^- \longrightarrow M^+(g) + 2e^-$ } ionise



Element Y

Ion: Y^+

Isotopes: $^{33}Y^+$, $^{34}Y^+$, $^{35}Y^+$

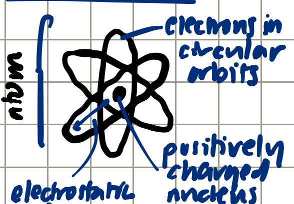
Relative abundance: $7/15 \times 100\%$, ...

Average atomic mass: 33.8667 amu

THE STRUCTURE OF ATOMS II: THE ELECTRONIC STRUCTURE OF ATOMS

- Understand the differences and relations between Bohr's Model and Quantum Mechanic model
- Define quantum numbers and understand the principles of quantum numbers
- Recall usual order of their relative energies and describe the shape of orbitals
- Define Aufbau Principle, the Pauli Exclusion Principle and Hund's Rule
- Write the electron configurations of an atom in orbital box notations, simplified notations and noble gas notation
- Determine the relationship between quantum numbers, valence electron and the periodic table

NIELS BOHR



✗ only applies to simplest atom (Hydrogen, 1 proton, 1 electron)

LOUIS DE BROGLIE

"matter has wave-like properties"

ERWIN SCHRÖDINGER's

wave equation: electrons – wave, particles

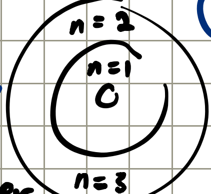
↳ occupy 3D space (electron cloud)

ORBITAL

↳ the probability of finding the electron in a specific place around the nucleus } determined by QUANTUM NUMBERS (address of electrons)

1 Principal Quantum Number, n

($n = 1, 2, 3, 4 \ldots$) energy level of electrons



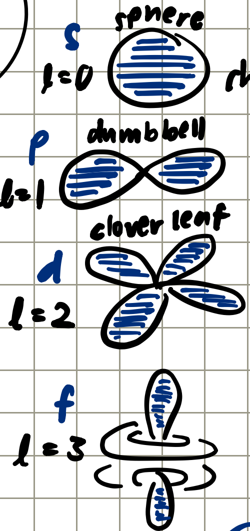
↑n, ↑e (further from nucleus)

number of shells = period!

max no of $e^- = 2n^2$

2 Angular Momentum Quantum Number, l

↓ shape of sublevel within an energy level



$l \leq n-1$

when $n = 1$, $l = 0$ – s

when $n = 4$, $l = 0, 1, 2, 3$ (s, p, d, f)

3 Magnetic Quantum Number, m_l

each orbital max 2 electrons

orbital orientation within sublevel

$-l \leq m_l \leq l$

l	m_l	number of orbitals / orientations
0	0	1
1	-1 0 1	3
2	-2 -1 0 1 2	5
3	-3 -2 -1 0 1 2 3	7

4 Electron Spin, m_s

$m_s = \pm 1/2$

$+1/2$ ↑↓ $-1/2$

$\boxed{3d^8}$

$n = 3$ $m_l = 0$

$l = 2$ $m_s = -1/2$

↑↓ ↑↓ ↑↓ ↑ ↑
-2 -1 0 1 2

O (Z=8)

