

Organic Chemistry: Some Basic Principles and Techniques

The Syllabus Breakdown (Micro-Modules)

We will divide this massive chapter into **8 manageable modules**. We won't move to the next module until you have scored 100% in the practice questions for the current one.

- **Module 1: The Basics of Carbon & Hybridization** (Tetravalency, shapes of molecules, calculating sigma σ and pi π bonds).
- **Module 2: Structural Representations & Functional Groups** (Expanded, condensed, and bond-line formulas, plus identifying functional groups and homologous series).
- **Module 3: IUPAC Nomenclature** (The rules of naming, priority order of functional groups—this requires heavy practice).
- **Module 4: Isomerism** (Structural isomerism and an introduction to stereoisomerism).
- **Module 5: Reaction Mechanisms & Intermediates** (Homolytic/Heterolytic bond fission, Nucleophiles vs. Electrophiles, Carbocations, Carbanions, and Free Radicals).
- **Module 6: Electronic Displacements** (Inductive effect, Resonance/Mesomeric effect, Electromeric effect, and Hyperconjugation—*This is the most important topic for reasoning questions!*)
- **Module 7: Purification Methods** (Crystallization, Sublimation, Distillation types, Chromatography).
- **Module 8: Qualitative & Quantitative Analysis** (Lassaigne's test for detecting N, S, Halogens, and mathematical formulas for Dumas, Kjeldahl, and Carius methods).

How Our Study Cycle Will Work:

For every single module:

1. **I will teach you the concept** in the simplest, most easy-to-understand way, using real-life analogies where possible.
 2. **I will ask you 2-3 basic check-up questions** to ensure it clicked in your brain.
 3. **We will tackle the tough questions from your PDFs** together. I won't just give you the answer; I will teach you *how to think* to arrive at the answer.
 4. **You will ask me any silly or small doubt** you have. (There are no bad questions here!).
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Let's dive into **Module 1: The Basics of Carbon & Hybridization**.

Concept 1: The Golden Rule of Carbon

Carbon (Atomic Number 6) has 4 electrons in its outermost shell. To become stable (complete its octet), it needs 4 more electrons.

- **The Golden Rule:** Carbon will **ALWAYS** make exactly **4 bonds**. Never 3, never 5. If you draw a carbon atom and it has 5 lines connecting to it, erase it immediately! It's a sin in organic chemistry!

Concept 2: Counting Sigma (σ) and Pi (π) Bonds

When two atoms decide to bond, they share electrons.

1. **Sigma (σ) Bond:** This is the *first* bond formed between two atoms. It is formed by a direct, head-on overlap of orbitals. It is very strong. Think of it as a solid concrete bridge between two islands.
2. **Pi (π) Bond:** If the atoms want to share *more* electrons, they form a double or triple bond. After the first sigma bond is built, any additional bonds are **Pi (π) bonds**. These are formed by sideways overlap and are comparatively weaker.

The Ultimate Cheat Sheet for Bonds:

- **Single Bond (—):** 1 Sigma (σ)
- **Double Bond (=):** 1 Sigma (σ) + 1 Pi (π)
- **Triple Bond (\equiv):** 1 Sigma (σ) + 2 Pi (π)

Let's solve a Case-Based Question from your PDF (Page 11, Q1c):

Question: Identify the type of bonds present in ethene (C_2H_4) and ethyne (C_2H_2). How many sigma (σ) and pi (π) bonds are there in each?

My Solution Breakdown: Let's look at **Ethene** (C_2H_4): Its structure is $H_2C = CH_2$. Let's open it up completely: $H \quad H \quad / \quad C = C \quad \backslash \quad H$
 $H \quad H$

- There are 4 single bonds between Carbon and Hydrogen (C—H). Each single bond is 1 σ . So, 4σ bonds.
- There is 1 double bond between Carbon and Carbon (C=C). A double bond is 1 σ + 1 π .
- **Total for Ethene:** $4 + 1 = 5$ **Sigma (σ) bonds** and **1 Pi (π) bond**.

Let's look at **Ethyne** (C_2H_2): Its structure is $H - C \equiv C - H$.

- There are 2 single C—H bonds $\rightarrow 2\sigma$ bonds.
- There is 1 triple C \equiv C bond $\rightarrow 1\sigma + 2\pi$.

- **Total for Ethyne:** $2 + 1 = 3$ **Sigma (σ) bonds** and **2 Pi (π) bonds**.

See? No memorization required, just counting!

Concept 3: Hybridization (The "Mixing" of Orbitals)

What is hybridization? In simple terms, Carbon has different types of "rooms" for its electrons (one s orbital and three p orbitals). Before bonding, Carbon mixes these rooms together to create identical, equal-energy rooms called "hybrid orbitals".

The Easiest Trick to Find the Hybridization of ANY Carbon Atom: Just count the number of **Sigma (σ) bonds** connected to that specific carbon atom! (Ignore the pi bonds completely).

- **4 Sigma bonds** \rightarrow We need 4 rooms. Mix one s and three $p \rightarrow sp^3$ **hybridization**.
 - *Shape:* Tetrahedral. *Bond Angle:* 109.5° . (Found in alkanes/single bonds).
- **3 Sigma bonds** \rightarrow We need 3 rooms. Mix one s and two $p \rightarrow sp^2$ **hybridization**.
 - *Shape:* Trigonal Planar (flat). *Bond Angle:* 120° . (Found in alkenes/double bonds).
- **2 Sigma bonds** \rightarrow We need 2 rooms. Mix one s and one $p \rightarrow sp$ **hybridization**.
 - *Shape:* Linear (straight line). *Bond Angle:* 180° . (Found in alkynes/triple bonds).

Let's solve an Assertion-Reasoning Question from your PDF (Page 9, Q14): *Assertion (A):* The angle between bonds in methane (CH_4) is 109.5° .
Reason (R): Methane has an sp^2 hybridized carbon atom.

My Solution Breakdown:

1. Let's check the Assertion: Methane has 4 single bonds. As we just learned, 4 single (σ) bonds mean sp^3 hybridization, and the angle for sp^3 is indeed 109.5° . So, **Assertion is TRUE**.
2. Let's check the Reason: It says Methane is sp^2 . We just proved it is sp^3 . So, **Reason is FALSE**. *Answer: (c) Assertion is correct but Reason is wrong.*

Let's solve a tricky Subjective Question from your PDF (Page 10, Section B, Q5): *Question:* Identify the hybridized state of each C atom in the following compound: $CH_2 = CH - C \equiv N$

My Solution Breakdown: Let's expand the structure so we can see every bond clearly: $H_2C = CH - C \equiv N$ (Note: The bond between Carbon and Nitrogen in a cyanide group is always a triple bond).

