AKTU

GATEWAY CLASSES

B.Tech I-Year

Engg.Chemistry

Unit-5

ONE SHOT Revision

All Topics Unit-5

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POLYMER

POLYMER (poly = many; merose = parts).
Polymers are macromolecules made of repeating units called monomers.
Example: Polythene, PVC, nylon-6,6.

MONOMERS

Monomers are small repeating units of polymers.
For example, ethene ($CH_2=CH_2$), act as monomer in polythene.

POLYMERISATION

Is the process where monomers join by strong covalent bonds to form polymers.

FUNCTIONALITY

Number of binding sites in a monomer is called its functionality.

For example, the functionality of ethene and propene is 2, as it can form two new bonds.

*Condition for a molecule to act as monomer: A molecule can act as a monomer only if it is at-least bifunctional in nature.

DEGREE OF POLYMERISATION (DP)

The number of repeating units (n) in a polymer chain is known as degree of polymerisation.

Degree of Polymerization (DP) = M/m = n

Where M= Mass of Polymer and m = mass of monomeric unit.

CHARACTERISTICS OF POLYMERS

- All the polymers are macromolecules, but all the macromolecules are not polymers.
- Low tensile strength, low density.
- Easy to work with.
- High resistance to corrosion.
- Generally insulators, few are conductors.
- Properties of polymers depend on their molecular weight, type of bonds between various chains.

CLASSIFICATION OF POLYMER

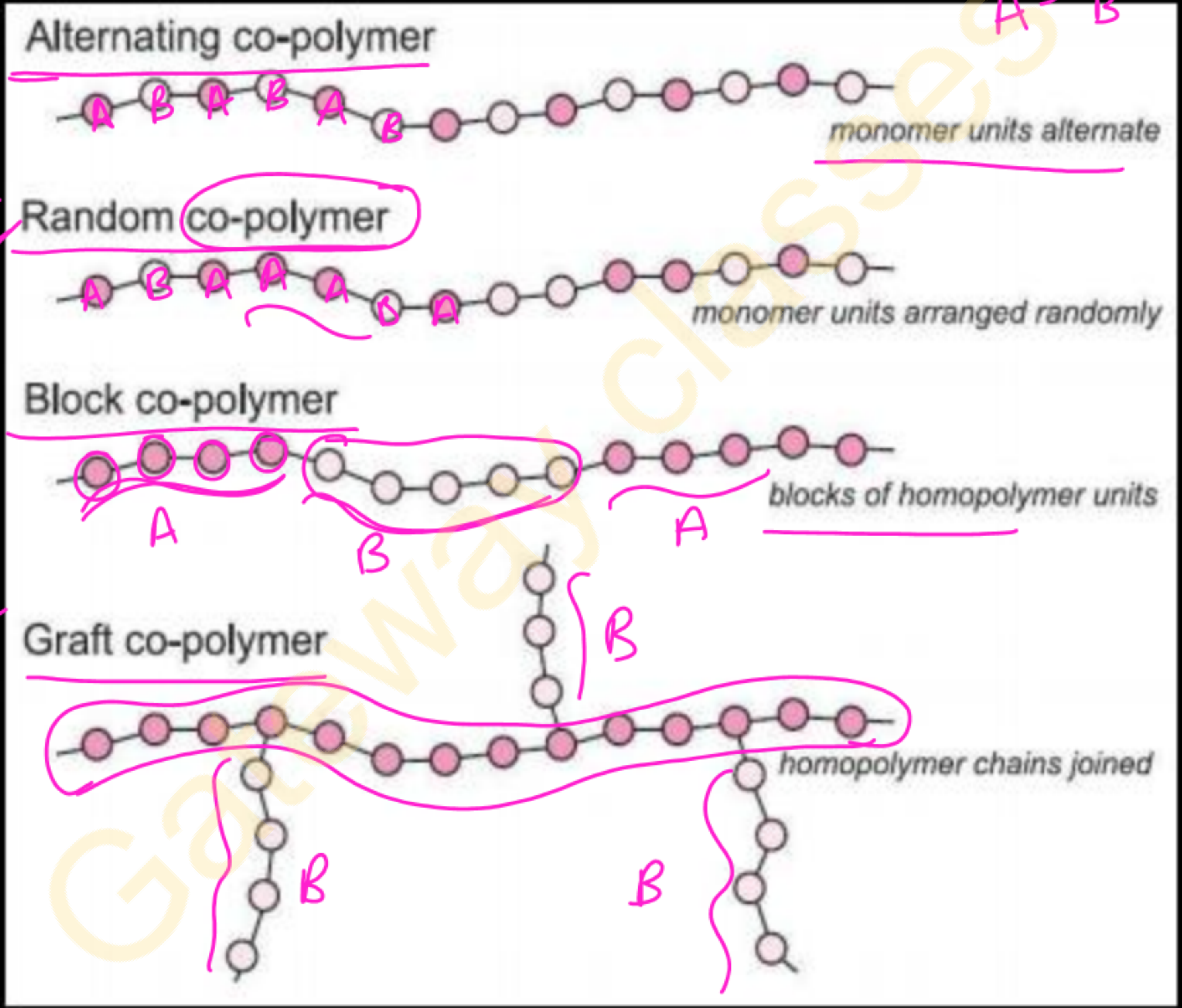
- Based on Number of Monomers
- Based on Action of Heat
- Based on Mode of Formation (polymerisation) → process
- Based on Structure
- Based on Tacticity (or configuration)

or arrangement → side groups / side chain

BASED ON NUMBER OF MONOMERS

HOMOPOLYMERS	COPOLYMERS
Polymers made up of same monomer units.	Polymers made up of two or more than two different monomer units.
Example: Polyethene, PVC.	Example: Buna-N, Buna-S, Nylon-6,6.

CLASSIFICATION OF CO-POLYMER



ON THE BASIS OF ACTION OF HEAT

Thermoplastic resins (or) Polymers	Thermosetting resins
Formed by additional polymerization.	Formed by condensation polymerization.
Chains are linked by weak Vander Waal's forces.	Have three dimensional network structure.
On heating they soften and on cooling become	On heating become stiff & hard.
They can be remoulded.	They cannot be remoulded.
Can be reused.	Cannot be reused.
Soft, weak and less brittle.	Hard, strong tough & more brittle.
Soluble in organic substances.	Insoluble in organic solvents.
Long chain polymer with no cross linkage.	They have 3D network structure.
Ex- PCV	Ex- Bakelite

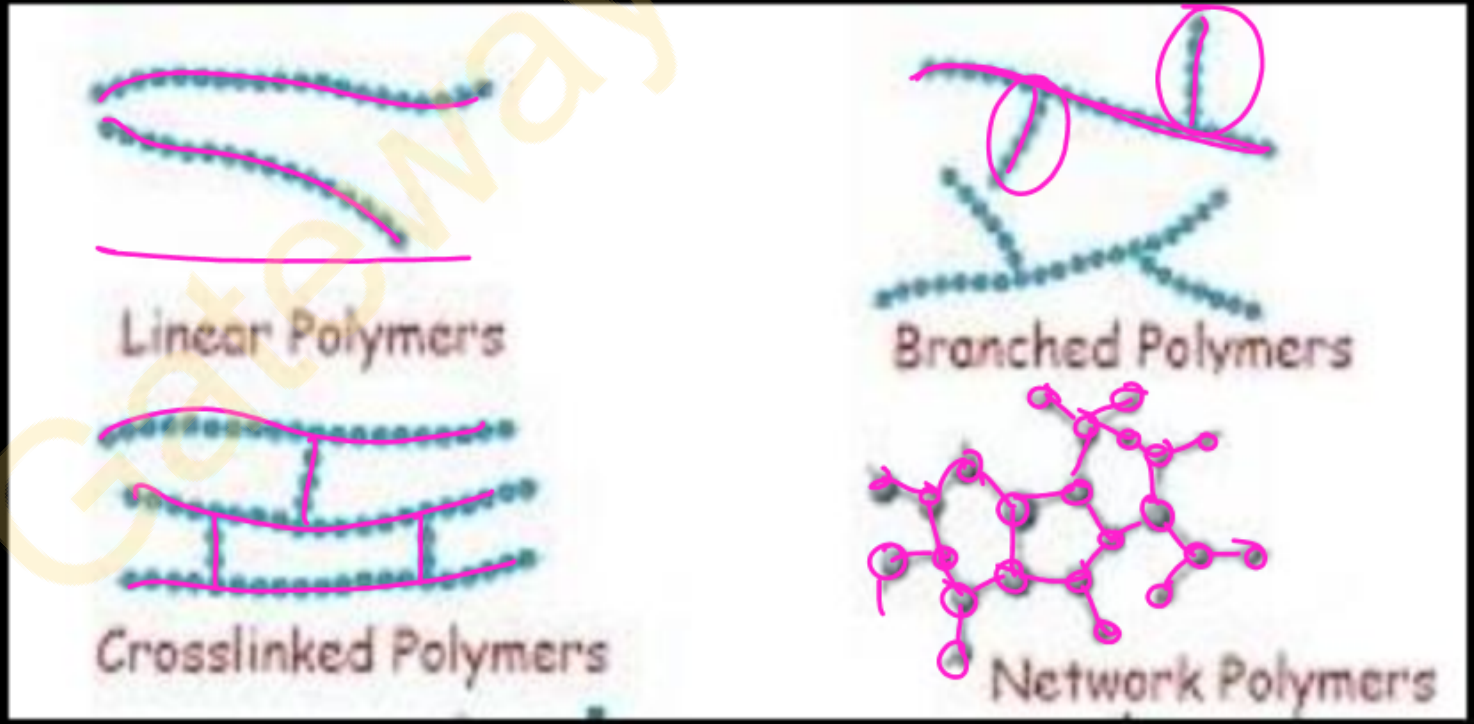
ON THE BASIS OF STRUCTURE

Linear polymers: Long straight chains without any side chains. Ex – HDPE

Branched polymers: Long chains with different side chains. Ex – LDPE

Cross linked polymers: Monomeric units link together into 3 dimensional network structures. Ex – Bakelite.