Pauli Exclusion Principle

each orbital hold max 2 electrons with opposite spin

Aufbau Principle

electrons fill lower energy orbitals before higher ones

Hund's Rule

one electron is added into each subshell before two electrons are added

↑↓ ↑↓ ↑
1 4 2 5 3

Aufbau Diagram

1s
2s 2p
3s 3p 3d
4s 4p 4d 4f
5s 5p 5d 5f

ELECTRON CONFIGURATION

Simplified notation

$1s^2 2s^2 2p^4$

Orbital notation

[↑↓] [↑↓] [↑↓|↑|↑]
1s 2s 2p

Noble gas notation

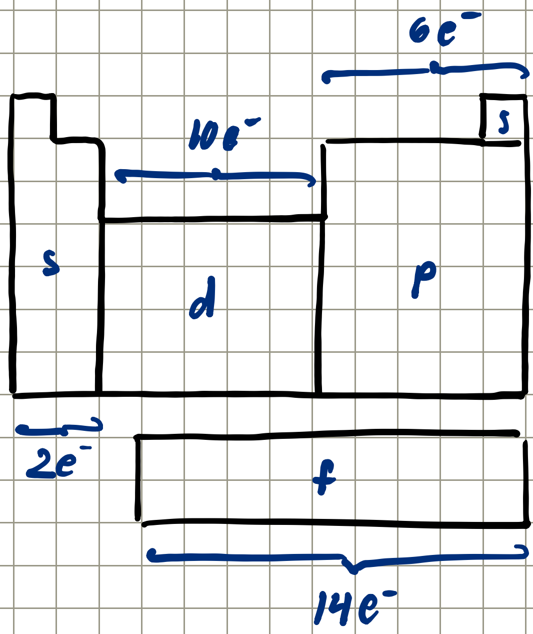
$[He] 2s^2 2p^4$

THE STRUCTURE OF ATOMS II:
THE ELECTRONIC STRUCTURE OF ATOMS

Exceptional cases!

Chromium ($Z=24$)
✓ $4s^1\ 3d^5$ ✗ $4s^2\ 3d^4$
Copper ($Z=29$)
✓ $4s^1\ 3d^{10}$ ✗ $4s^2\ 3d^{10}$
full half full

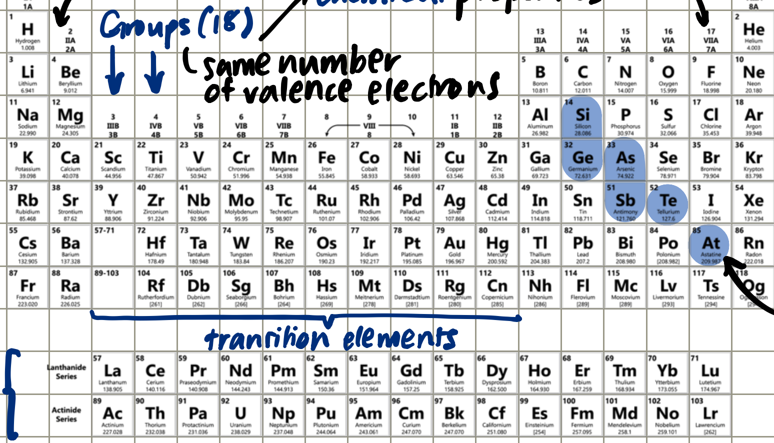
Valence Electrons
- electrons on outer shell
- determine chemical properties



CHEMICAL PERIODICITY: PERIODIC PROPERTIES OF THE ELEMENT

(1) In the periodic table, elements are arranged in order of atomic number (proton) × atomic weight!

(2) metals on the left
non-metals on the right



Metals
- lustrous (shiny)
- good electricity & heat conductor
- malleable (sheets) & ductile (wire)
- solid
- ≤3 valence e^-
- form cations
- form ionic comp.

Non-metals
- not lustrous
- poor electricity & heat conductor
- low melting point
- low density
- solid / liquid / gas

physical property

- ≥4 valence e^-
- form anions
- form ionic & molecular comp.

chemical property

Metalloids
- semimetal
- both metal & non-metal properties

Periodicity
└ similarities in behaviour and reactivity due to similar outer shell electron config.
└ atomic radius, ionic size, ionization energy

Electronegativity
└ measure of an atom's ability to attract and hold onto electrons

↑ electronegativity, ↑ e^- attraction

Period →
↑ nuclear charge
↓ size

Group ↑
shielding effect
↑ size

* F has highest electronegativity

Atomic radius

* electrons between valence e^- & nucleus shield the valence e^-

$Z_{eff} = Z - S$
(Z: no of protons; S: inner core e^-)