Now, let's check carbon by carbon:

- **Carbon 1** ($CH_2=$): It is attached to two H's (2 single bonds) and has a double bond with the next C. That means 2 σ (from H) + 1 σ (from double bond) = **3 σ bonds**. 3 sigma bonds means it is sp^2 .
- **Carbon 2** ($=CH-$): It has a double bond on the left (1 σ), a single bond with H (1 σ), and a single bond with the right Carbon (1 σ). Total = **3 σ bonds**. 3 sigma bonds means it is sp^2 .
- **Carbon 3** ($-C\equiv N$): It has a single bond on the left (1 σ) and a triple bond on the right (1 σ). Total = **2 σ bonds**. 2 sigma bonds means it is sp .

Answer: The hybridization states from left to right are sp^2 , sp^2 , sp .

Module 1 Summary Check:

- Single bond = 1 σ (sp^3)
- Double bond = 1 σ , 1 π (sp^2)
- Triple bond = 1 σ , 2 π (sp)
- *Fun fact from your PDF (Page 8, Q9):* Ethene (sp^2) is a planar (flat) molecule because trigonal planar shapes are flat!

Take a moment to digest this. Look at how logically we arrived at the answers without blind memorization.

Module 2: Structural Representations & Functional Groups.

Concept 1: Structural Representations (How to draw lazy but smart!)

Organic molecules can get massive. If we draw every single Carbon (C) and Hydrogen (H) with all their bonds, we would run out of ink and time. So, chemists invented three ways to write them:

1. **Complete Structural Formula:** You show *every single bond* as a dash (—). It looks like a giant spiderweb.
2. **Condensed Structural Formula:** You hide the dashes and just write the atoms together.
 - *Example:* Instead of drawing $H - C(H)(H) - C(H)(H) - H$, you just write CH_3CH_3 . If a group repeats, you use brackets: $CH_3(CH_2)_3CH_3$.
3. **Bond-Line Formula (The VIP Method):** This is what you will use 90% of the time in exams. It looks like zig-zag lines.
 - **Rule 1:** Every end of a line and every corner (vertex) represents a **Carbon** atom.
 - **Rule 2:** We **DO NOT** draw Hydrogens that are attached to Carbon. We just assume they are there to complete Carbon's 4 bonds.
 - **Rule 3:** Any atom that is *not* Carbon or Hydrogen (like O, N, Cl, Br) **MUST** be written out. If a Hydrogen is attached to one of these (like in -OH), you must write that H too!

Let's solve a 3-Marker from your PDF (PDF 1, Page 4, Section C, Q2):

Question: What is the bond-line formula for Isopropyl alcohol ($CH_3 - CH(OH) - CH_3$)?

My Solution Breakdown:

1. Look at the carbon chain: There are 3 carbons in a row ($CH_3 - CH - CH_3$).
 2. Let's draw 3 carbons as a zig-zag: Draw a "V" shape (that's 3 points: the two top ends and the bottom point).
 3. The middle carbon has an $-OH$ group attached to it. So, from the bottom point (the middle Carbon), draw a straight line down and write "OH". *Answer:* It looks like an upside-down 'Y' with an OH at the bottom. The three ends/corners are the Carbons, and we hid all the Hydrogens attached to them. Simple!
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Concept 2: Functional Groups (The "Spices" of Chemistry)

Think of a pure carbon-hydrogen chain (alkane) like plain boiled rice. It's boring and doesn't react much. But if you add a specific group of atoms to it, it completely changes the "flavor" (chemical properties) of the molecule. These groups are called **Functional Groups**.

Here are the superstars you absolutely must recognize:

- **Alcohol (-OH):** Makes things behave like alcohols.
 - **Aldehyde (-CHO):** Has a Carbon double-bonded to Oxygen, and single-bonded to a Hydrogen ($C = O$ at the *end* of a chain).
 - **Ketone (-CO-):** Has a Carbon double-bonded to Oxygen ($C = O$) sitting in the *middle* of two other Carbons.
 - **Carboxylic Acid (-COOH):** The king of groups. It has a $C = O$ and an $-OH$ attached to the *same* Carbon.
 - **Halogens (-F, -Cl, -Br, -I):** Known as Fluoro, Chloro, Bromo, Iodo.
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Concept 3: Homologous Series (The Family Tree)

A **Homologous Series** is a family of organic compounds that have the **same functional group** and similar chemical properties.

- *The Magic Rule:* Every successive member in this family differs from the previous one by exactly one $-CH_2-$ **unit** (which has a molecular mass of 14u).
- *Example:* Methane (CH_4), Ethane (CH_3CH_3), Propane ($CH_3CH_2CH_3$). They are all alkanes, differing by one $-CH_2-$ each time.

Let's smash a 5-Mark Case-Study Question from your PDF (PDF 2, Page 11, Q2): Context: Nisha is given a chart with the following compounds:
Compound A: CH_3CH_2OH Compound B: CH_3COOH Compound C: CH_3Cl Compound D: CH_3CHO Compound E: $CH_3CH(OH)CH_3$

Question (a): Identify the functional group in compound B and D. **My Solution Breakdown:** Let's look at B (CH_3COOH). I see "-COOH". That is the **Carboxylic acid** group. Let's look at D (CH_3CHO). I see "-CHO". That is the **Aldehyde** group.

Question (c): Which compounds among A–E belong to the same homologous series? Name the series. **My Solution Breakdown:** To be in the same homologous series, they **MUST** have the exact same functional group. Let's scan the list for matching groups. Compound A has "-OH" (Alcohol). Compound E has "-OH" (Alcohol). Do they differ by $-CH_2-$ units? Yes! A has 2 carbons, E has 3 carbons. **Answer: Compound A and Compound E.** They belong to the **Alcohol** homologous series.

Module 2 Summary Check:

- **Bond-line:** Hide Carbons as corners/ends. Hide attached Hydrogens. Show heteroatoms (O,N,X).
- **Functional groups:** -OH (Alcohol), -CHO (Aldehyde), -CO- (Ketone), -COOH (Acid).
- **Homologous Series:** Same family, same functional group, diff by $-CH_2-$.

Look at how fast we are moving! You just secured marks that usually confuse students who can't tell the difference between an aldehyde and a ketone.

Take a sip of water. Review this. If the difference between condensed formulas, bond-line formulas, and functional groups is crystal clear, say "Clear" and we will enter the beast: Module 3 (IUPAC Nomenclature)!

Module 3: IUPAC Nomenclature.

Many students try to memorize names, which is a massive mistake. IUPAC is literally just a set of grammar rules. If you know the formula, you can name a molecule with 100 carbons without breaking a sweat.

