Nomenclature

The language of chemistry

Assigning Oxidation States

The concept of oxidation numbers (or oxidation states) was devised as a simple way of keeping track of electrons in reactions. We use the following rules for assigning oxidation numbers:

Free Elements (Na, O_2, etc.)	**0**
Group 1 Elements in a compound[1]	**+1**
Group 2 Elements in a compound	**+2**
Group 3 Elements in a compound	**+3**
"O" in a compound[2]	**-2**
"F" in a compound	**-1**

[1]Exception to this rule occurs for hydrogen in hydrides (e.g. LiH, where the oxidation state of hydrogen is –1).

[2]Exception to this rule occurs in peroxides (e.g. H_2O_2, where the oxidation state of oxygen is –1).

***NOTE*:** **Three transition metals, Cd^{2+}, Zn^{2+} and Ag^{+}, are understood to exist in these oxidation states (numbers); therefore, Roman numerals are NOT included in parentheses. Also note that the mercury(I) ion is written as a diatomic ion (dimer): Hg_2^{+2}.**

Practice

Determine the oxidation state of each underlined atom:

$K\underline{Mn}O_4$, $\underline{Cl}O_4^-$, $\underline{S}_2O_3^{2-}$.

$K+Mn+4O = 0$ **$Cl + 4O = -1$** **$2S + 3O = -2$**

$1 + Mn + 4(-2) = 0$ **$Cl + 4(-2) = -1$** **$2S + 3(-2) = -2$**

$Mn = 8-1 = +7$ **$Cl = 8-1 = +7$** **$2S = -2 +6 = +4$**

$S = +2$

Self-study #6A

Give the oxidation state for the following:

A) $HClO$
B) $HClO_3$
C) WS_2
D) Na_2WO_4
E) $WOCl_4$
F) $H_3PW_{12}O_{40}$

Phosphotungstic acid

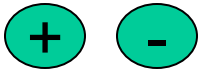
Chemical Bonds

Bonds

"glue"

Ionic

- **e- transfer**
- **Crystal lattice**
- ions



- Na + Cl → Na^+ Cl^-
- **"salts"**
- **very strong bonds generally between metals and non metals.**
- **Solids at room temp.**
- **Poor conductors of electricity in a solid state**

Covalent

- **sharing**
- **"molecules"**
- **hypothetical charge**
- **H + H → H H**
- **. orbital overlap**
- **Bonding e- are localized between two atoms**
- **Formed between two nonmetals**