Period ←
↑ protons,
↑ nuclear charge
↑ nuclear attract
↓ size

Group ↓
↑ shells
valence e^- further
shielding effect *
↓ nuclear attract
↑ size

Ionic size
cations < neutral $e^- < p$
anions > neutral $e^- > p$

Ionization energy
↑ Energy required to remove an electron from a gaseous atom

$M(g) + IE \rightarrow M^+(g) + e^-$

↑ . nuclear charge
↓ . size of atom
↓ . shielding effect
↓ . e-e repulsion

Period →
↑ nuclear charge
↓ size
hard to remove e^-
↑ IE

Group ↑
shielding effect
↑ e-e repulsion
↑ size
↓ IE

does not apply to

Mg > Al
$3s^2$ $3p^1$
experiences more shielding

P > S
$3p^3$ $3p^4$
more e-e repulsion

2nd IE: energy to remove 2nd e^-
> 1st IE, increases subsequently

IE1	IE2	IE3	IE4
736	1450	7740	10500

big jump

∴ element is in group 2

CHEMICAL BONDING & SHAPES OF MOLECULES

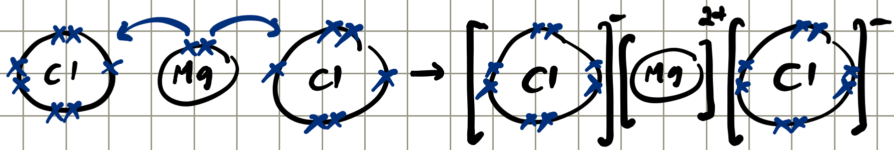
Noble gas structure — eight electrons in their outer energy levels (, or two for He!)
- L desirable structure for atoms } octet rule
- L can be achieved by loss or gain of electrons
  - L cation
  - L anion

Lewis Structure
(only valence e shown)

H ˣ• Cl :

- bonding pair (BP)
- non-bonding pair (NBP)

Ionic Bonding
metal + non-metal = ionic compound
↑ electrostatic attraction



- solid
- high melting point
- soluble in water
- electrolyte (conduct electric)

Covalent Bonding
sharing of electrons

single bond — CH_4: H ˣ• C •ˣ H (obey octet rule; H obey duplet rule)

double bond — :Ö::C::Ö:

- gas / liquid / solid
- low melting point
- soluble in organic solvent
- non-electrolyte

Steps!

	NH_3	CO_2
1. Decide central atom	N	C
2. Count valence electrons	$VE = (3 \times 1) + 5 = 8$	$VE = (2 \times 6) + 4 = 16$

3. Form sigma bonds (single bond) between central atom & surrounding atoms

H ˣ• N •ˣ H (with H below) O ˣ• C •ˣ O

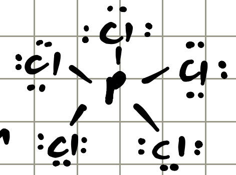
4. Remaining electrons as NBP

H ˣ• N̈ •ˣ H (with H below) :Ö ˣ• C •ˣ Ö:

5. To give C an octet, form pi bonds (double bond)

:Ö ˣ• C •ˣ Ö: → :Ö::C::Ö:

Exception to octet rule
- electron deficient
  - L B or Be — BF_3: only 6 electrons!
- odd electron
  - L NO or NO_2 — •N̈ ˣˣ Ö: radical / reactive
- valence shell expansion
  - L central atom > 8 VE (period 3 onwards)



Formal Charge
L the charge of an atom in any compound if the electrons are shared equally in a comp.

FC = VE − NBE − BP

$[:\ddot{O}-C\equiv N:]^-$

C : 4 − 4 − 0 = 0
O : 6 − 6 − 1 = −1
N : 5 − 5 − 0 = 0
} −1

closer to 0 = more stable

CHEMICAL BONDING & SHAPES OF MOLECULES

Electronegativity ⟷ Type of bond

0	0.4	1.7	3.3
Covalent		Ionic	
Non polar	Polar		

NH_3, N = 3, H = 2.1
3 − 2.1 = 0.9
∴ polar covalent

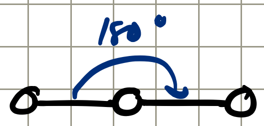
Valence **S**hell **E**lectron **P**air **R**epulsion — electron groups position themselves around the nucleus to minimize interactions

Steric Number = NBP + BP

Electron-pair geometry
↳ arrangement of structural electron pairs around the central atom

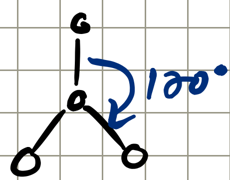
Molecular geometry
↳ 3D arrangement of atoms in a molecule (when central atom has lone pairs)