Network polymers: A polymer network is like a three-dimensional net made out of long, molecular string. Ex- Nylon-6,6.



ON THE BASIS OF SYNTHESIS

Condensation polymerisation	Additional polymerisation
Also known as step growth polymerisation	Also known as chain growth polymerization
Shown by monomers with reactive functional groups.	Shown by monomers with multiple bonds.
Elimination of simple molecule like H_2O, NH_3, HCl etc.	No elimination.
Monomers are different.	Monomers are same.
The polymer is formed in steps.	Reaction is fast and polymer is formed at once.
The molecular mass increases throughout.	Very little change in the molecular mass.
E.g.:- Bakelite, polyester ,polyamides etc.	E.g:-Polyethylene, PVC, poly styrene.

ON THE BASIS OF TACTICITY

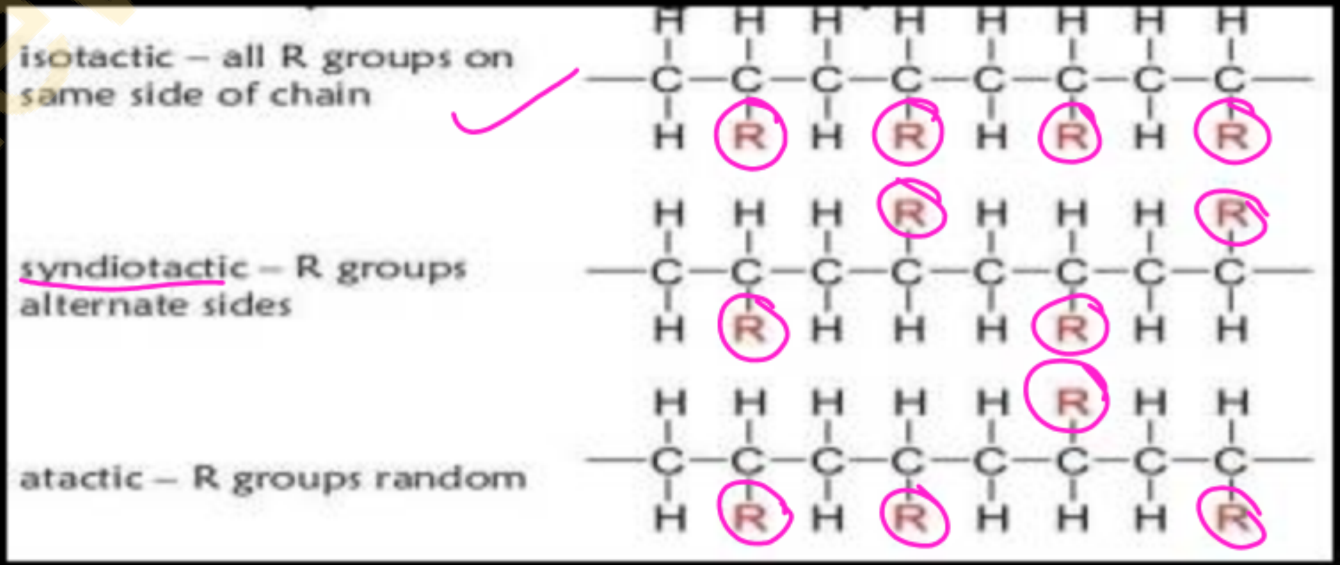
Tacticity: It is orientation or arrangement of side chains/groups on both the sides of main polymeric chain.

On the basis of tacticity there are three types of polymers:

i) **Isotactic:** Functional groups on the same side of the main carbon skeleton e.g. Natural rubber

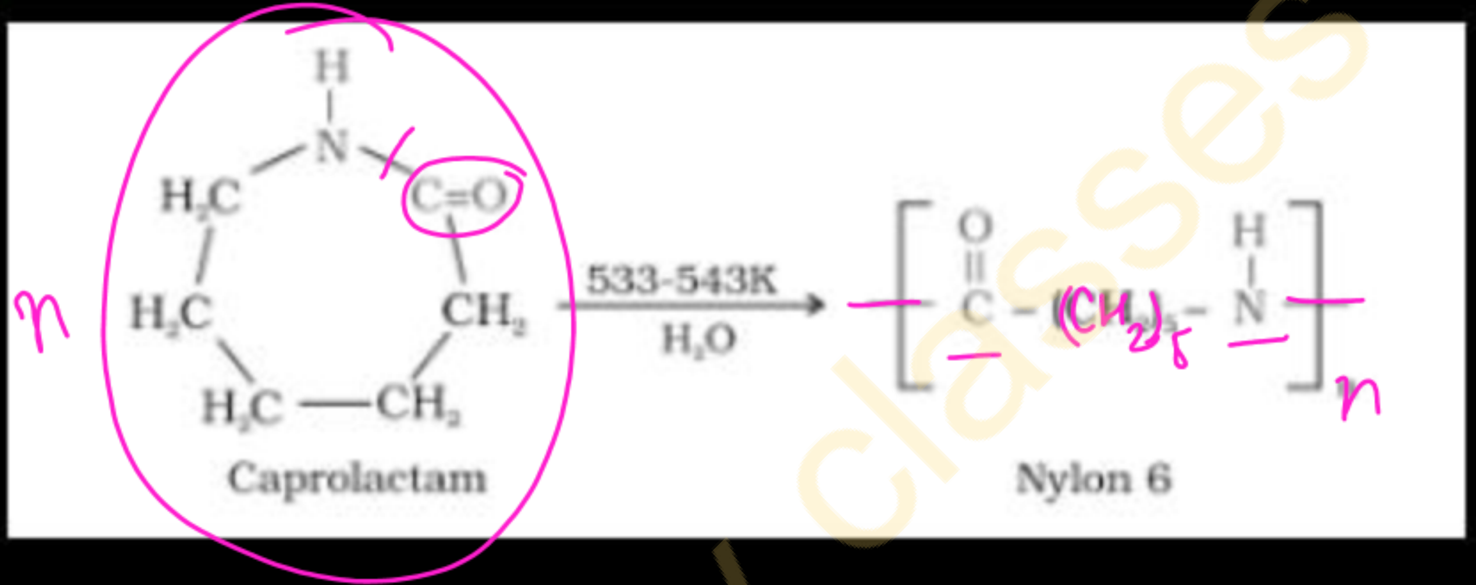
ii) **Syndiotactic**: Functional groups arranged in the alternate fashion of the main carbon skeleton e.g. Gutta percha

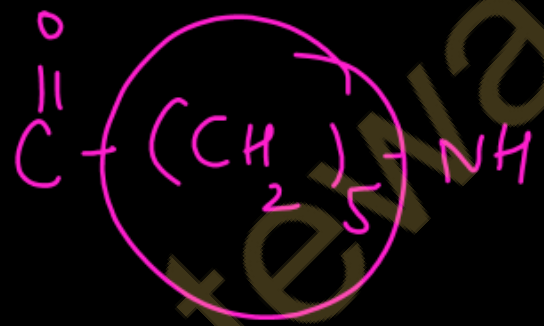
iii) **A-tactic**: Functional groups arranged in a random manner around the main carbon skeleton e.g. all vinyl polymers



PREPARATION OF POLYMER

NYLON-6





Properties:

Tough, High tensile strength, elastic in nature, have shine.

Applications

- Gears, fittings and bearings.
- In toothbrushes.
- In guitars, sitars, violins etc.
- Making threads, ropes, nets.

Environmental Impact:

(i) Energy Consumption: The production process involves the polymerization of caprolactam, which requires high temperatures and pressures. This process results in a significant contribution to greenhouse gas emissions.