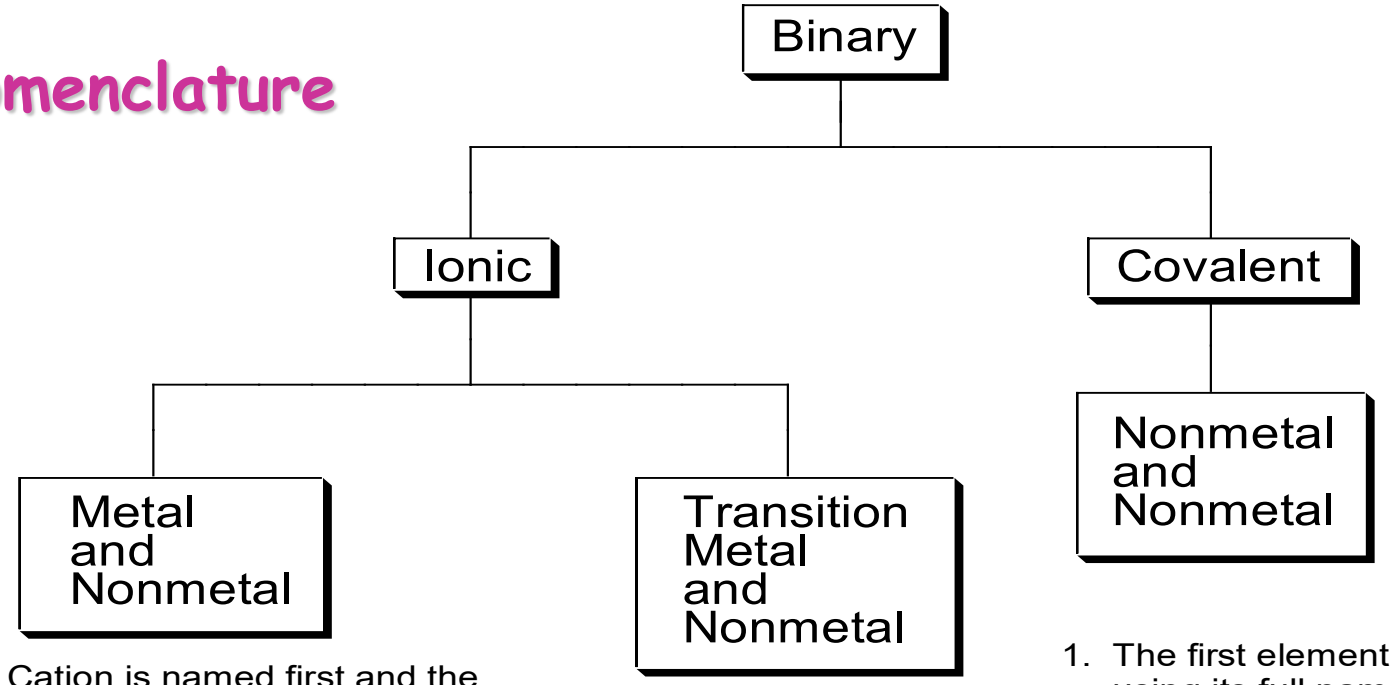
Metallic

- **"sea" of e-**
- **e- are delocalized.**

Common Polyatomic Ions – *YOU MUST MEMORIZE THESE*!!!

acetate	$C_2H_3O_2^-$	hydrogen phosphate	HPO_4^{2-}
ammonium	NH_4^+	hydrogen sulfate	HSO_4^-
carbonate	CO_3^{2-}	hydroxide	OH^-
chromate	CrO_4^{2-}	nitrate	NO_3^-
hypochlorite	ClO^-	nitrite	NO_2^-
chlorite	ClO_2^-	oxalate	$C_2O_4^{2-}$
chlorate	ClO_3^-	permanganate	MnO_4^-
perchlorate	ClO_4^-	peroxide	O_2^{2-}
cyanide	CN^-	phosphate	PO_4^{3-}
dichromate	$Cr_2O_7^{2-}$	sulfate	SO_4^{2-}
dihydrogen phosphate	$H_2PO_4^-$	sulfite	SO_3^{2-}
hydrogen carbonate	HCO_3^-	thiocyanate	SCN^-

Nomenclature



1. Cation is named first and the anion is named second.
2. Monatomic cation takes its name from the name of the element.
3. A monatomic anion is named by taking the first part of the element name and adding the *-ide* suffix.

examples:

NaCl	sodium chloride
MgO	magnesium oxide
Li_3N	lithium nitride

Metals that can form more than one type of positive ion have Roman numerals in parentheses (no space) to indicate the charge of the cation.

examples:

$CoBr_2$	cobalt(II) bromide
$CrCl_3$	chromium(III) chloride

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3. Prefixes are used to denote the numbers of atoms present (note: *mono-* is NEVER used to name the first element).

examples:

N_2O	dinitrogen monoxide
NO_2	nitrogen dioxide
N_2O_3	dinitrogen trioxide

Non-binary - ionic compounds that contain *polyatomic* ions

Nomenclature

Manganese dioxide

Cesium oxalate

Manganese(II) oxalate

Strontium iodide

Triphosphorous Pentanitride

General Rules for Nomenclature

1) Naming is actually related to bonding so you need to know about bonding. (chapter 8 & 9)

2) Until you understand quantum mechanics, you need to memorize the oxidation states. (chapter 6 & 7)

3) Decisions made in naming requires understanding of electronegativity. (chap 6-9)

So why naming now? Because it is the language of chemistry but we will revisit naming in 102 AFTER you develop the knowledge needed to really get naming.