The Ultimate IUPAC Formula

Every organic name is built like this: **Secondary Prefix + Primary Prefix + WORD ROOT + Primary Suffix + Secondary Suffix**

Let's break these down into plain English:

1. **Word Root (The Core):** How many carbons are in the *longest continuous chain*?
 - 1C = Meth, 2C = Eth, 3C = Prop, 4C = But, 5C = Pent, 6C = Hex, 7C = Hept, etc.
 2. **Primary Suffix (The Bond Type):** Are there double or triple bonds in that main chain?
 - All single bonds = **-ane**
 - Has a double bond = **-ene**
 - Has a triple bond = **-yne**
 3. **Secondary Suffix (The VIP / Main Functional Group):** Who is the boss of the molecule?
 - Alcohol (-OH) = **-ol**
 - Aldehyde (-CHO) = **-al**
 - Ketone (-CO-) = **-one**
 - Carboxylic Acid (-COOH) = **-oic acid**
 4. **Primary Prefix:** Is the chain a closed ring? Add **cyclo-**. If it's open, skip this.
 5. **Secondary Prefix (The Sidekicks / Substituents):** Anything attached to the main chain that *isn't* the main VIP.
 - Halogens: **fluoro, chloro, bromo, iodo**
 - Alkyl groups: **methyl** ($-CH_3$), **ethyl** ($-CH_2CH_3$)
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The 3 Golden Rules of Naming

1. **Find the Longest Chain:** Find the longest continuous carbon path. *Crucial:* If there is a VIP functional group containing a carbon (like -COOH or -CHO), or a double/triple bond, they **MUST** be included in this chain, even if it makes the chain shorter!
2. **Numbering (The Lowest Locant Rule):** Number the carbon chain from the end that gives the VIP functional group the *lowest possible number*. If there's no VIP, give the double/triple bond the lowest number. If there's none of those, give the sidekicks (branches) the lowest number.
3. **Alphabetical Order:** If you have a "bromo" and a "methyl" attached as branches, Bromo gets written first in the name because B comes before M.

Let's Apply This to Your PDF Questions!

Level 1 (Easy) - From PDF 1, Page 1, Q1: Question: The IUPAC name of CH_3CHO is: (a) Acetaldehyde (b) Methylaldehyde (c) Formyl chloride (d) Ethanal

My Solution Breakdown:

1. **Word Root:** Let's count the carbons. There are 2 carbons (CH_3 and CHO). 2 Carbons = **Eth**.
2. **Primary Suffix:** The bond between the two carbons is a single bond. = **-ane**.
3. **Secondary Suffix (VIP):** The group is $-CHO$, which is an aldehyde. Suffix = **-al**.
4. Combine them: Eth + ane + al = **Ethanal**. (Note: We drop the 'e' from 'ane' because 'al' starts with a vowel). Answer: (d) Ethanal. (Acetaldehyde is its common name, not IUPAC!)

Level 2 (Medium - Working Backwards) - From PDF 1, Page 1, Q2:

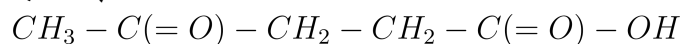
Question: The structure of 4-Methylpent-2-en-1-ol is:

My Solution Breakdown: When given a name, work from the **middle** outwards.

1. **Word Root:** "pent" → Draw a chain of 5 carbons:
 $C - C - C - C - C$. Let's number them 1 to 5 from right to left.
 2. **Primary Suffix:** "-2-en" → Put a double bond starting at Carbon 2:
 $C - C - C - C = C$.
 3. **Secondary Suffix:** "-1-ol" → Put an $-OH$ group on Carbon 1:
 $C - C - C - C = C - OH$.
 4. **Prefix:** "4-Methyl" → Put a $-CH_3$ group on Carbon 4. Now fill in the missing hydrogens so every carbon has 4 bonds.
 - C1 has 2 bonds (=C and -OH), needs 2 H's → CH_2OH
 - C2 has 3 bonds, needs 1 H → $=CH-$
 - C3 has 3 bonds, needs 1 H → $-CH=$
 - C4 has 3 bonds, needs 1 H → $-CH(CH_3)-$
 - C5 has 1 bond, needs 3 H's → CH_3- Put it together:
 $CH_3 - CH(CH_3) - CH = CH - CH_2OH$. Let's look at the options.Option (c) is $(CH_3)_2CHCH = CHCH_2OH$. This perfectly matches our structure! Answer: (c)
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Level 3 (Boss Level - Multiple Functional Groups) - From PDF 1, Page 3,

Q14: Question: Find the IUPAC name for



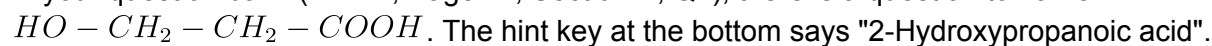
My Solution Breakdown: This molecule has TWO functional groups: a Ketone ($-C(=O)-$) and a Carboxylic Acid ($-COOH$). *Who is the Boss?* According to the priority order in your summary notes (PDF 2, Page 2): $-COOH$ is the **supreme boss of all functional groups**. It always gets priority #1.

1. **Longest Chain:** 5 Carbons. Word root = **pent**.
2. **Numbering:** Start from the right so the Boss ($-COOH$) gets Carbon #1.
3. **Secondary Suffix:** Because $-COOH$ is the boss, the suffix is **-oic acid**.
4. **Prefix:** What happens to the Ketone on Carbon #4? Since it lost the boss battle, it becomes a lowly sidekick (prefix). The prefix name for a ketone is **oxo**. So it's **4-oxo**.
5. Combine: 4-oxo + pent + ane + oic acid = **4-oxopentanoic acid**.

Answer: (iv) 4-oxopentanoic acid.

A Quick Warning (Teacher's Secret) 🙊

In your question bank (PDF 2, Page 11, Section E, Q2), there is a question to name:



That is a typo in your school's/coaching's material! Let's apply our rules:

1. Longest chain = 3 carbons (Prop).
2. Boss is $-COOH$ (Carbon 1).
3. Numbering: C1 is $-COOH$, C2 is middle $-CH_2-$, C3 is the end $-CH_2-$ which has the $-OH$.
4. The $-OH$ is on Carbon 3. As a prefix, it's called "hydroxy". The correct name is **3-hydroxypropanoic acid**. If you see this in the exam, write the correct logical answer, not the memorized typo!

Module 3 Summary Check:

- Identify the VIP functional group first (Priority: $COOH > SO_3H > Ester > COCl > Amide > CN > CHO > Ketone > OH > NH_2 > Double\ bond > Triple\ bond$).
- Number the chain to give the VIP the lowest number.
- Assemble using the formula: Prefix + Root + Suffix.

Take your time with this one. Does the logic of building a name and deciding "Who is the Boss" make sense?

Module 4: Isomerism

Concept 1: What is an Isomer?