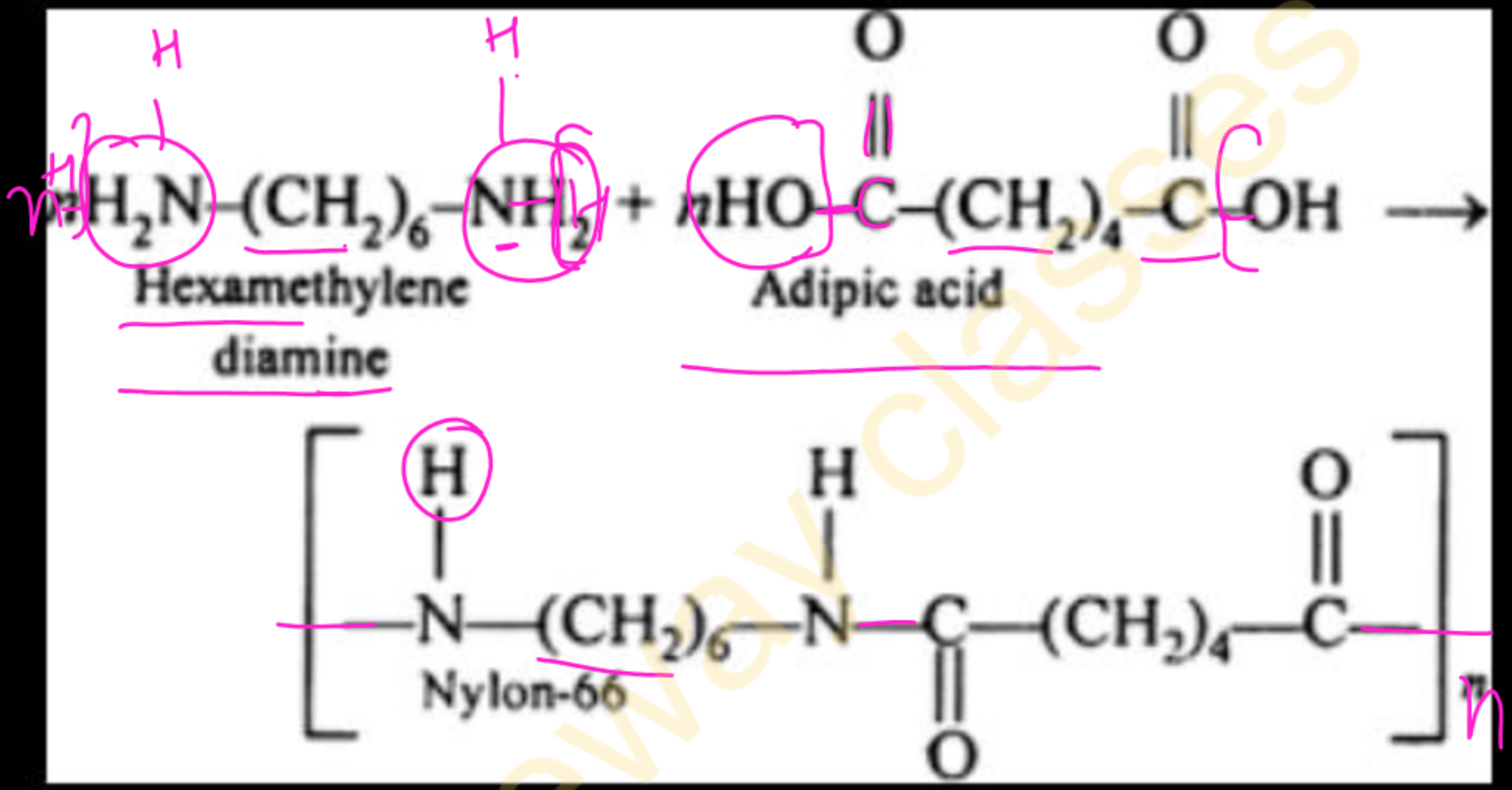
(ii) Water Consumption: The production of Nylon 6 requires a large amount of water. Water is used in the production of the raw materials, as well as in the manufacturing process. The production of Nylon 6 can therefore have a significant impact on local water resources.

(iii) Landfill Waste: Nylon 6 is not biodegradable and can take hundreds of years to break down in landfills. This can lead to significant waste management issues and contribute to environmental pollution.

(iv) Recycling Challenges: Nylon 6 can be recycled, but it requires a specialized recycling process that is not widely available. This makes recycling Nylon 6 more difficult and costly than other material.

NYLON-6,6

Copolymer



NYLON-6,6

Properties:

Light weight, water resistant, high melting point.

Applications

- Used in parachutes.
- To make swimwear
- Used to make machine parts.
- To make airbags, socks, carpets, ropes, tyres.

Environmental Impact:

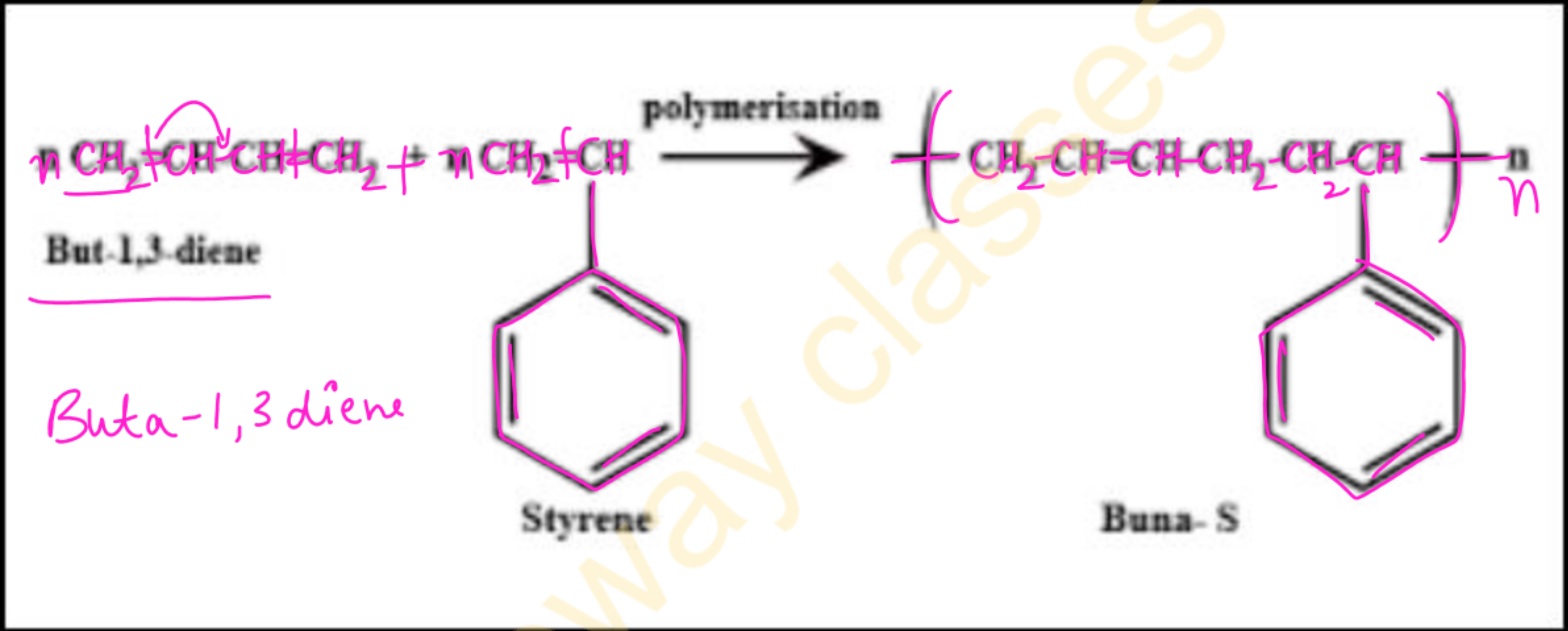
(i) Energy Consumption: Nylon-6,6 production requires a significant amount of energy, primarily derived from fossil fuels. The production of nylon 6,6 also releases greenhouse gases and other pollutants into the atmosphere, contributing to climate change.

(ii) Water Consumption: The production of nylon-6,6 requires a substantial amount of water, especially during the manufacturing of the raw materials. The water usage can be further leads to water scarcity and depletion of freshwater resources.

(iii) Waste Generation: Nylon-6,6 production generates significant amounts of waste, including solid and liquid waste. The solid waste includes nylon scraps and trimmings, which may end up in landfills, contributing to environmental pollution.

(iv) Chemical Pollution: The production of nylon-6,6 involves the use of various chemicals, including adipic acid, which can be harmful to human health and the environment. These chemicals can be released into the air, water, or soil, potentially contaminating surrounding ecosystems.

BUNA-S



n CH2=CH-CH=CH2 + n CH2=CH
polymerisation
CH2-CH=CH-CH2-CH2-CH
n
But-1,3-diene
Buta-1,3 diene
Styrene
Buna- S

Properties:

High load bearing capacity; gets oxidized in the presence of ozone; Swells in oils and solvents.

Applications:

- Used in shoe soles, gaskets
- Chewing gum
- As a sealing and binding agent
- Car, motor cycle, scooter & cycle tyres
- Electrical insulation

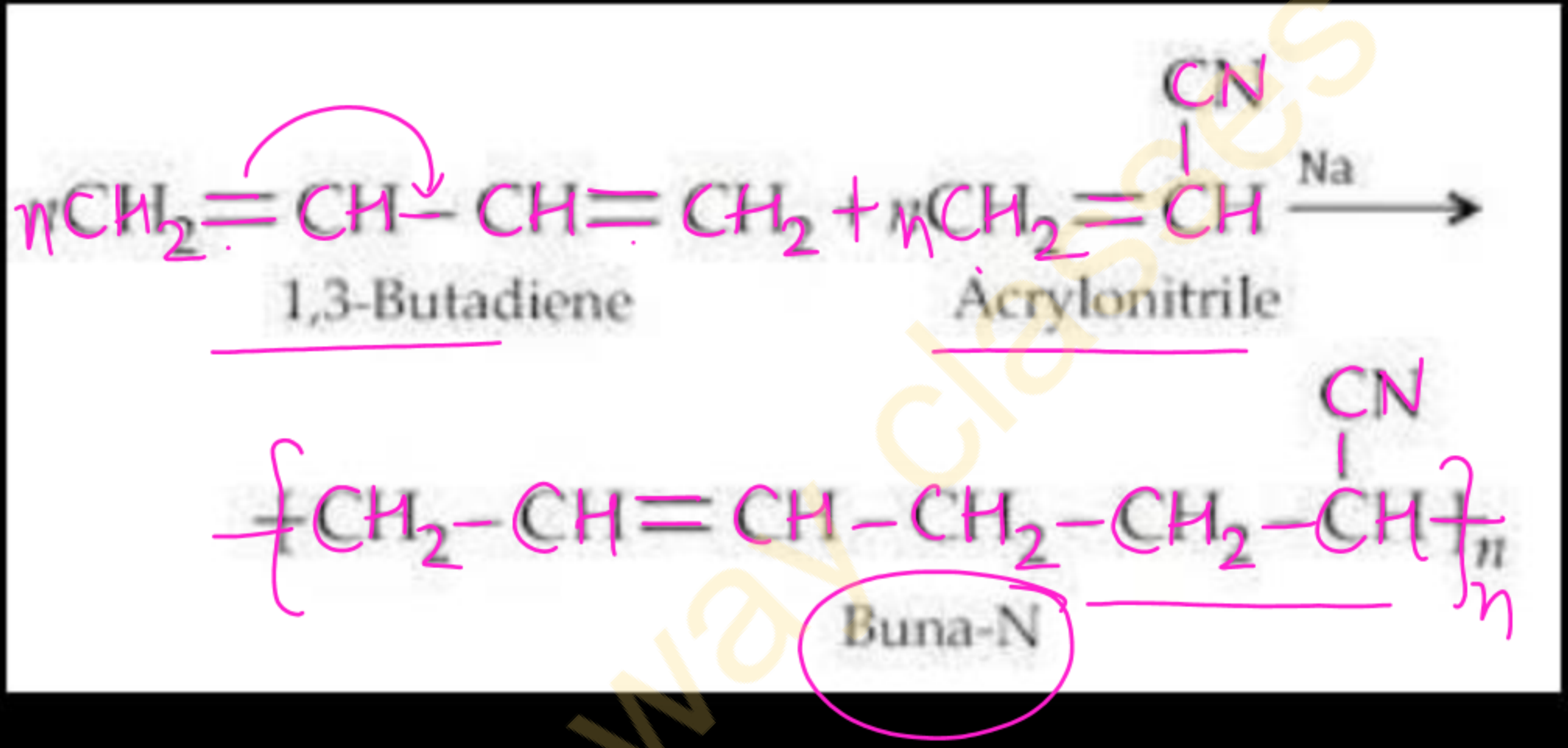
Environmental Impact:

(i) Air pollution: The production of Buna-S involves the emission of volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) such as butadiene, styrene, and benzene. These chemicals can have harmful effects on human health, and they contribute to the formation of smog and ground-level ozone, which can damage crops and other vegetation.

(ii) Water pollution: Buna-S production also generates wastewater that can contain high levels of pollutants such as heavy metals, solvents, and other organic compounds. These pollutants can be harmful to aquatic life and can also contaminate drinking water sources.

(iii) Energy consumption: The production of Buna-S is an energy-intensive process that requires significant amounts of fossil fuels. This contributes to greenhouse gas emissions and climate change.

BUNA-N



BUNA-N

Properties:

Highly polar, oil resistant.

Applications:

- Conveyor belts
- Seals, gaskets
- Protective gloves in the nuclear industry
- Aeronautical application
- Tank lining
- Adhesives

Environmental Impact:

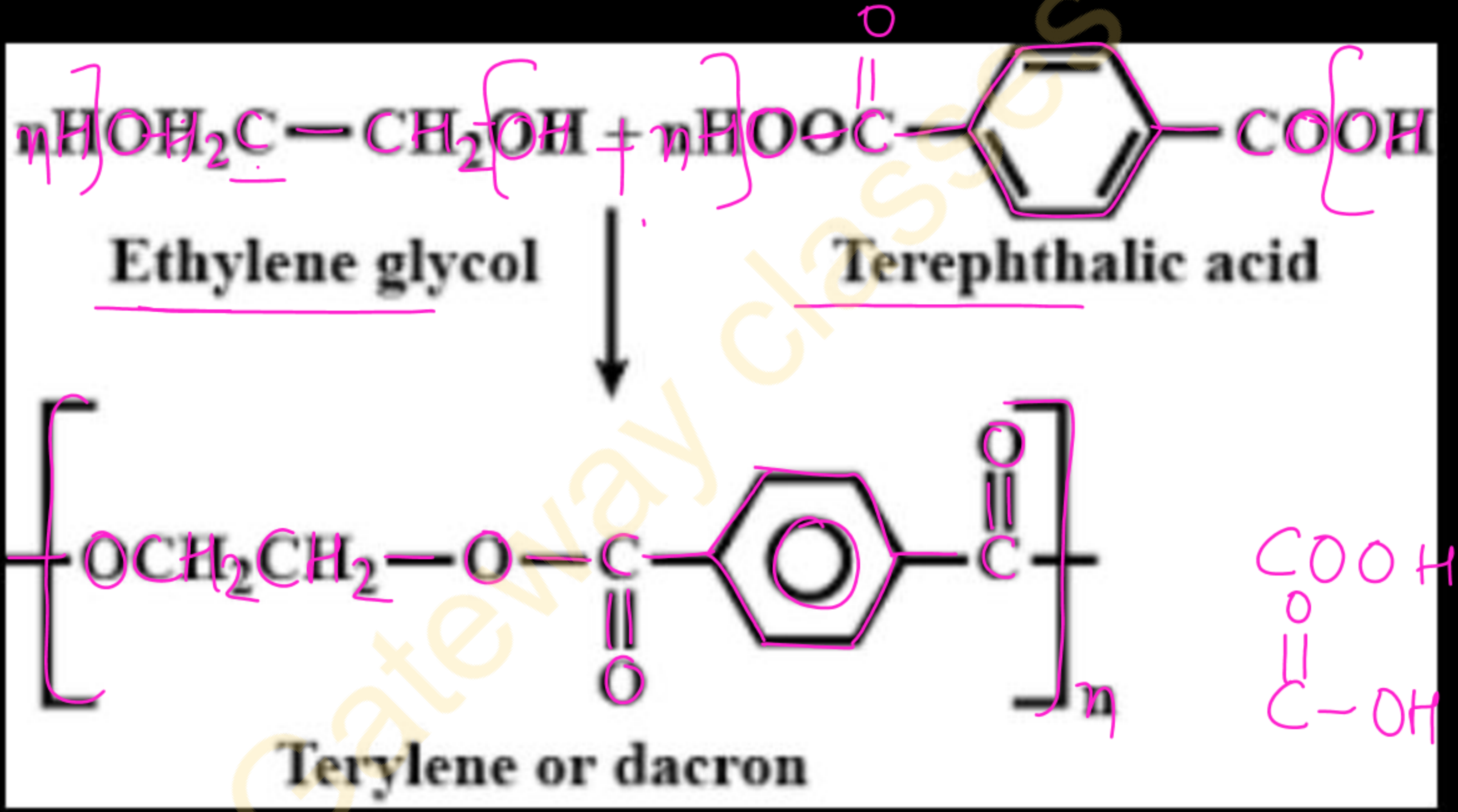
(i) Production: The production of Buna-N requires the use of petroleum-based feedstocks and various chemicals, which can contribute to air and water pollution.

(ii) Disposal: Buna-N rubber is not biodegradable, so it will persist in the environment for a long time if not properly disposed of.

(iii) Recycling: While Buna-N rubber can be recycled, the process is not as straightforward as recycling other materials, such as plastic or metal. This means that recycling Buna-N products is less common, which can contribute to waste and pollution.

(iv) Health impacts: Buna-N rubber can release harmful chemicals into the environment, such as acrylonitrile, which is a known carcinogen. These chemicals can also be harmful to wildlife and ecosystems.

DACRON/ TERYLENE/ POLYETHYLENE TEREPHTHALATE



Properties:

Resistant to mineral & organic acids, Hydrophobic in nature, high melting point.

Applications

- Used in Ropes, Nets, Thread.
- To make Raincoats

Environmental Impact:

(i) Energy Consumption: The process of manufacturing Dacron involves several stages, including the production of PET, the spinning of the fiber, and the weaving or knitting of the fabric. The energy used in these processes contributes to greenhouse gas emissions and contributes to climate change.

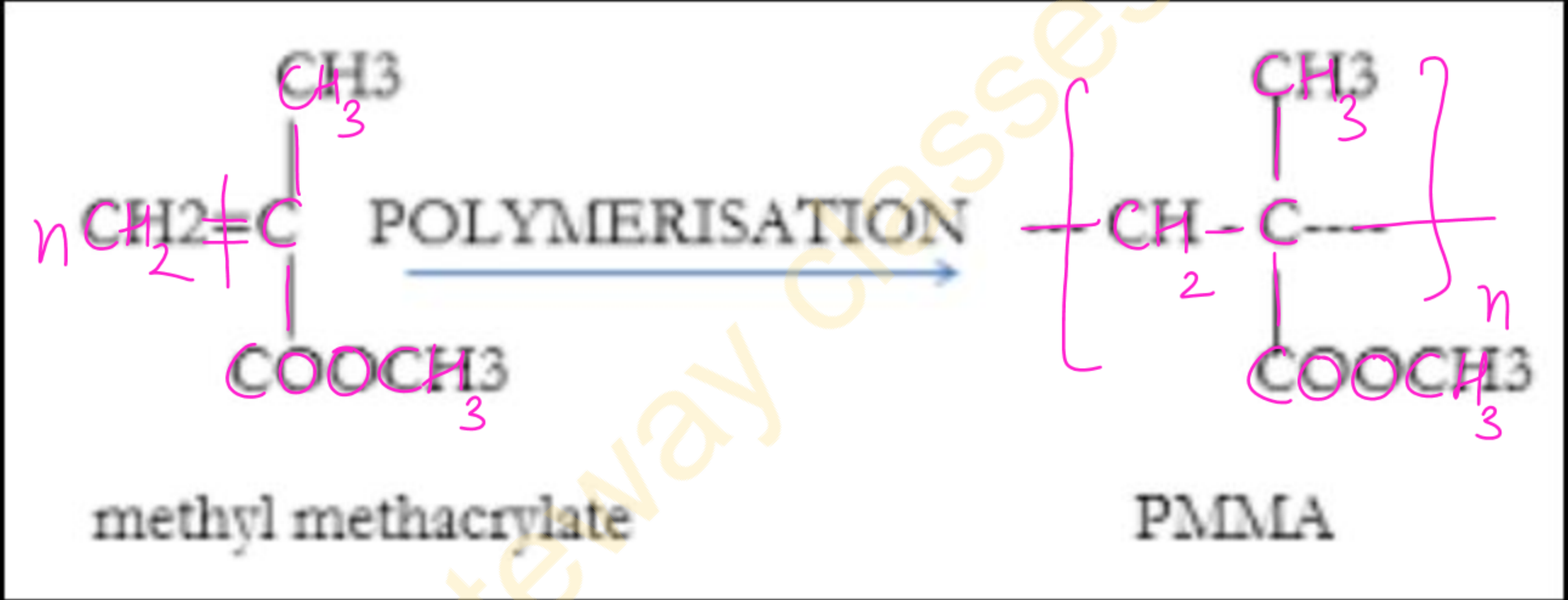
(ii) Pollution: The manufacturing process of Dacron produces several pollutants such as sulfur dioxide, nitrogen oxides, and volatile organic compounds that can have harmful effects on human health and the environment.