General Rules for Nomenclature

1) Memorize element and polyatomic names, ionic charges and spelling. (see table on ions on website)

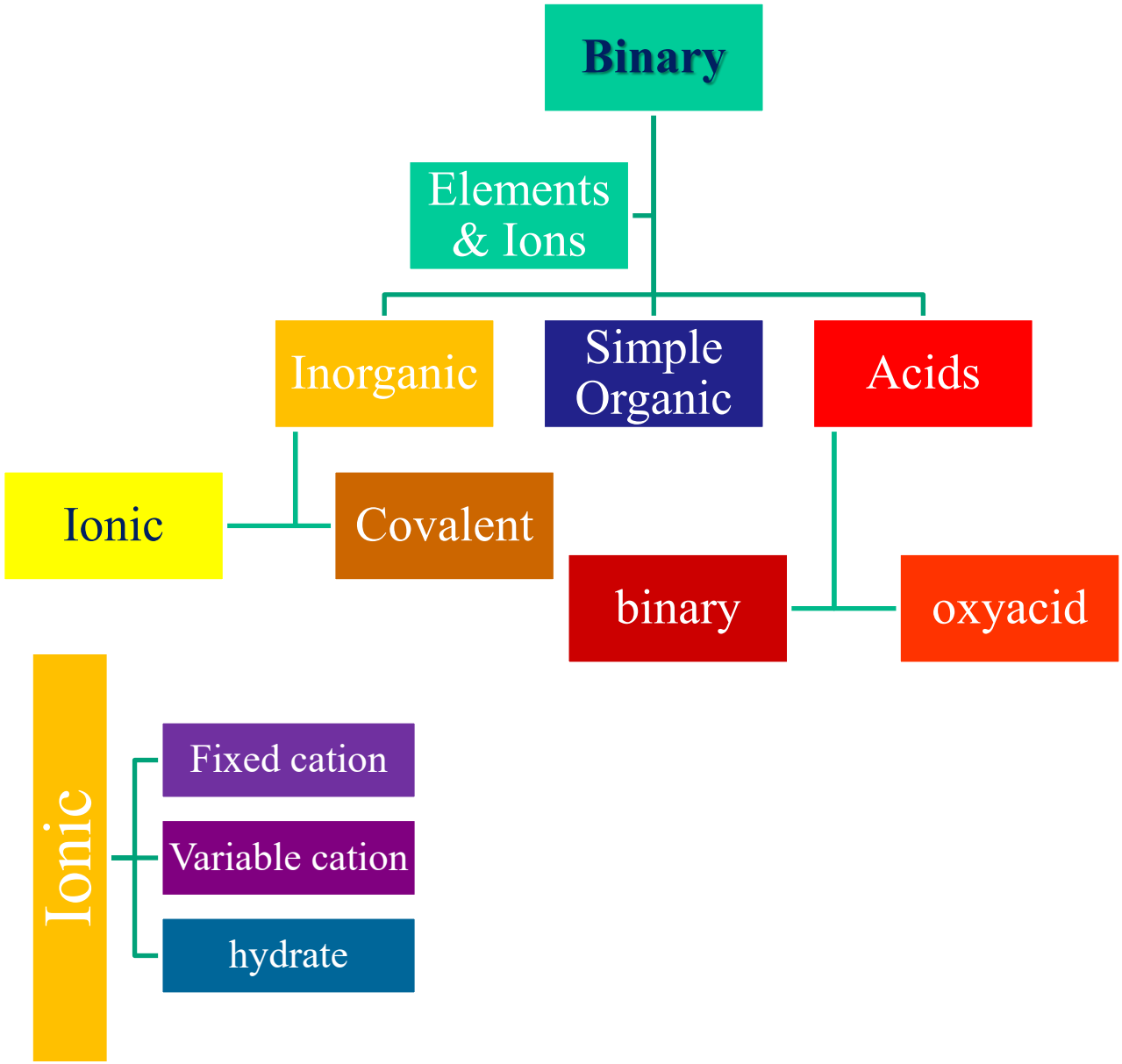
2) Decide if *organic* or inorganic or acid.