Imagine I give you exactly 5 black LEGO bricks (Carbons) and 12 white LEGO bricks (Hydrogens). I ask you to build a structure. You build a straight line. Your friend takes the exact same bricks and builds a shape that looks like a "T".

You both used the **exact same formula** (C_5H_{12}), but you built **different structures**. Those structures are called **Isomers**. *Isomerism = Same molecular formula, but different physical or chemical properties.*

There are two main branches of Isomerism: **Structural** (different connections) and **Stereo** (different 3D shapes). Let's focus on Structural first, as it's heavily tested.

Concept 2: The "Big 4" Structural Isomers

You need to be a detective and spot the difference between two molecules. Here are the 4 main types you will face:

1. Chain Isomerism (The Skeleton changes)

- The length of the main carbon chain changes. One might be a straight chain of 5 carbons (Pentane), and the other might be a chain of 4 carbons with a branch (2-Methylbutane).
- *Trick to identify:* Name them! If the "Word Root" changes (e.g., Pentane vs. Butane), it's a chain isomer.

2. Position Isomerism (The "Seat" changes)

- The carbon skeleton stays exactly the same, but the functional group or double/triple bond moves to a different carbon "seat".
- *Example:* Propan-1-ol ($CH_3 - CH_2 - CH_2OH$) vs. Propan-2-ol ($CH_3 - CH(OH) - CH_3$).
- *Trick to identify:* The numbers in the IUPAC name change, but the Word Root stays the same.

3. Functional Isomerism (The "Magic Trick")

- The molecular formula is identical, but the actual **functional group** changes completely!
- *The Classic Pairs you MUST memorize:*
 - **Alcohols and Ethers** (e.g., CH_3CH_2OH and $CH_3 - O - CH_3$ both are C_2H_6O).
 - **Aldehydes and Ketones** (e.g., Propanal and Propanone both are C_3H_6O).
 - **Carboxylic Acids and Esters**.

4. Metamerism (The "Bridging" Isomer)

- This only happens with functional groups that sit in the *middle* of a chain (like Ethers $-O-$ or Ketones $-CO-$).
 - The functional group stays the same, but the number of carbons on the left and right sides changes.
 - *Example:* Diethyl ether ($CH_3CH_2 - O - CH_2CH_3$) vs. Methyl propyl ether ($CH_3 - O - CH_2CH_2CH_3$). Both have 4 carbons and 1 oxygen, but the distribution around the Oxygen bridge is different (2,2 vs 1,3).
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Let's solve a massive 5-Mark Question from your PDF!

(From PDF 2, Page 11, Section E, Q1)

You are given 7 structures. Let's analyze what they are first:

1. $CH_3CH_2CH_2CH_2OH$ (Butan-1-ol \rightarrow Alcohol, 4 Carbons)
2. $CH_3CH_2CH(OH)CH_3$ (Butan-2-ol \rightarrow Alcohol, 4 Carbons)
3. $CH_3CH_2 - O - CH_2CH_3$ (Diethyl ether \rightarrow Ether, 4 Carbons)
4. $CH_3CH_2COCH_2CH_3$ (Pentan-3-one \rightarrow Ketone, 5 Carbons)
5. $CH_3COCH_2CH_2CH_3$ (Pentan-2-one \rightarrow Ketone, 5 Carbons)
6. $CH_3 - CH_2CH_2CH_2CH_3$ (Pentane \rightarrow Straight chain, 5 Carbons)
7. $(CH_3)_2CHCH_2CH_3$ (2-Methylbutane \rightarrow Branched chain, 5 Carbons)

Let's answer the exam questions:

(a) Point out the pair of compounds that are metamers. *My Logic:* Look for the "bridge" groups (Ethers or Ketones) where the left/right balance changes. Look at #4 (Pentan-3-one): The Ketone bridge $-CO-$ has 2 carbons on the left and 2 on the right (Ethyl-Ethyl). Look at #5 (Pentan-2-one): The Ketone bridge $-CO-$ has 1 carbon on the left and 3 on the right (Methyl-Propyl). *Answer: 4 and 5.*

(b) Which ones form a pair of functional group isomers? *My Logic:* Remember the "Classic Pairs"? Alcohols and Ethers are functional isomers! Let's find an Alcohol and an Ether with the same number of carbons. #1 is Butan-1-ol (Alcohol, $C_4H_{10}O$). #3 is Diethyl ether (Ether, $C_4H_{10}O$). *Answer: 1 and 3 (or 2 and 3).*

(c) Which of the listed compounds exhibit position isomerism? *My Logic:* Find two molecules with the exact same chain and same group, but a different "seat number". Look at #1 (Butan-1-ol) and #2 (Butan-2-ol). The $-OH$ group just moved from Carbon 1 to Carbon 2! *Answer: 1 and 2.* (You could also say 4 and

5 exhibit position isomerism because the ketone moves from position 3 to 2, but metamerism is a more specific and better answer for ketones).

(d) Identify the pairs of compounds that represent chain isomerism. My

Logic: Find two molecules with the same formula, but the main carbon chain gets shorter because of branching. Look at #6 (Pentane: straight chain of 5).

Look at #7 (2-Methylbutane: main chain of 4, with 1 branch). Both are C_5H_{12} .

Answer: 6 and 7.

Concept 3: Stereoisomerism (Just the definition for now)

Your PDF asks for the definition of Stereoisomerism (Part 'e' of that same question).

Definition: When two isomers have the exact same structural formula (the atoms are connected to each other in the exact same order), but they differ in the **3-dimensional arrangement of atoms in space**. (*Think of your left and right hands. They have the same thumb-to-pinky connections, but you can't perfectly overlap them in 3D space!*)

Module 4 Summary Check:

- **Chain:** Longest chain changes (Straight vs. Branch).
- **Position:** The number of the functional group changes.
- **Functional:** The actual group changes (Alcohol \leftrightarrow Ether).
- **Metamerism:** The split around a middle group (like -O- or -CO-) changes.

How did you find this LEGO game? Is it making sense how we can categorize these molecules just by looking at their structures?

Fantastic! Now we are entering the action movie phase of organic chemistry: **Module 5: Reaction Mechanisms & Intermediates**.

So far, we just looked at molecules sitting still. But chemistry is about *reactions*. To make a new molecule, you have to break old bonds and form new ones.

Let's look at exactly how bonds break and who the players are.

Concept 1: Bond Fission (Breaking the Bond)

A covalent bond is made of **2 shared electrons**. Imagine two friends sharing a pizza (the bond). When they stop being friends, there are two ways to split the pizza:

1. Homolytic Fission (The Fair Split)

- Both atoms take exactly **1 electron** each.
- Because it's a fair split, nobody gets a plus or minus charge.
- They become **Free Radicals** (atoms with one single, unpaired electron, written with a dot, like C^\bullet).
- *Hint:* This usually happens in the presence of sunlight (UV), heat, or peroxides.