2



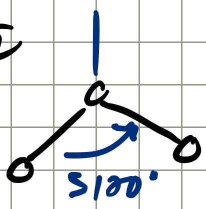
Linear

3



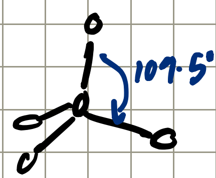
Trigonal planar

①



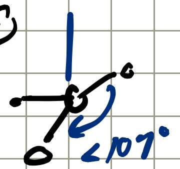
Bent

4



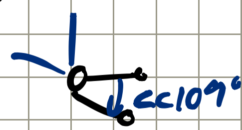
Tetrahedral

①



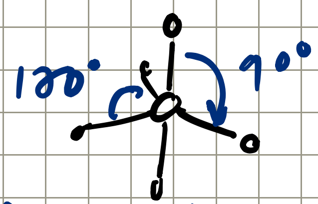
Trigonal pyramid

②



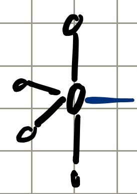
Bent

5



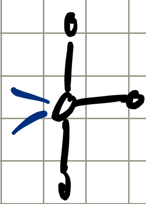
Trigonal bipyramidal (two pyramids)

①



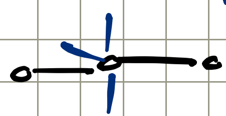
see-saw

②



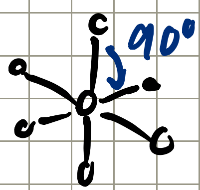
T-shaped

③



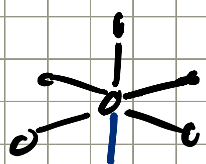
Linear

6



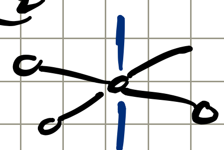
octahedral

①



Square pyramidal

②



Square planar

INTRODUCTION TO ORGANIC CHEMISTRY

obtained from living things → **Organic** vs **Inorganic** ← from non-living things

contains carbon!

Organic	Inorganic
covalent	ionic
gas / liquid	solid
low melting point	high melting point
insoluble in water	soluble in water
nonconductors	conductor in aqueous & molten

Carbon!

└ no ions, only covalent bonds!

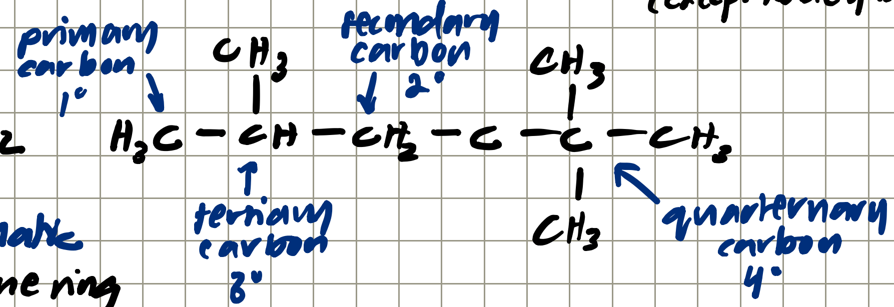
forms up to 4 → chains or rings

up to 4 to P, H, O, N, S & all non-metals (except noble gas)

Hydrocarbon

└ compounds containing only carbon and hydrogen

└ nonpolar, soluble in organic solvents



① Aliphatic

nonbenzenoid rings

- alkanes, alkenes, alkynes etc.

② Aromatic

benzene ring

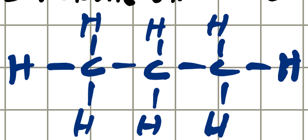
- benzene
- naphtalene } has smell

Molecular Representation

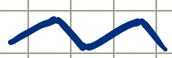
1 Condensed formula

$CH_3(CH_2)_3CH_3$

2 Kekule Structure

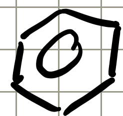


3 Skeletal Structure



Functional Group

(structural features that classifies compounds by reactivity / chemical behaviour

Alkane	C – C (single bond)
Alkene	C = C (double bond)
Alkyne	C ≡ C (triple bond)
Arene	 (benzene ring)
Alcohol / Phenol	–OH
Ether	–O–
Haloalkane	– halogen, –F, –Cl, –Br
Aldehyde	$-\overset{O}{\overset{\|}{C}}-H$
Ketone	$-\overset{O}{\overset{\|}{C}}-$
Carboxylic acid	–COOH
Ester	–COO–
Amine	$-NH_2$
Amide	$-CONH_2$