3) INORGANIC: Determine if ionic or covalent bonding – if ionic then decide if it is *fixed* oxidation state or *variable.* (see flow chart, follow directions).

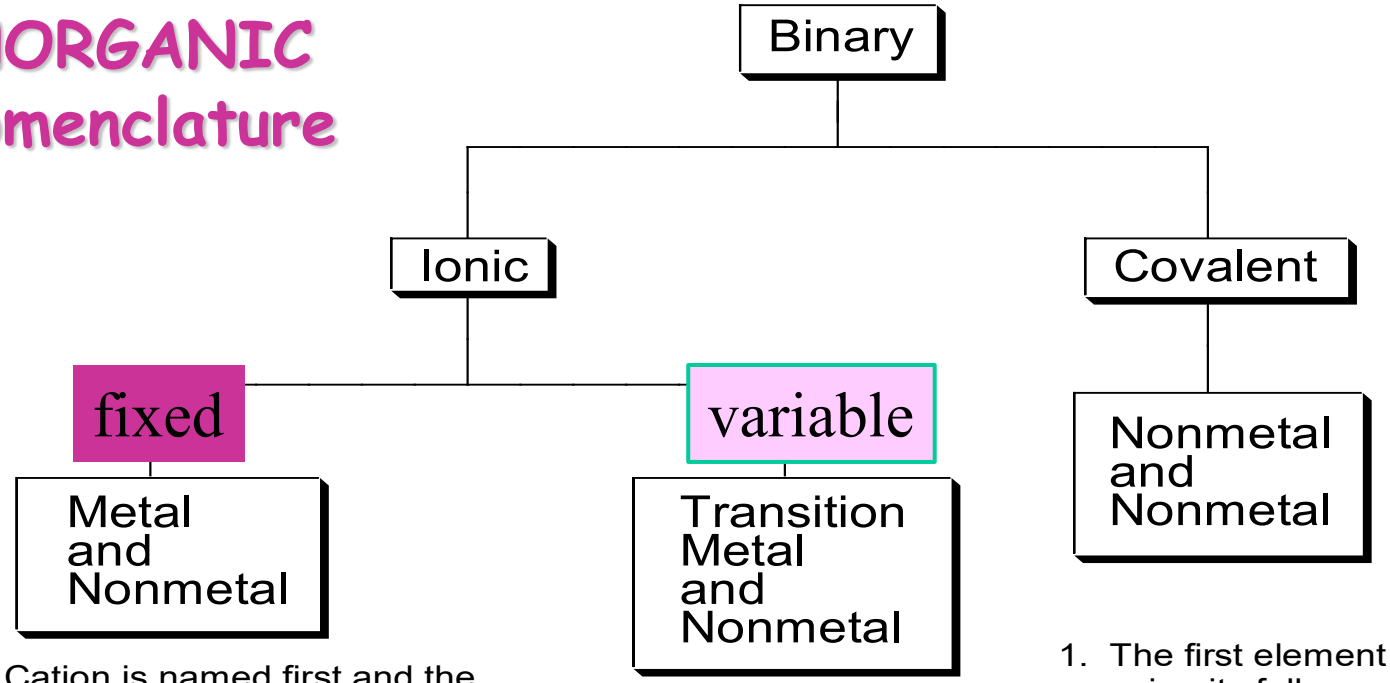
4) ACID: Decide of binary or oxyacid.
Binary = *hydro root ic acid* Oxyacid = *root-ic/ous acid*

5) *ORGANIC*: Determine # of carbon atoms, type of bond between carbons, and functional groups

Nomenclature 101



INORGANIC Nomenclature



Mono
Di
tri
Tetra
Penta
Hexa
Hepta
Octa
Nona
Deca

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N_2O_3	dinitrogen trioxide

Non-binary - ionic compounds that contain *polyatomic* ions

Naming Hydrates

Hydrates are ordinary chemical substances that have associated with them a certain number of water molecules. For example, $CuSO_4 \bullet 5H_2O$ is read *copper(II) sulfate pentahydrate*. As we will see later, when determining the overall molecular weight of this particular compound, you ADD five water molecules to the initial $CuSO_4$ (as opposed to multiply, where the "•" is commonly misinterpreted by beginner chemistry students; more on this later)!