2. Heterolytic Fission (The Unfair Split)

- One atom is a bully (more electronegative) and snatches **BOTH electrons**.
- The bully gets a negative charge (Anion).
- The victim loses its electron and gets a positive charge (Cation).
- If Carbon is the victim, it becomes a **Carbocation** (C^+). If Carbon is the bully, it becomes a **Carbanion** (C^-).

Let's solve a quick MCQ from your PDF (PDF 2, Page 8, Q4): *Question:*

Homolytic fission of a covalent bond results in: (a) Carbocation and carbanion
(b) Free radicals (c) Two ions (d) Nucleophile and electrophile

My Solution Breakdown: "Homo" means same/equal. An equal split of electrons means no charges are formed, just single dots. Those are Free Radicals!

Answer: (b) Free radicals.

Concept 2: The Attackers (Electrophiles vs. Nucleophiles)

Once a bond is broken, these "attackers" look for new partners. Their names literally tell you what they want!

1. Electrophiles (E^+)

- "Electro" = Electron. "Phile" = Loving. **They love electrons!**
- Why do they love electrons? Because they are poor (electron-deficient). They usually have a **positive charge** (like H^+ , CH_3^+) or an **incomplete octet** (like BF_3 , $AlCl_3$).
- They will attack the negative part of a molecule.

2. Nucleophiles (Nu^-)

- "Nucleo" = Nucleus (which is positive). "Phile" = Loving. **They love positive charges!**
- Why? Because they are rich! They have extra electrons to give away. They usually have a **negative charge** (like OH^- , Cl^- , CN^-) or a **lone pair of electrons** (like $H_2\ddot{O}$, $\ddot{N}H_3$).

Let's solve another MCQ (PDF 2, Page 8, Q1): Question: Select the compound that behaves as a nucleophile. (a) BF_3 (b) NH_3 (c) $AlCl_3$ (d) H^+

My Solution Breakdown: A nucleophile is rich in electrons.

- H^+ is positively charged (Electrophile).
- BF_3 and $AlCl_3$ are famous exceptions you must memorize: Boron and Aluminum only make 3 bonds here, meaning they only have 6 electrons in their outer shell. They are hungry for 2 more. So, they are Electrophiles!
- Nitrogen in Ammonia (NH_3) makes 3 bonds but has a **lone pair** of electrons sitting on top of it, ready to be donated. *Answer: (b) NH_3 .*

Concept 3: Reaction Intermediates & Their Stability

When a reaction happens, it doesn't go from A to B instantly. It forms a temporary, highly reactive "middleman" called an intermediate. The most important one is the **Carbocation**.

The Nature of a Carbocation (C^+):

- It has lost an electron, so it has a positive charge.
- Count its electrons: It only has 3 bonds now ($3 \text{ bonds} \times 2 \text{ e}^- = \mathbf{6 \text{ electrons}}$). It is a "sextet", meaning it is short of an octet (8).
- **Because it is poor, it needs rich friends.** Alkyl groups (like $-CH_3$) act like wealthy friends who donate a little bit of electron density to the poor C^+ to stabilize it.

The Golden Rule of Carbocation Stability: The more friends (carbon groups) attached directly to the C^+ , the more stable it is!

- **3° (Tertiary):** The C^+ is attached to 3 other carbons. (*Most stable - 3 rich friends!*)
- **2° (Secondary):** The C^+ is attached to 2 other carbons.

- **1° (Primary):** The C^+ is attached to 1 other carbon.
- **Methyl (CH_3^+):** Attached to 0 other carbons. (*Least stable - zero friends*).

Note: Free Radicals (C^\bullet) follow the EXACT same stability order as carbocations ($3^\circ > 2^\circ > 1^\circ$). Carbanions (C^-) are the exact opposite! They are already rich and negatively charged. Giving them more electron-donating friends makes them unstable. Stability is ($1^\circ > 2^\circ > 3^\circ$).

Let's solve an Assertion-Reasoning Question (PDF 2, Page 9, Q11):

Assertion (A): Carbocations are electron-deficient species. *Reason (R):* Carbocations have a sextet of electrons in the valence shell of the positively charged carbon.

My Solution Breakdown:

1. Is a Carbocation electron-deficient? Yes, it has a positive charge because it lost an electron. (Assertion is TRUE).
 2. Does it have a sextet (6 electrons)? Yes, it makes 3 bonds ($3 \times 2 = 6$). 6 is less than an octet (8), which perfectly explains *why* it is electron-deficient. (Reason is TRUE and is the correct explanation).
- Answer: (a) Both A and R are correct, and R is the correct explanation.*

Let's solve one more MCQ (PDF 2, Page 8, Q2): *Question:* Out of the following which one is the correct order of stability of carbocations? (a) $1^\circ > 2^\circ > 3^\circ$ (b) $3^\circ > 2^\circ > 1^\circ$

My Solution Breakdown: Carbocations want rich friends. More carbon attachments = more stability. Tertiary (3°) has 3 friends, Secondary (2°) has 2, Primary (1°) has 1. *Answer: (b) $3^\circ > 2^\circ > 1^\circ$.*

Module 5 Summary Check:

- **Homolytic** = Fair = Free Radicals.
- **Heterolytic** = Unfair = Ions (+ and -).
- **Electrophiles** = Poor / Want negative (+ or incomplete octet).
- **Nucleophiles** = Rich / Want positive (- or lone pairs).
- **Carbocations** = 6 electrons, $3^\circ > 2^\circ > 1^\circ$ stability.

We are flying through the syllabus! If you understand the logic behind *why* tertiary carbocations are the most stable (the "rich friends" analogy).

Module 6: Electronic Displacements.

Concept 1: The Inductive Effect (The "Tug-of-War")

This happens in **single (σ) bonds**. When a greedy (highly electronegative) atom is attached to a carbon chain, it pulls the shared electrons towards itself.

- **Key traits:** It is a **permanent** effect. But, it gets weaker the further away you get. After 3 or 4 carbons, it completely dies out.

There are two types of players:

1. **$-I$ Effect (The Withdrawers / Greed):** Atoms that *pull* electrons away from the carbon chain.
 - *Examples:* Halogens ($-F$, $-Cl$, $-Br$, $-I$), $-NO_2$, $-OH$, $-CN$.
2. **$+I$ Effect (The Donors / Rich Friends):** Atoms that *push* electrons into the carbon chain.
 - *Examples:* All Alkyl groups! (Methyl $-CH_3$, Ethyl $-CH_2CH_3$, etc.).

How do we use this? (The Acidity Trick) An acid wants to throw away an H^+ ion. When it does, it is left with a **negative charge** (it becomes an anion).