ALKANE, C_nH_{2n+2}

- non-polar
- tetrahedral
- suffix –ane

meth, dec, prop, but, pent, hex, hept, oct, non, dec

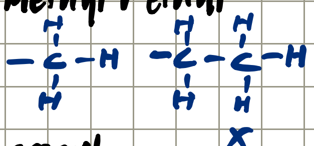
> 3 Carbons ⇒ > 1 molecular arrangement

Isomers
same number & kinds of atom different arrangement

remove one hydrogen

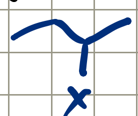
ALKYL, C_nH_{2n+1}

methyl & ethyl

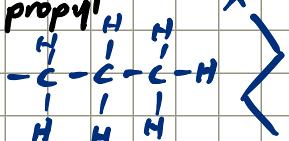


butyl

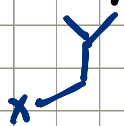
sec-butyl



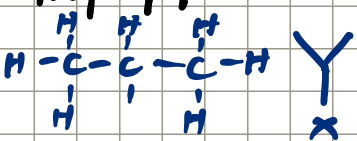
propyl



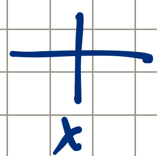
isobutyl



isopropyl



t-butyl

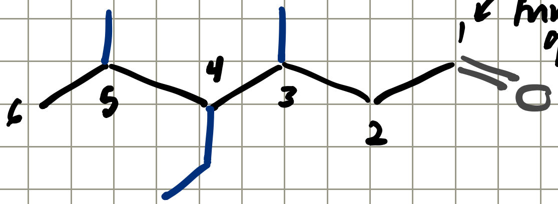


INTRODUCTION TO ORGANIC CHEMISTRY

[IUPAC Naming]

prefix parent suffix

start from functional group



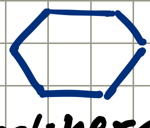
4-ethyl-3,5-dimethyldecanal

alphabetical (ignoring prefixes)

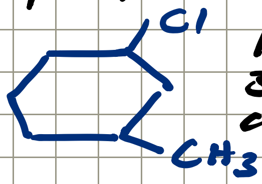
trimethyl, diethyl, sec-butyl
sec-butyl, diethyl, trimethyl

CYCLOALKANE

remove two hydrogens



cyclohexane



1-chloro-3-methylcyclohexane

Physical Properties of Alkanes

1. increase in melting / boiling point

$CH_4 \rightarrow C_4H_{10}$ gas
$C_5H_{12} \rightarrow C_{16}H_{34}$ liquid
$C_{16}H_{34}$ onwards solid

↑ size, ↑ surface area, ↑ Van der Waals

2. branched vs unbranched

boiling point of branched < unb
↓ surface area, ↓ Van der Waals

melting point of odd < even
↑ less tightly-packed

Reaction of Alkanes

1. Combustion

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

* Collect 22.0g CO_2 and 13.5g H_2O * 11.5g of sample

$$\frac{12.01}{44.01} \times 22.0g = 6.0gC = 0.5 \text{ mol } C$$

$$\frac{2.016}{18.016} \times 13.5g = 1.5gH = 1.5 \text{ mol } H$$

$$11.5g - 6.0g - 1.5g = 4g\,O = 0.25 \text{ mol } O$$

$C_{0.5}H_{1.5}O_{0.25}$
C_2H_6O

2. Halogenation

Alkane → Haloalkane

hydrogen atoms replaced with halogen atoms

>100°C or irradiated by UV

$$CH_4 + Cl_2 \xrightarrow{\text{heat or light}} CH_3Cl + HCl$$

Mechanism of Free Radical Substitution

1. Initiation

$$Br-Br \rightarrow Br^\cdot + Br^\cdot$$

2. Propagation

$$Br^\cdot + C_2H_6 \rightarrow HBr + {}^\cdot C_2H_5$$

$${}^\cdot C_2H_5 + Br-Br \rightarrow C_2H_5Br + Br^\cdot$$

3. Termination

$$Br^\cdot + Br^\cdot \rightarrow Br_2$$

$$Br^\cdot + {}^\cdot C_2H_5 \rightarrow C_2H_5Br$$

$${}^\cdot C_2H_5 + {}^\cdot C_2H_5 \rightarrow C_4H_{10}$$

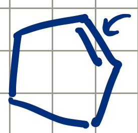
ORGANIC CHEMISTRY

Alkane – Saturated (max # of H)
Alkene } Unsaturated
Alkyne

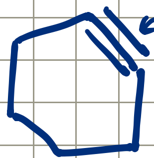
C_nH_{2n} Alkene & Cycloalkene C_nH_{2n-2}