$MgSO_4 \bullet 7H_2O$ is commonly known as Epsom salt, what is it chemical name?

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

Naming Acids

There are two main types of acids that we will encounter at the onset of this course, binary acids, and oxoacids.

1. Binary Acids – certain compounds of H with other nonmetal atoms.

Examples:

HF(aq) = hydrofluoric acid
HCl(aq) = hydrochloric acid
HBr(aq) = hydrobromic acid
HI(aq) = hydroiodic acid
H_2S(aq) = hydrosulfuric acid

2. Oxoacids – Hydrogen with two other nonmetals, one of which is oxygen.

Examples:

HClO = hypochlorous acid
$HClO_2$ = chlorous acid
$HClO_3$ = chloric acid
$HClO_4$ = perchloric acid

HNO_2 = **nitrous acid**
HNO_3 = **nitric acid**
H_2SO_4 = **sulfuric acid**

H_2SO_3 (aq)

Simple Organic Compounds

When dealing with organic (or carbon-containing) compounds, we refer to the following prefixes:

1)

Number of Carbons	Prefix
1	Meth-
2	Eth-
3	Prop-
4	But-
5	Pent-
6	Hex-
7	Hept-
8	Oct-
9	Non-
10	Dec-

2) NEXT: consider the TYPE of bonding between the carbon atoms.