- **Rule of Nature:** Charges are a heavy burden. Molecules hate having a concentrated charge.
- If a molecule has **$-I$ groups** (withdrawers), they help *pull* that negative charge away and spread it out. Spreading the burden = **More Stability = Stronger Acid**.
- If a molecule has **$+I$ groups** (donors), they push *more* negative charge onto an already negative atom. Increasing the burden = **Less Stability = Weaker Acid**.

Let's destroy a 2-Mark Question from your PDF (PDF 1, Page 3, Section B, Q1): Question: Which of the two is expected to be more stable and why:
 $O_2NCH_2CH_2O^-$ or $CH_3CH_2O^-$?

My Solution Breakdown: Both molecules have an oxygen with a negative charge (O^-). Let's look at their "friends".

- Molecule 1 has an **$-NO_2$ group**. As we learned, $-NO_2$ is a powerful **$-I$ group** (withdrawer). It pulls electron density towards itself, reducing the negative burden on the Oxygen. This spreads the charge and makes it highly stable.
- Molecule 2 has a **$-CH_3$ group**. Alkyl groups show the **$+I$ effect** (donors). It pushes *more* electrons onto the already negative Oxygen. This makes the Oxygen very unstable. *Answer: $O_2NCH_2CH_2O^-$ is more stable due to the strong $-I$ effect of the $-NO_2$ group dispersing the negative charge.*

Let's solve another famous one (PDF 1, Page 5, Q9): Question: Explain the correct order of acidity: $Cl_3CCOOH > Cl_2CHCOOH > ClCH_2COOH$.

My Solution Breakdown: All of them are carboxylic acids. The only difference is the number of Chlorine ($-Cl$) atoms. Chlorine is highly electronegative; it shows a $-I$ **effect** (it pulls electrons).

- Cl_3CCOOH has **THREE** Chlorines pulling the negative charge. Massive stabilization!
 - $Cl_2CHCOOH$ has **TWO** Chlorines pulling. Good stabilization.
 - $ClCH_2COOH$ has only **ONE** Chlorine. Answer: More $-I$ groups = more dispersal of negative charge = stronger acid. Hence, 3 Chlorines make it the strongest acid.
-

Concept 2: Resonance Effect (The "Relay Race")

Inductive effect plays with single (σ) bonds. **Resonance plays with double/triple (π) bonds and lone pairs.**

- **Key traits:** Permanent effect. It involves the actual *movement* (delocalization) of π electrons across a molecule.
- **Rule:** Resonance can only happen if there is "Conjugation" (an alternating pattern like: Double-Single-Double, or Double-Single-Lone Pair, or Double-Single-Positive charge).

Think of resonance like passing a hot potato. If an atom has a positive charge, it can shift its double bond to move that positive charge to a neighboring atom. By sharing the burden across multiple atoms, the molecule becomes **extremely stable**.

Let's solve a MCQ (PDF 1, Page 3, Q12): Question: Which of the ions is the most resonance stabilized? (a) $C_2H_5O^-$ (b) $C_6H_5O^-$ (c) $(CH_3)_3CO^-$ (d) $(CH_3)_2CHO^-$

My Solution Breakdown: Resonance requires π bonds (double bonds). Options (a), (c), and (d) are just straight/branched carbon chains with single bonds. No double bonds = No resonance. Option (b) is $C_6H_5O^-$ (Phenoxide ion). C_6H_5- is a Benzene ring! A Benzene ring has alternating double and single bonds. The negative charge on Oxygen can participate in a relay race all around the benzene ring. Answer: (b) $C_6H_5O^-$

Concept 3: Electromeric Effect (The "Temporary Fake Friend")

This is the easiest one.

- **Key traits:** It is **TEMPORARY**. It *only* happens when an outside attacking chemical (reagent) approaches a multiple bond (like $C = C$ or $C = O$).
- The moment the attacker comes close, the π electrons completely shift to one of the atoms. If you remove the attacker, the electrons go back to normal.

Let's solve a 1-Mark MCQ (PDF 1, Page 2, Q10): Question: The displacement of electrons in a multiple bond in the presence of an attacking reagent is called:
My Solution Breakdown: Keyword here is "in the presence of an attacking reagent". The only temporary effect that requires an attacker is the Electromeric effect. *Answer: (b) Electromeric effect.*

Concept 4: Hyperconjugation (The "Sacrifice" or "No-Bond Resonance")

We know $+I$ effect pushes electrons. But there's another reason why Alkyl groups stabilize Carbocations (C^+). It's called Hyperconjugation.

- **How it works:** If you have a Carbocation (C^+), it has an empty p-orbital. If the Carbon *right next to it* (the Alpha-carbon) has a C-H single bond, those electrons in the C-H bond will temporarily lean over and overlap with the empty orbital to help out.
- Because the electrons leave the Hydrogen, it looks like there is "No Bond" between C and H for a split second.
- **The Trick:** Just count the **Alpha (α) Hydrogens!**
 - Alpha Carbon = The carbon directly attached to the C^+ (or double bond).
 - Alpha Hydrogens = The H's attached to the Alpha Carbon.
 - **More α -Hydrogens = More Hyperconjugation = More Stability!**

Let's solve a 1-Mark MCQ (PDF 1, Page 1, Q3): Question: Hyperconjugation is most useful for stabilizing which of the following carbocations? (a) Neopentyl (b) Tert-butyl (c) Iso-propyl (d) Ethyl

My Solution Breakdown: Let's count α -hydrogens for the common ones:

- **Tert-butyl:** $(CH_3)_3C^+$. The C^+ is attached to THREE $-CH_3$ groups. $3 \times 3 = 9$ α -hydrogens! (Massive stability).
 - **Iso-propyl:** $(CH_3)_2CH^+$. The C^+ is attached to TWO $-CH_3$ groups. $2 \times 3 = 6$ α -hydrogens.
 - **Ethyl:** $CH_3CH_2^+$. The C^+ is attached to ONE $-CH_3$ group. 3 α -hydrogens. *Answer: (b) Tert-butyl has the maximum number of α -hydrogens (9), so it has the maximum hyperconjugation.*
-

Module 6 Summary Check:

1. **Inductive (*I*) Effect:** Permanent tug-of-war in σ bonds. $-I$ (withdrawers) makes acids stronger. $+I$ (donors) stabilizes C^+ .
2. **Resonance (*R*) Effect:** Permanent relay race of π electrons in conjugated systems (like benzene). Extremely stabilizing.
3. **Electromeric (*E*) Effect:** Temporary shift of π electrons *only* when an attacker is present.
4. **Hyperconjugation:** Permanent "No-bond resonance" where adjacent σ C-H bonds stabilize an empty orbital. Count the α -hydrogens!

This was the heaviest module in the entire chapter. Read it twice if you need to.

Does the difference between Inductive (pulling through single bonds) and Resonance (moving through double bonds) make complete sense?