C_nH_{2n-2} Alkyne & Cycloalkyne C_nH_{2n-4}

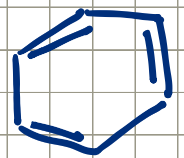
Aromatic hydrocarbon



—ene

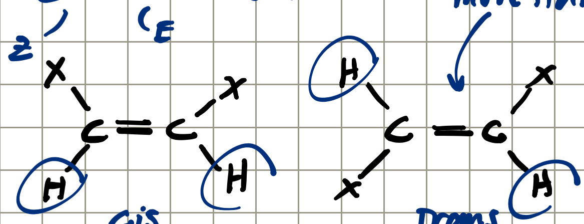


–yne



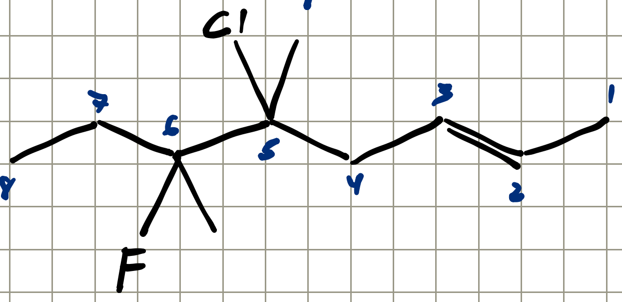
Cis-Trans Isomers

more stable!



eg. cis-1,2 dichloroethene

IUPAC Naming



5-chloro-6-fluoro-5,6-dimethyloct-2-ene

Reactions of Alkenes

* Electrophile
chemical compound that is attracted to electrons

* Electrophilic Addition

① $>C=C< + E^+ \rightarrow -\overset{E}{C}-C<^+$

pi electrons attack electrophile

② $-\overset{E}{C}-C<^+ + Nuc:^- \rightarrow -\overset{E}{C}-\overset{Nuc}{C}-$

nucleophile attacks carbocation

1 Hydrogenation forms alkanes
(add H)

$C=C$ or $C\equiv C$ $+ H-H \xrightarrow{\text{catalyst}} H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H$

Pt, Ni, Pd

2 Halogenation forms haloalkanes
(add Br or Cl) di- or tetra-

$>C=C< + X-X \rightarrow -\overset{X}{C}-\overset{X}{C}-$

carried out in a solvent

3 Hydrohalogenation forms haloalkanes
(add HCl, HBr or HI)

$>C=C< + H-X \rightarrow -\overset{X}{C}-\overset{X}{C}-$

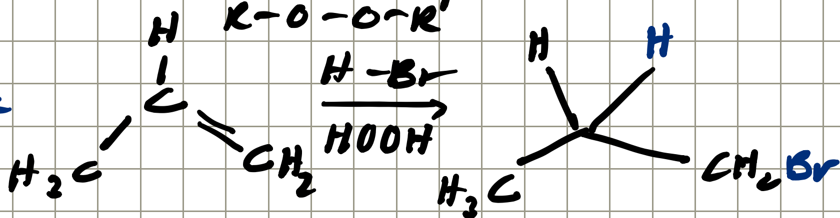
Markovnikov's Rule
H goes to C w most H
X goes to C w least H

$CH_2CH=CH_2 \xrightarrow{H-X}$ (unsymmetrical)

$\cancel{CH_3CHCH_2}$ (H, X)

CH_3CHCH_2 (X, H)

Anti-Markovnikov's Rule
if the reaction has peroxide R–O–O–R



4 Hydration forms alcohol
(add water)

$>C=C< + H-OH \xrightarrow{H^+} -\overset{H}{C}-\overset{OH}{C}-$

catalysed by a strong acid

5 Polymerisation forms polymers

(alkene) m → polyalkene

6 Hydroxylation
(with potassium permanganate) Baeyer's Reagent

$>C=C< \xrightarrow[H_2O]{KMnO_4} -\underset{OH}{C}-\underset{OH}{C}- + MnO_2$

purple → clear (decolourised); MnO_2 brown solid