(iii) Landfill waste: Dacron products are not biodegradable. This results in landfill waste, which can contribute to the depletion of available landfill space.

(iv) Microplastics: Over time, Dacron products break down into smaller pieces known as microplastics. These microplastics can end up in waterways, oceans, and soil, where they can harm wildlife and the environment.

LUCITE/POLYMETHYL METHACRYLATE

PMMA



PMMA/LUCITE/PERSPEX

Properties:

Good shock resistance ability

It is colourless and highly transparent

Applications:

- Boat windshields
- Camera lens
- Automobile stoplights and taillights

Environmental Impact:

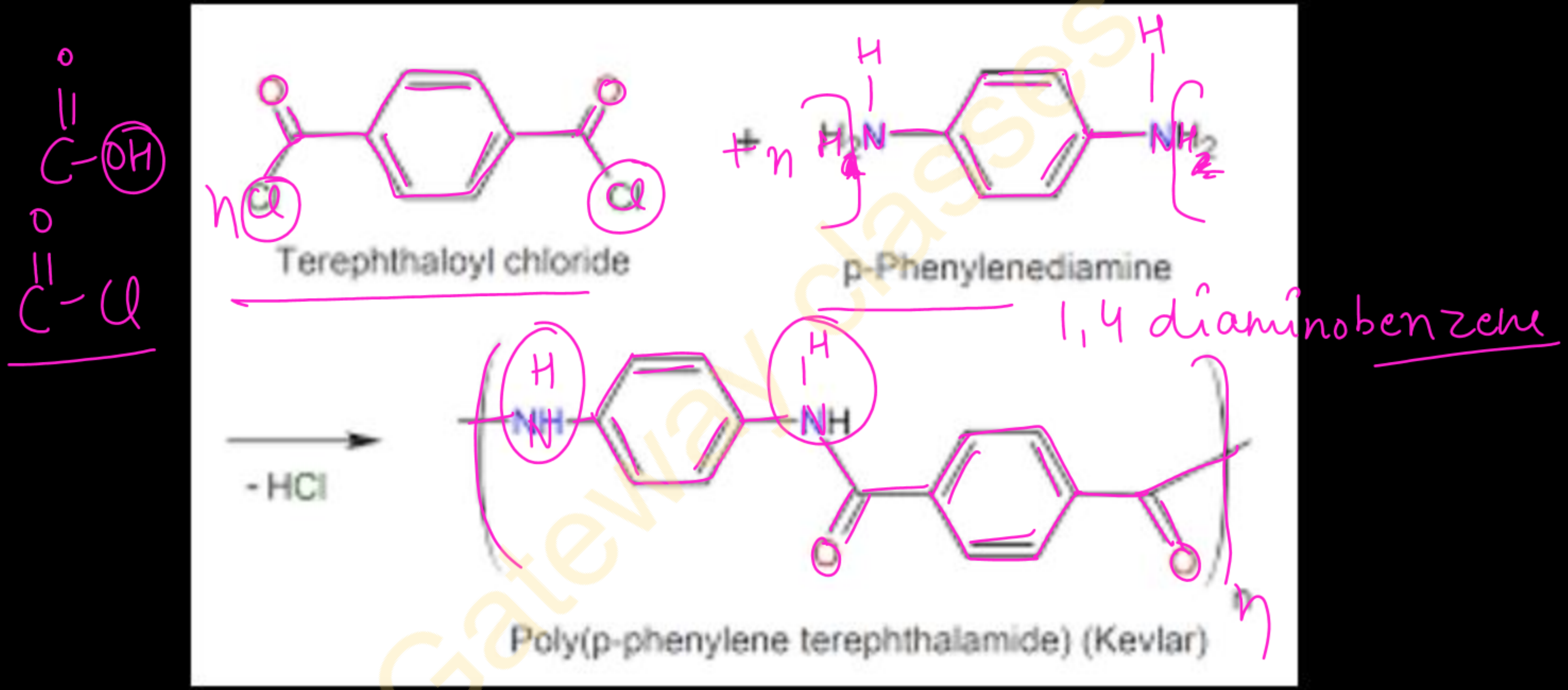
(i) The production of PMMA involves the extraction and processing of fossil fuels, which contributes to greenhouse gas emissions and other forms of pollution.

(ii) LUCITE can contribute to plastic pollution if they are not properly disposed of. If LUCITE ends up in a landfill, it may take hundreds of years to break down, releasing toxic chemicals and microplastics into the environment.

(iii) LUCITE has some environmental benefits. For example, it is durable and long-lasting, which means it can be used for a wide range of applications, such as in the construction industry where it can be used for windows, roofing, and insulation.

(iv) LUCITE is also recyclable, and it can be turned into a variety of products, including new acrylic sheets and other plastic materials.

KEVLAR


Terephthaloyl chloride
p-Phenylenediamine
1,4 diaminobenzene
- HCl
Poly(p-phenylene terephthalamide) (Kevlar)

Properties:

High strength, toughness and high heat stability.

Applications:

- Tyres, breaks, clutch lining and other car parts.
- Bullet-proof vests.
- Motor cycle helmets.
- Aerospace and aircraft industries.

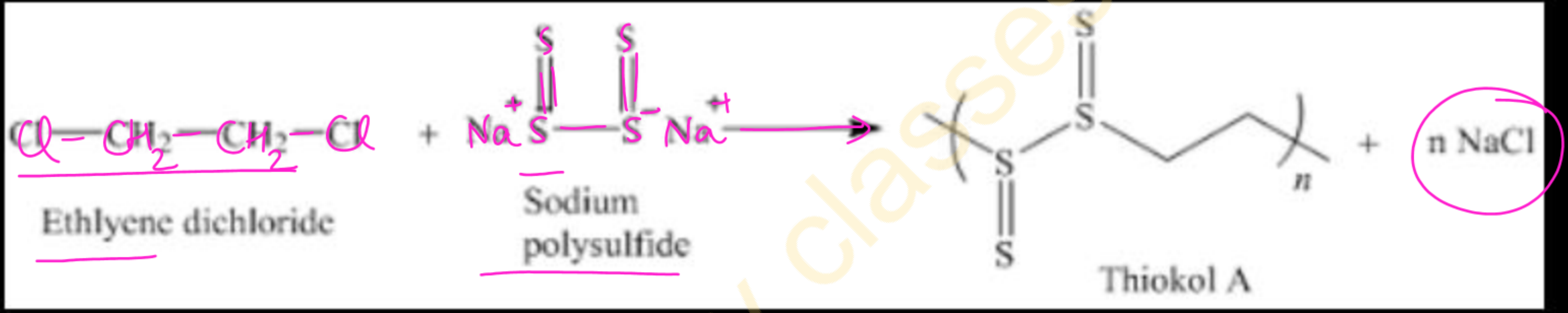
Environmental Impact:

(i) Production of Kevlar involves the use of several toxic chemicals, including sulfuric acid, nitric acid, and para-phenylenediamine. These chemicals can cause severe environmental pollution if not handled correctly.

(ii) The production of Kevlar also requires a considerable amount of energy, which contributes to greenhouse gas emissions and climate change.

(iii) Kevlar is not biodegradable, and it does not break down easily in landfills. Burning of Kevlar products releases toxic fumes into the air, which can be harmful to human health and the environment.

THIOKOL



$(CH_2)_2Cl_2 + Na_2S_n$

or

$ClCH_2CH_2Cl$

$\{CH_2-CH_2-S_n\}$

Thiokol

Properties:

Good crack resistance, outstanding low temperature flexibility

Good resistance to oil, ozone, oxygen and many chemicals including ethers, ketones and aromatic hydrocarbons.

Applications:

- Sealants and adhesives in building construction.
- Aircraft, and automobile industry.