Module 7: Purification Methods.

In Organic Chemistry, when we make a compound in the lab, it's never 100% pure. It's like cooking—you have the main dish, but also eggshells, oil splatters, and burnt bits (impurities).

You need to know **WHICH method fits WHICH type of mixture**.

Key Trick: Look for the physical property difference (Boiling Point, Solubility, or Volatility).

Part 1: Purifying Solids

1. Sublimation (The "Poof" Method)

- **Concept:** Some solids skip the liquid phase and turn directly into gas when heated.
- **When to use:** When one component is "sublimable" (camphor, naphthalene, anthracene, benzoic acid) and the impurity is not.
- **Keywords:** "Solid to Gas", "Camphor", "Naphthalene".

From your PDF (PDF 1, Page 12, Q4a): *Question:* How is camphor purified?

Answer: **Sublimation.**

2. Crystallization (The "Sugar" Method)

- **Concept:** Solubility changes with temperature. Most things dissolve better in hot water than cold water.
- **When to use:** To separate a solid from impurities based on solubility differences.
- **Keywords:** "Sugar", "Solubility difference".

From your PDF (PDF 1, Page 1, Q5): *Question:* The most satisfactory method to separate a mixture of sugar is: *Answer:* **(a) Fractional crystallization.**

Part 2: Purifying Liquids (Distillation)

This is the most important part. There are 4 types. You must memorize the "Condition" for each.

Method	Condition / When to Use	Example
1. Simple Distillation	For liquids with a LARGE boiling point difference ($> 25K$ or $25^{\circ}C$).	Acetone ($329K$) and Water ($373K$).
2. Fractional Distillation	For liquids with a SMALL boiling point difference (Crude oil, Petroleum, separating Oxygen/Nitrogen from air.

Method	Condition / When to Use	Example
	$< 25K$). Uses a fractionating column.	
3. Vacuum Distillation (Reduced Pressure)	For liquids that DECOMPOSE (break down) at their normal boiling point.	Glycerol , Soap Industry, Sugarcane juice.
4. Steam Distillation	For substances that are Steam Volatile but Immiscible in water .	Aniline , Essential Oils, o-nitrophenol.

Let's solve a tricky Case-Study (PDF 1, Page 5, Q1c): *Question:* Which method is used to separate a mixture of glycerol and spent-lye in the soap industry?

My Solution Breakdown: Glycerol has a very high boiling point. If you heat it to boil it, it burns/decomposes. To save it, we lower the pressure so it boils at a lower temperature. *Answer: Distillation under reduced pressure (Vacuum Distillation).*

Let's solve a reasoning question (PDF 1, Page 4, Section C, Q1a): *Question:* Which distillation method is used to separate a mixture of o-nitrophenol and p-nitrophenol?

My Solution Breakdown: This is a classic!

- **o-nitrophenol** has Intramolecular Hydrogen Bonding (binds to itself). This makes it "selfish" and volatile (easy to turn to gas).
- **p-nitrophenol** has Intermolecular Hydrogen Bonding (binds to neighbors). This makes it "clingy" and non-volatile.
- Because "o-nitro" is steam volatile and "p-nitro" is not, we use Steam Distillation. *Answer: Steam Distillation.*

Part 3: Differential Extraction (The Separating Funnel)

- **Concept:** Oil and Water don't mix. If you have an organic compound dissolved in water, you can shake it with an organic solvent (like ether or chloroform). The compound prefers the organic solvent and moves there.
- **When to use:** To separate an organic compound from an aqueous (water) solution.
- **Keywords:** "Immiscible liquids", "Separating Funnel", "Kerosene and Water".

From your PDF (PDF 1, Page 4, Q10i): *Question:* Suggest a method to purify Kerosene containing water. *Answer: Use a Separating Funnel (Differential Extraction).*

Part 4: Chromatography (The Modern Way)

This separates mixtures based on how fast they move.

- **Stationary Phase:** The thing that stays still (e.g., Paper, Silica gel).
- **Mobile Phase:** The solvent that moves up.

Two Principles:

1. **Adsorption:** The substance *sticks* to the surface. (Used in **Column** and **TLC**).
2. **Partition:** The substance *dissolves* into the liquid trapped in the pores. (Used in **Paper Chromatography**).

Let's solve a MCQ (PDF 1, Page 3, Q15): *Question:* The principle involved in paper chromatography is: (i) Adsorption (ii) Partition (iii) Solubility (iv) Volatility

My Solution Breakdown: Paper chromatography uses water trapped in the paper fibers as the stationary phase. The separation is based on "Partitioning" between the moving solvent and the stationary water. *Answer: (ii) Partition.*

Let's solve a Case Study Question (PDF 1, Page 6, Q4c): *Question:* How is chloroform (BP 334 K) and aniline (BP 457 K) separated? Why?

My Solution Breakdown: Look at the numbers. $457 - 334 = 123K$. Is the difference large ($> 25K$) or small ($< 25K$)? It is HUGE. *Answer: Simple Distillation, because the difference in boiling points is very large.*

Module 7 Summary Check:

- **Solid to Gas?** Sublimation.
- **Decomposes on heating?** Vacuum Distillation.
- **Steam volatile + Insoluble in water?** Steam Distillation.
- **Close boiling points?** Fractional Distillation.
- **Large boiling point gap?** Simple Distillation.
- **Paper Chromatography?** Partition Principle.

If you can look at a mixture and instantly pick the right tool for the job, say "I am a Purifier" and we will move to the final boss

Module 8: Qualitative & Quantitative Analysis.

This module is split into two parts: **The Detective Work (Qualitative)** and **The Math (Quantitative)**. This is where you score the "difficult" marks that other students usually skip.

Part 1: Qualitative Analysis (The Detective Work)

Organic compounds are covalent. They don't give ions in water. To test them, we must violently convert them into **ionic** forms.