Alkanes: single C—C bonds

alkenes: double C=C bonds

alkynes: triple C ≡ C bonds

$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$

heptane

$CH_3CH_2CH_3$

propane

CH_3CCCH_3

2-butyne

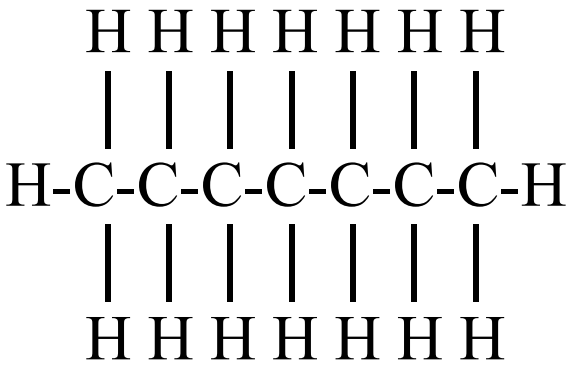
$CH_2CHCH_2CH_3$

1-butene

C_2H_2

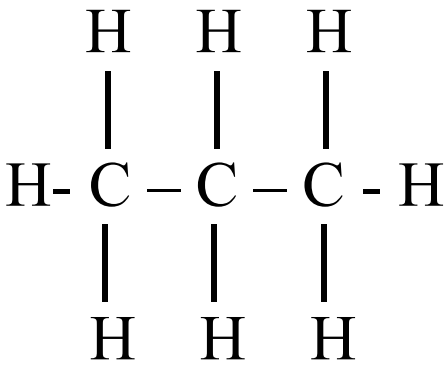
ethyne

$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$



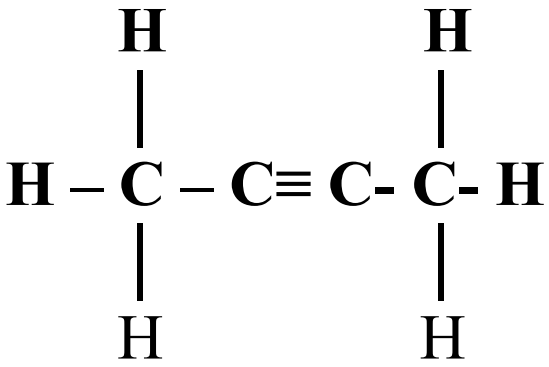
heptane

$CH_3CH_2CH_3$



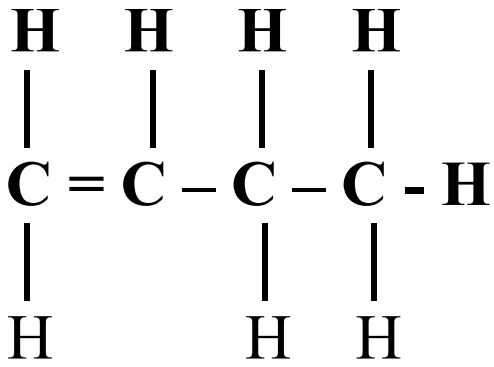
propane

CH_3CCCH_3

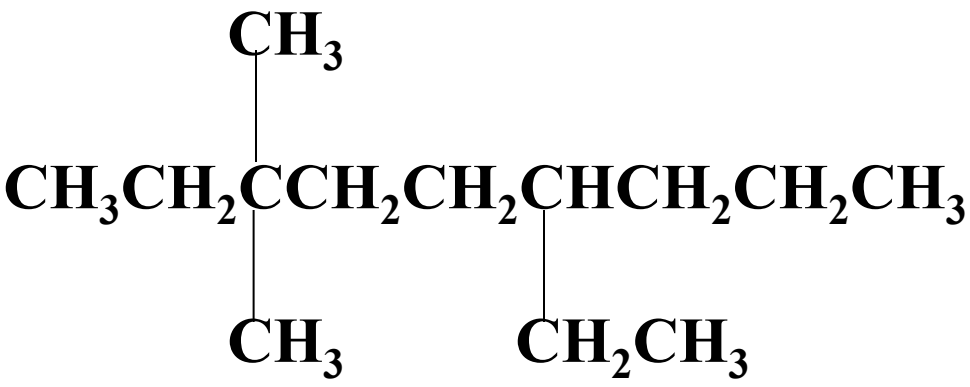


2-butyne

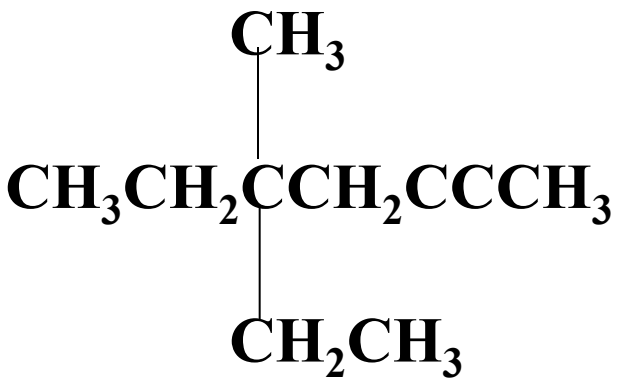
$CH_2CHCH_2CH_3$



1-butene



6-ethyl-3,3-dimethyl nonane



5-ethyl-5-methyl-2-heptene

1. **Name each of the following compounds:**

A) $HBrO_{4(aq)}$

B) $Ca_3(PO_4)_2$

C) $HIO_{3(s)}$

D) $FePO_4$

E) $KMnO_4$

F) $K_2Cr_2O_7$

G) C_2H_4

H) $Ba(OH)_2 \bullet 8H_2O$

2. Write formulas for the following compounds:

A. chromium(III) carbonate

B. potassium chlorate

C. octane

D. Nitrous acid