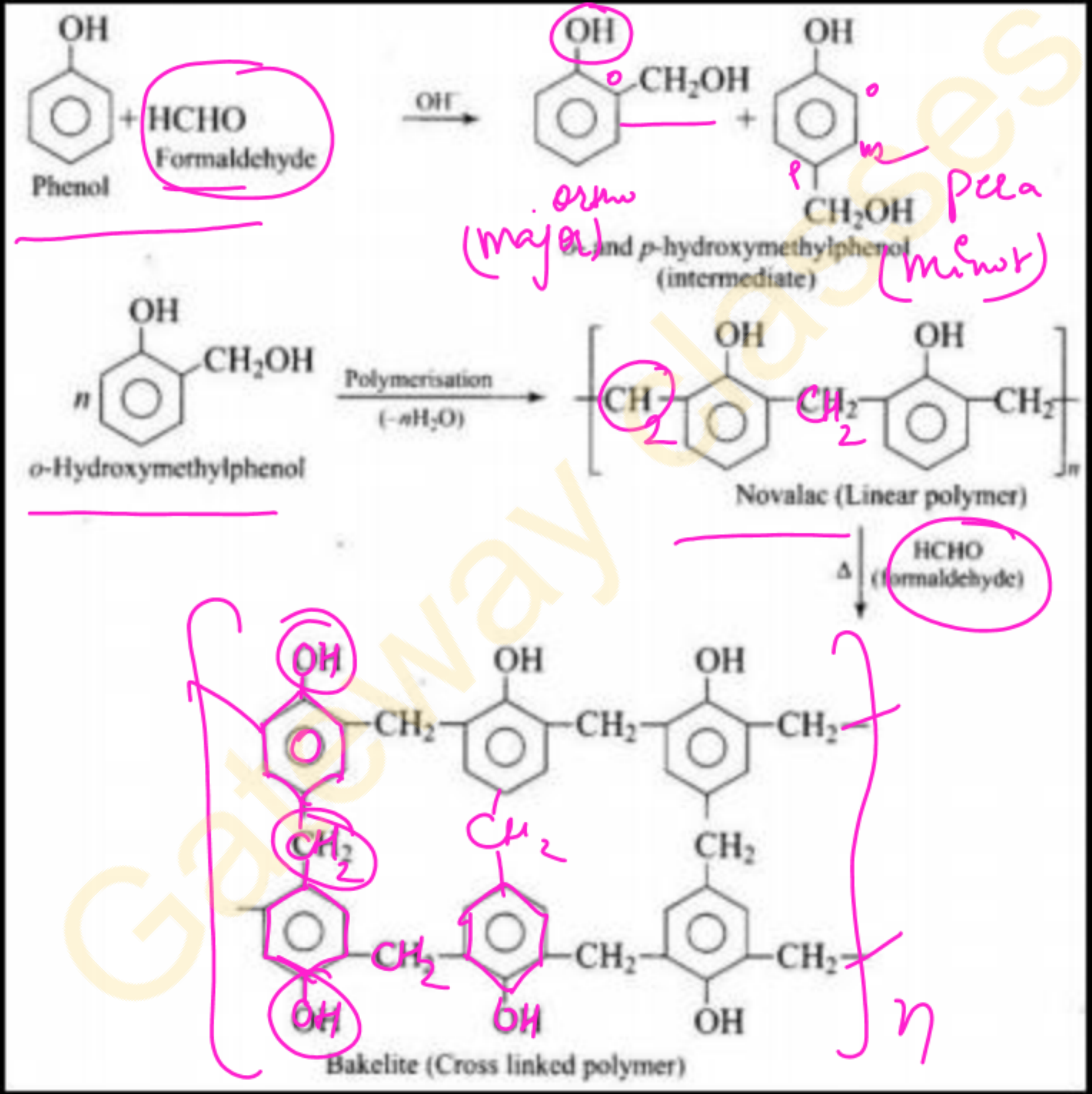
Environmental Impact:

(i) One of the main environmental concerns associated with thiokol polymer is its potential to release sulfur compounds, which can contribute to air pollution and acid rain.

(ii) When thiokol polymer-containing products are disposed of improperly or burned, they can release sulfur dioxide and other harmful gases into the atmosphere. Additionally, the production of thiokol polymer may generate hazardous waste and byproducts that require special handling and disposal procedures.

(iii) Another environmental impact of thiokol polymer is its potential to harm aquatic life. When thiokol-containing products are used in marine environments, the polymer can break down into small particles that can be ingested by aquatic organisms, potentially causing harm to their digestive systems and overall health.

BAKELITE



Phenol
HCHO
Formaldehyde
OH⁻
o- and p-hydroxymethylphenol
(intermediate)
o-Hydroxymethylphenol
Polymerisation
(−nH₂O)
Novalac (Linear polymer)
HCHO
(formaldehyde)
Bakelite (Cross linked polymer)

Properties:

Bakelite is resistant to electric current.

Applications:

- Used as moulded objects in radio cabinets/ TV, phone and automobile parts.
- Electrical fittings: Switches, plugs, heater handles, switch boards.

Bakelite

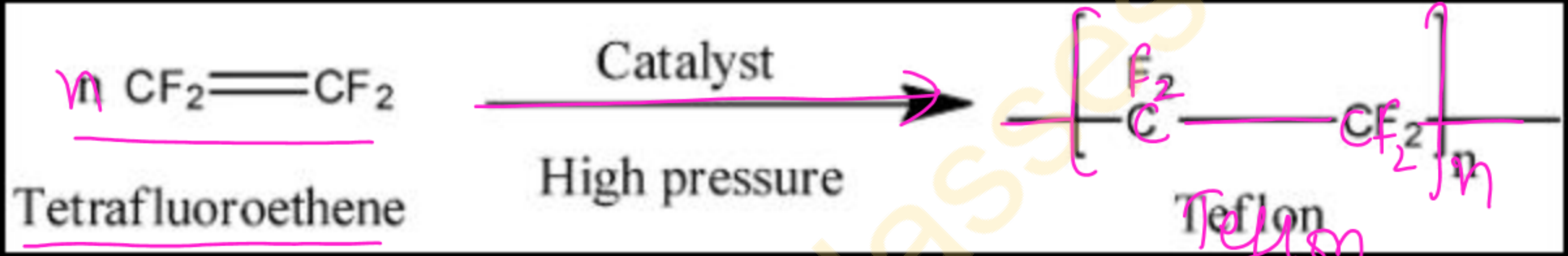
Environmental Impact:

(i) Production: The production of Bakelite polymer requires the use of formaldehyde, a toxic and carcinogenic chemical. While modern production methods have significantly reduced the amount of formaldehyde used, there is still some environmental impact associated with the production process.

(ii) Use: Bakelite is a very durable and long-lasting material, which can be both a positive and negative factor from an environmental perspective. Its durability means that it can be used for a long time without needing to be replaced, which reduces the need for new materials and manufacturing processes.

(iii) Non-biodegradable: Bakelite is difficult to recycle or dispose of properly, which can lead to environmental problems.

TEFLON


n CF2=CF2
Catalyst
High pressure
Tetrafluoroethene
CF2
n
Teflon

Properties:

It shows good resistance towards heat and low temperature.

It has an anti-adhesion ability due to which it is used as non-stick kitchen utensils.

Applications:

- It is used in making non-stick cookware.
- Due to its high resistance to corrosion, it is used for coating the laboratory appliances.

Environmental Impact:

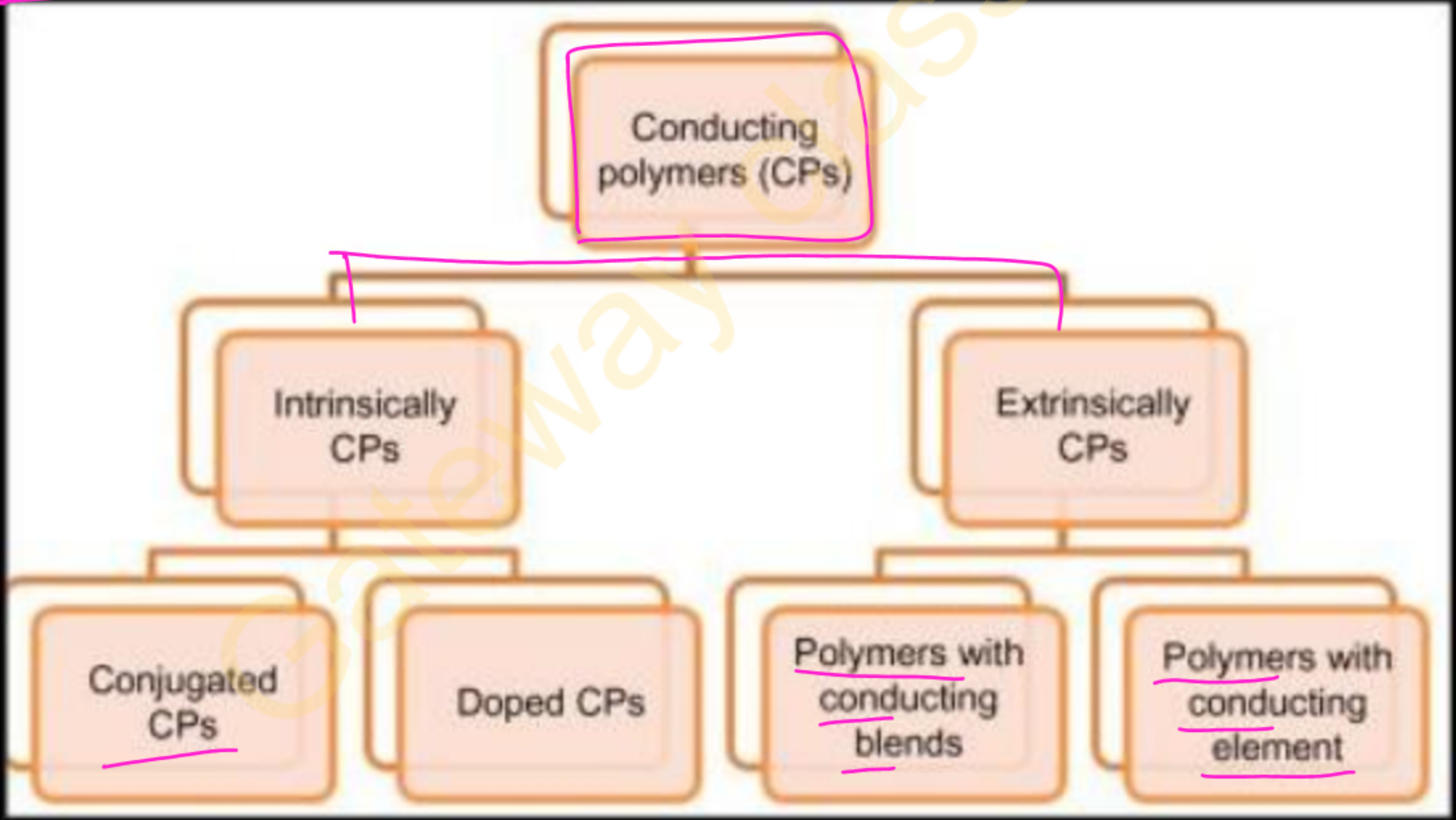
(i) Release of greenhouse gases: The production of Teflon involves the use of perfluorooctanoic acid (PFOA), a persistent organic pollutant that contributes to the emission of greenhouse gases. These emissions can contribute to climate change and its negative impacts.