1. Lassaigne's Test (Sodium Fusion Test)

- **The Concept:** We heat the organic compound with Sodium metal (Na). Sodium is eager to donate electrons, so it breaks the covalent bonds and forms ionic salts.
- **The Transformations (Memorize these!):**
 - **Carbon + Nitrogen** → **NaCN** (Sodium Cyanide)
 - **Sulphur** → Na_2S (Sodium Sulphide)
 - **Halogens (Cl, Br, I)** → **NaX** (Sodium Halide)
 - **Nitrogen + Sulphur (together)** → **NaSCN** (Sodium Thiocyanate)

Let's solve a MCQ (PDF 1, Page 2, Q7): *Question:* During Lassaigne's test, Sulfur and Nitrogen present in an organic compound change into: (a) Na_2S and $NaCN$... (d) $NaCN$ and $NaCNO$

My Solution Breakdown: If S and N are present separately, they form Na_2S and $NaCN$. However, if they are present *together* in the same compound, they usually form **NaSCN**. Looking at the options, option (a) lists them as separate entities (Na_2S and $NaCN$), which is the standard expectation for individual tests unless specified "together in the fusion tube". *Answer: (a) Na_2S and $NaCN$.*

2. The Color Tests (The Evidence):

- **Nitrogen:** We add Iron ($FeSO_4 + FeCl_3$).
 - *Result:* **Prussian Blue** color (due to Ferriferous cyanide, $Fe_4[Fe(CN)_6]_3$).
- **Sulphur:** We add Lead Acetate.
 - *Result:* **Black Precipitate** (PbS).
 - *Alternative:* Sodium Nitroprusside → **Violet** color.
- **Nitrogen + Sulphur:** We add $FeCl_3$.
 - *Result:* **Blood Red** color ($Fe(SCN)^{2+}$).
- **Halogens:** We add Silver Nitrate ($AgNO_3$).
 - **Chlorine:** White ppt (soluble in NH_4OH).
 - **Bromine:** Pale yellow ppt (slightly soluble).
 - **Iodine:** Dark yellow ppt (insoluble).

A Crucial Reasoning Question (PDF 1, Page 6, Q3d): Question: Why should we add HNO_3 to Lassaigne extract before testing for halogens?

My Solution Breakdown: The extract contains $NaCN$ (from Nitrogen) and Na_2S (from Sulphur). Both of these react with silver nitrate ($AgNO_3$) to give precipitates that confuse the test.

- $NaCN + AgNO_3 \rightarrow$ White ppt (looks like Chlorine!)
- $Na_2S + AgNO_3 \rightarrow$ Black ppt.
- **Boiling with HNO_3 destroys these imposters (HCN gas and H_2S gas escape), leaving only the halogens behind.**

Part 2: Quantitative Analysis (The Math)

Here, we calculate the **Percentage (%)** of an element. I will give you the "Cheat Codes" (Formulas) and we will apply them to the hardest numericals in your PDF.

1. Carbon and Hydrogen (Combustion)

- **Formulas:**

$$\begin{aligned} \circ \quad \%C &= \frac{12}{44} \times \frac{\text{Mass of } CO_2}{\text{Mass of Compound}} \times 100 \\ \circ \quad \%H &= \frac{2}{18} \times \frac{\text{Mass of } H_2O}{\text{Mass of Compound}} \times 100 \end{aligned}$$

Let's solve the Numerical (PDF 2, Page 9, Section B, Q3): Question: 0.45g of organic compound gave 1.10g CO_2 and 0.30g H_2O . Calculate %C and %H.

My Solution Breakdown: Mass of Compound (m) = 0.45g. Mass of CO_2 = 1.10g. Mass of H_2O = 0.30g.

Step 1: Calculate %C $\%C = \frac{12}{44} \times \frac{1.10}{0.45} \times 100$ Let's simplify: $\frac{12}{44} \approx 0.2727$.
 $\frac{1.10}{0.45} \approx 2.44$. $0.2727 \times 2.44 \times 100 = 66.67\%$

Step 2: Calculate %H $\%H = \frac{2}{18} \times \frac{0.30}{0.45} \times 100$ $\frac{2}{18} = \frac{1}{9}$. $\frac{0.30}{0.45} = \frac{30}{45} = \frac{2}{3}$. So,
 $\frac{1}{9} \times \frac{2}{3} \times 100 = \frac{2}{27} \times 100 = 7.41\%$

Answer: C = 66.67%, H = 7.41%

2. Nitrogen (The Heavyweights: Dumas vs. Kjeldahl)

Method A: Dumas Method (Collects Nitrogen gas)

- $$\%N = \frac{28}{22400} \times \text{Volume at STP (mL)} \times \frac{100}{\text{Mass of Compound}}$$
Formula:
- Note:** You often have to use $P_1V_1/T_1 = P_2V_2/T_2$ to convert the given volume to STP first!

Method B: Kjeldahl's Method (Converts N to Ammonia)

- $$\%N = \frac{1.4 \times \text{Molarity of Acid} \times \text{Volume of Acid Used}}{\text{Mass of Compound}}$$
Formula: (Note: If Normality is given, use 1.4. If Molarity is given, check the valency factor of the acid! Usually, for H_2SO_4 , Normality = $2 \times$ Molarity).

Let's solve the Numerical (PDF 1, Page 5, Q10): Question: Ammonia produced from **0.75g** of substance was neutralized by **30 mL** of **0.25 N** H_2SO_4 . Calculate % Nitrogen.

My Solution Breakdown: Mass (m) = 0.75g Normality (N) = 0.25 Volume (V) = 30 mL

Use the formula directly:
$$\%N = \frac{1.4 \times N \times V}{m} \quad \%N = \frac{1.4 \times 0.25 \times 30}{0.75}$$

Let's do the math: $1.4 \times 30 = 42$ $42 \times 0.25 = 10.5$ (Quarter of 42)
 $10.5/0.75 = 1050/75 = 14$

Answer: 14.00% Nitrogen

3. Halogens (Carius Method)

- $$\%X = \frac{\text{Atomic Mass of X}}{\text{Molar Mass of AgX}} \times \frac{\text{Mass of AgX}}{\text{Mass of Compound}} \times 100$$
Formula:
 - Atomic Masses: Cl=35.5, Br=80, I=127, Ag=108.
 - Molar Masses: AgCl=143.5, AgBr=188, AgI=235.

4. Sulphur (Carius Method)

- $$\%S = \frac{32}{233} \times \frac{\text{Mass of } BaSO_4}{\text{Mass of Compound}} \times 100$$
Formula:

Module 8 Summary Check:

- Lassaigne's Test:** NaCN (for N), Na₂S (for S), NaX (for Halogens).
- Prussian Blue:** Nitrogen.
- Blood Red:** N + S together.

- **Kjeldahl Formula:** $\%N = 1.4 \times N \times V/m$.
 - **Carius:** Uses Silver Nitrate (AgNO_3) for Halogens and Barium Chloride (BaCl_2) for Sulphur.
-

🚩 CONGRATULATIONS! 🚩

You have officially completed all 8 Modules of **Organic Chemistry: Some Basic Principles and Techniques**.

You now possess the logic to:

1. Count σ and π bonds.
2. Draw structures and identify functional groups.
3. Name any molecule (IUPAC).
4. Identify Isomers.
5. Predict reaction intermediates and mechanisms.
6. Use Inductive, Resonance, and Hyperconjugation to determine stability/acidity.
7. Choose purification methods based on BP/Solubility.
8. Detect elements and calculate percentages.

This is the moment of truth. I want you to open your PDF question banks. Scroll through them randomly. Pick a question. Try to solve it in your head or on paper.