E. cobalt(II) chloride heptahydrate

F. 2-butene

G. Sodium hypochlorite

H. Sulfur hexafluoride

I. aluminum hydroxide

J. Lead(IV) phosphate

LECTURE GROUP QUIZ 6B # NOMENCLATURE

A) AlI_3

B) SiF_4

C) V_2O_5

D) $Ca(HSO_3)_2$

E) C_5H_{12}

F) TiO_2

H. peroiodic acid

I. carbon tetrafluoride

J. sodium peroxide

K. copper(I) chromate

L. copper(II) acetate

M. germanium dioxide

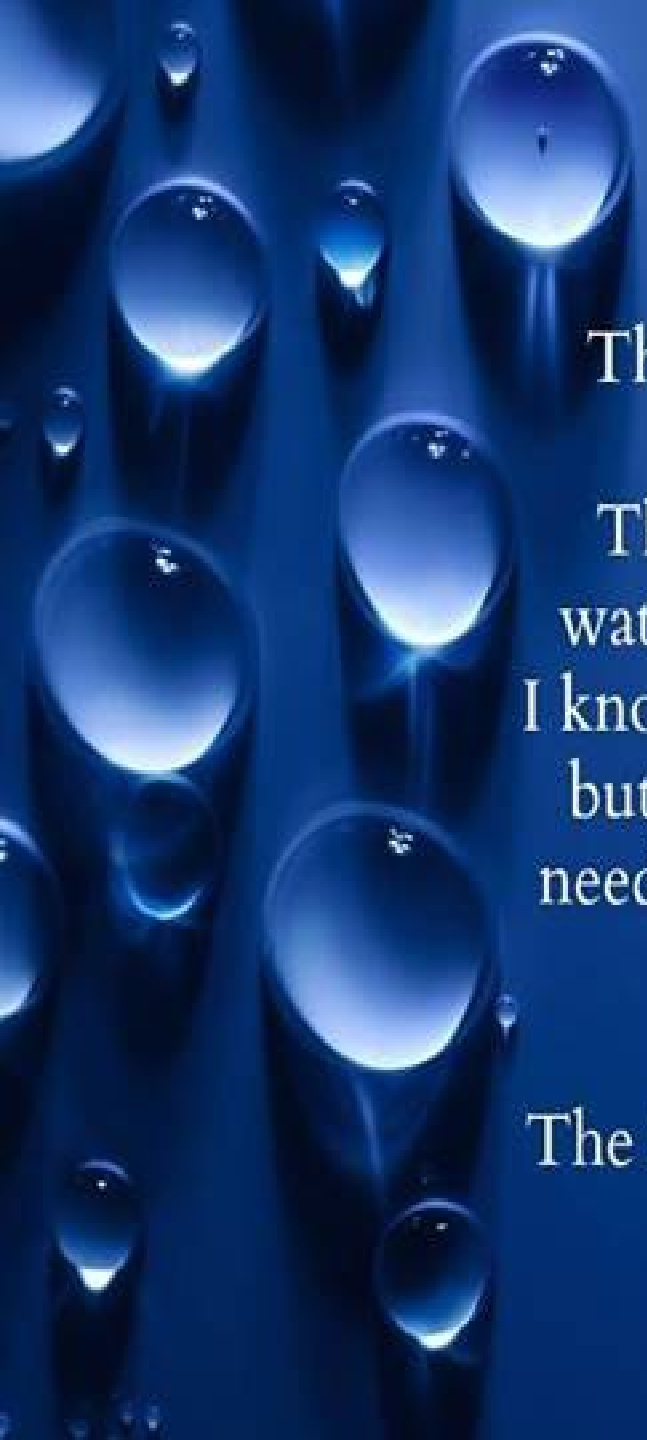
Two men walk into a bar.

One man orders H_2O.

The other says,

"I'll have H_2O, too."

The second man dies.



Two scientists walk into a bar.

The first scientist says, "I'll have some H2O."

The second scientist says, "I'll have a glass of water, too. Wh… why did you say H2O? Like, I know it's the chemical formula for water and all, but it's the end of the day and there's really no need to intentionally over-complicate things like that in a situation outside of work."

The first scientist stares at his drink, angry that his assassination plan has failed.