(ii) Health risks: Studies have linked the use of Teflon-coated cookware to the release of toxic fumes when heated to high temperatures. These fumes can cause flu-like symptoms and long-term health effects, including cancer in humans and animals.

(iii) Land pollution: Teflon waste including packaging can contaminate soil, affecting the health and growth of plants and other organisms in the area.

CONDUCTING POLYMERS

Conducting polymers are organic polymers that conduct electricity, due to extensive conjugation in their backbone.

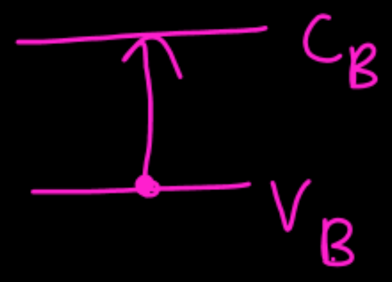


1. Intrinsically conducting polymers

They have pie-conjugation in the main chain and can conduct electricity either normally or on doping. They can be further classified as:

a) Conjugated conducting polymers:

They contain conjugated pie bonds in their backbone, which helps them to form valence band and conduction band. So, there is movement of electrons. Example: polypyrrole, polythiophene etc.



(b) Doped conducting polymers:

These are the polymers which have gap between valance and conduction band and cannot conduct electricity normally. They are doped with electron donor or electron acceptors to make them conducting.

Doping can be done by:

i) p-Doping:

Formed by removal of electron from backbone. This is done by using Lewis acid.

Ex.- $FeCl_3$.

(ii) n-Doping:

Formed by addition of electron in backbone. This is done by adding Lewis base

Ex.- Na, Li.

2. Extrinsic polymers:

They do not contain the factors responsible for conduction and are made conducting by adding external factors in them.

a) Polymers with conducting element:

- Conductive elements such as C black, metal oxide are added to polymer.
- Polymer acts as binder and hold these elements.

b) Polymers with Conducting blend or Blended conducting polymer:

- Blending a conventional polymer with conducting polymer takes place.
- Conventional polymer gains the conducting property.

BIODEGRADABLE POLYMERS

The polymers which can degrade in nature by the action of enzymes and microbes are known as biodegradable polymers.

Characteristics of Biodegradable Polymers

- Inert
- Permeable
- Non- toxic
- Bio-compatible
- Controlled rate of degradation

Factors affecting biodegradation

- **Size and shape:** Polymers should not be very large and too branched.
- **Crystallinity**: Polymers should be semi-crysatalline. The percentage if crystallinity should be less.
- **Hydrophillic**: Polymers should be water soluble.
- Presence of functional groups: Polymers should be having biodegradable functional groups.
- Presence of suitable microorganism.
- Presence of favourable conditions like suitable temperature, pressure, moisture, Oxygen, Light, type and concentration of salts, pH etc.

BIODEGRADATION PROCESS

STEP- 1:

The long polymer molecules are reduced to shorter lengths and undergo oxidation. The molecules become hydrophilic (water attracting) and small.

STEP 2:

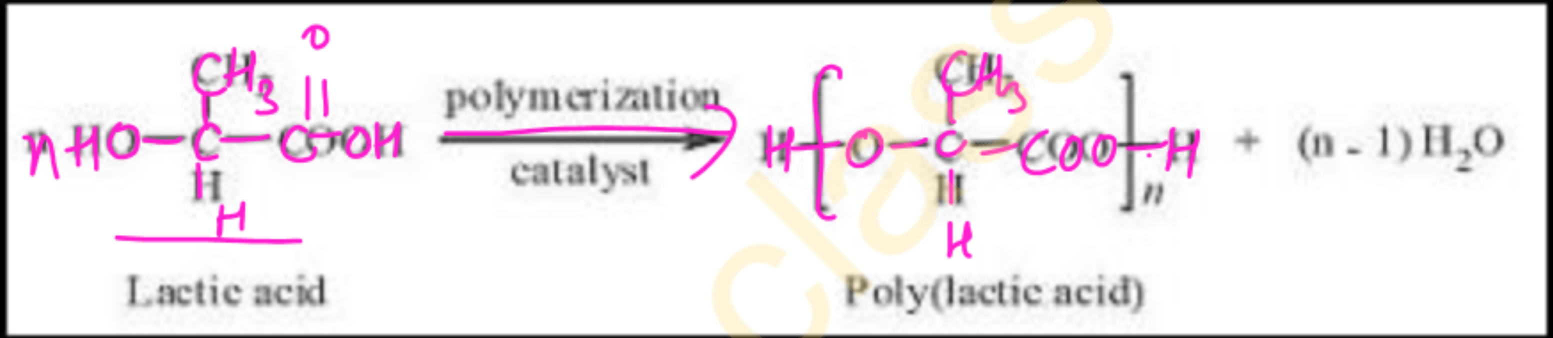
Biodegradation occurs in the presence of moisture and micro-organisms. The polymer is completely broken down in to the residual products.

STEP 3:

Micro- organisms consume the degraded plastic. Carbon dioxide, water and biomass are produced and returned to nature.

SOME BIODEGRADABLE POLYMERS

POLYLACTIC ACID



POLYGLYCOLIC ACID

Properties of PLA:

PLA is compostable and biodegradable. It is resistant to grease and moisture.

Uses:

- It is used in food packaging.
- Used for surgical sutures, implants.
- Used in drug delivery systems.

Properties of PGA:

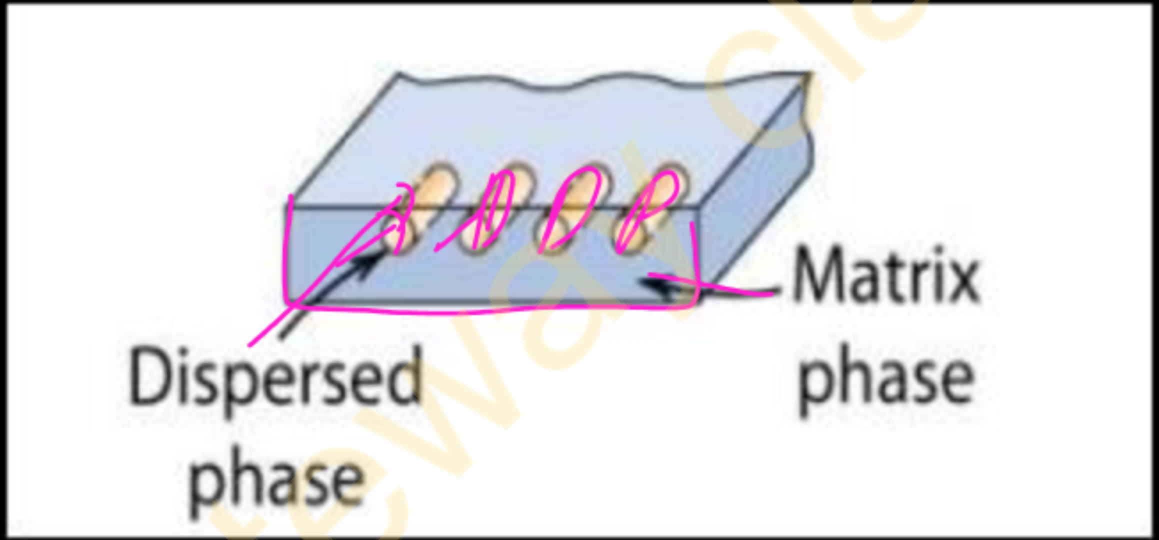
- Highly crystalline, High melting point and low solubility in organic solvents.

Uses:

- In tissue engineering.
- In controlled drug delivery.
- In biodegradable sutures.

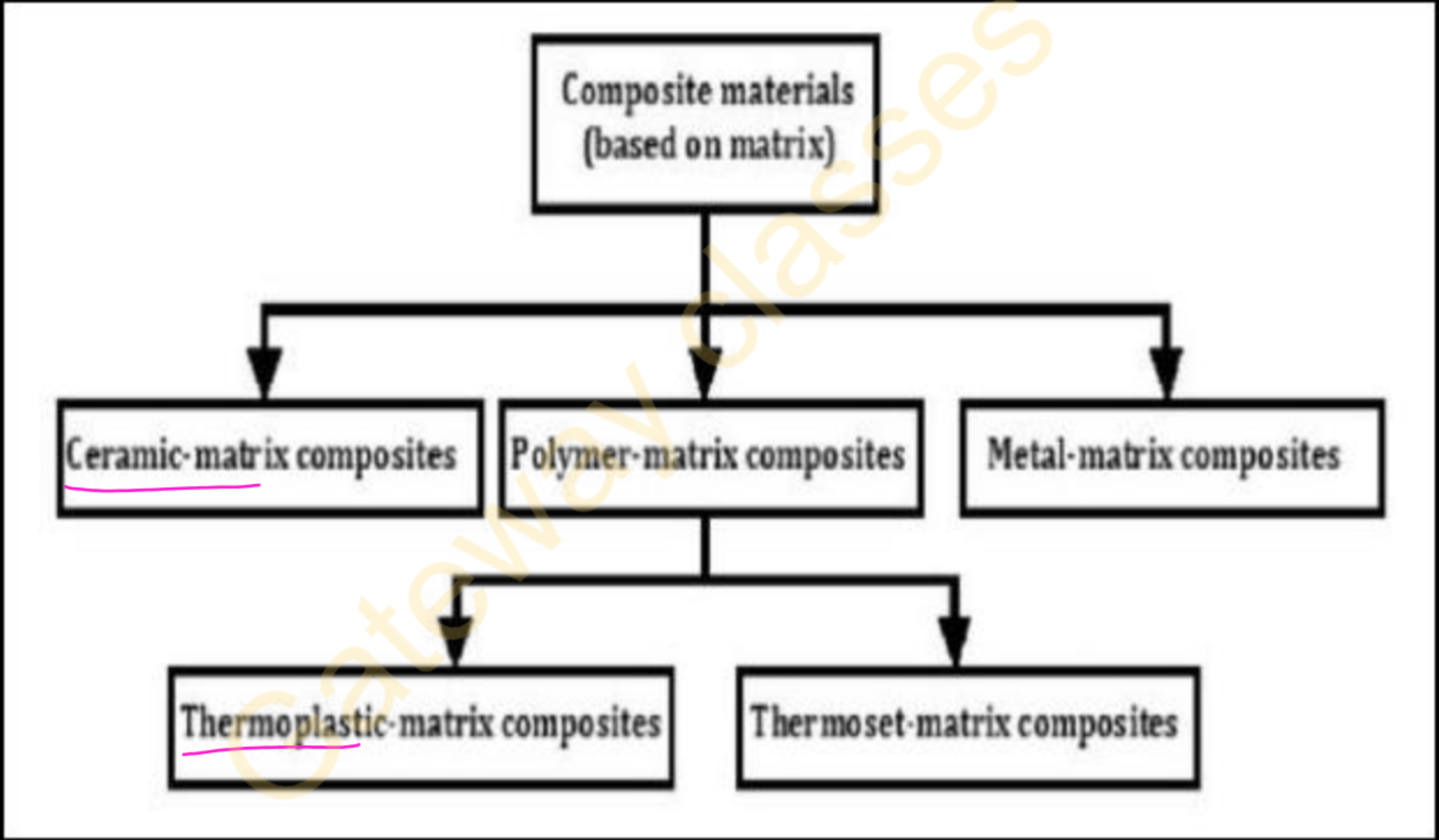
COMPOSITES

Composite material is a material made up of two or more phases (matrix phase and dispersed phase) and properties of composites are different from those of any of the phases.

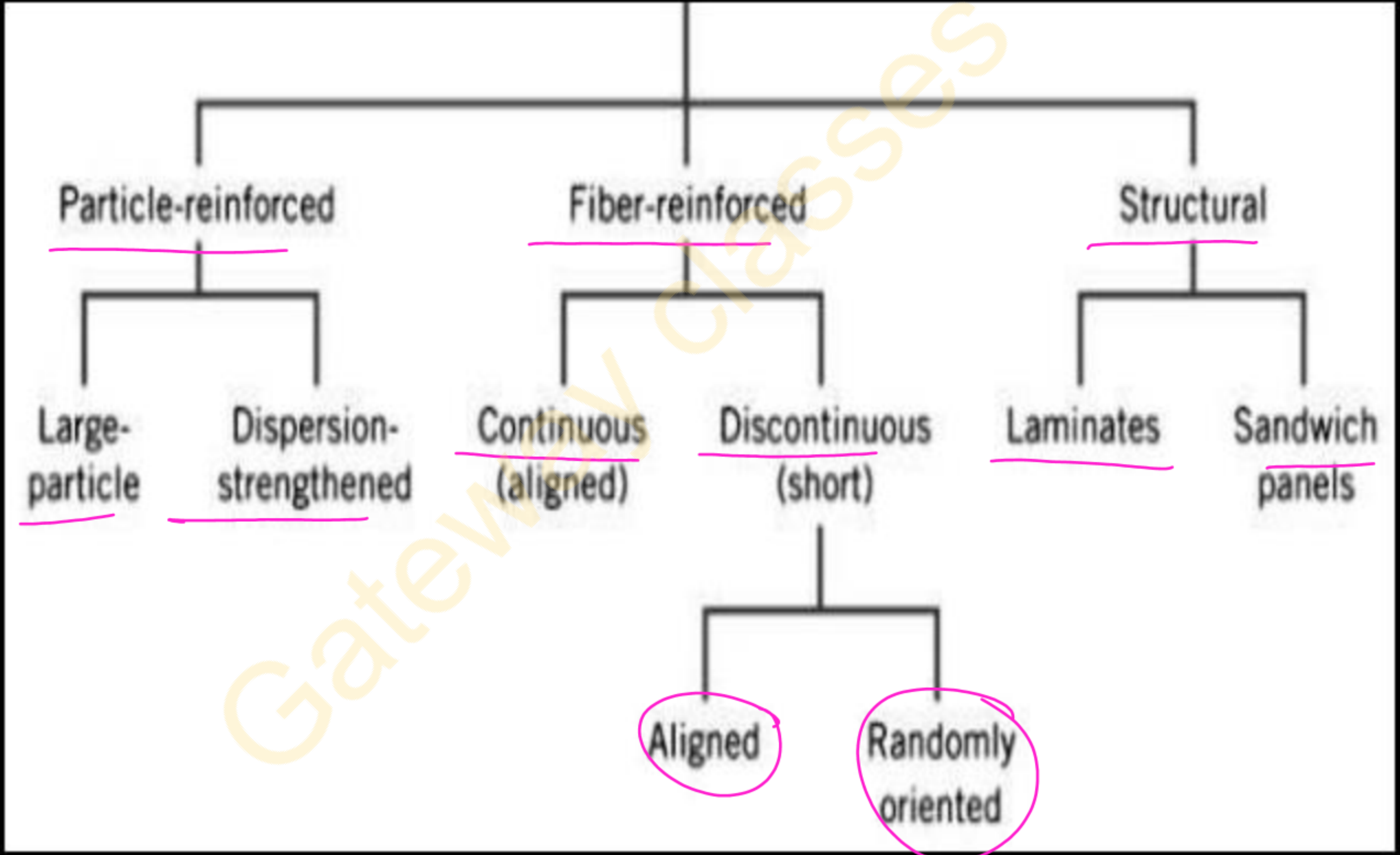


Matrix Phase	Dispersed or Reinforcing Phase
It is primary phase.	It is secondary force.
It is in continuous form.	It is in discontinuous form.
It holds the dispersed phase and shares load with it.	It is embedded in matrix.
Weaker than dispersed phase.	Stronger than matrix phase.

CLASSIFICATION BASED ON MATRIX PHASE



CLASSIFICATION BASED ON DISPERSED PHASE



Advantages of composite materials

Light Weight
Chemical resistance
Corrosion resistant
Good performance at high temperatures
Durable
Very good electrical insulation

POLYMER BLENDS

"Polymer Blend is defined as a mixture of two or more same or different polymers, having physical properties different from the component polymers".

The components of polymer blend should be friendly with each other.

Blending is done to improve the properties of components.

Example: Mixture of wool and terylene.

Types of polymer blends:

(1) Miscible polymer blend

Homogenous.

It is a single-phase structure.

Negative value of the free energy of mixing

(2) **Immiscible polymer blend**

Heterogeneous.

Positive value of the free energy of mixing.

(3) **Homologous polymer blend**

Mixture of same polymers with different molecular weight distribution.

(4) **Isomorphic polymer blend**

Polymer blends of two or more different semi-crystalline polymers.

(5) **Compatible polymer blend**

Blends that are miscible in a certain range of composition and temperature, but immiscible in others.

Advantages of blending

Production of desired materials which are low in cost.
It improves Solvent and Chemical Resistance.
It improves Flame Resistance.
Plastic wastes are recycled.
Blending reduces the material cost.

ORGANOMETALLIC COMPOUNDS

The compounds in which the carbon atom is directly linked to metal atom are known as organometallic compounds.

Classification Based on groups attached to metal atom

(1) **Simple organometallic compounds:** Metal atom is bonded to only carbon and hydrogen atoms. E.g. $(C_2H_5)_4Pb$. They are of two types:

Symmetrical: Metal atom is bonded to same type of groups. E.g. $(C_2H_5)_2Hg$.

Unsymmetrical: Metal atom is bonded to different hydrocarbon radicals. E.g. $C_2H_5HgC_4H_9$.

(2) **Mixed organometallic compounds:** In addition to carbon the metal atom is attached to other groups also. E.g. C_2H_5MgBr.

On the basis of type of C-M bond

Ionic Organometallic Compound: Ionic bond between metal atom and carbon atom. E.g. Organo sodium compounds (C_6H_5Na), Organo potassium compounds (C_5H_5K).

Covalent Organometallic Compounds or sigma bonded compounds: Covalent bond between carbon and atom. E.g. Metal alkyl compounds-$Pb(C_2H_5)_4$, $Zn(C_6H_5)_2$

Electron deficient Organometallic Compounds: These include the compounds having bridge alkyl groups. E.g. Dimeric boron hydride (B_2H_6), Dimeric trialkyl aluminium $[Al_2(CH_3)_6]$

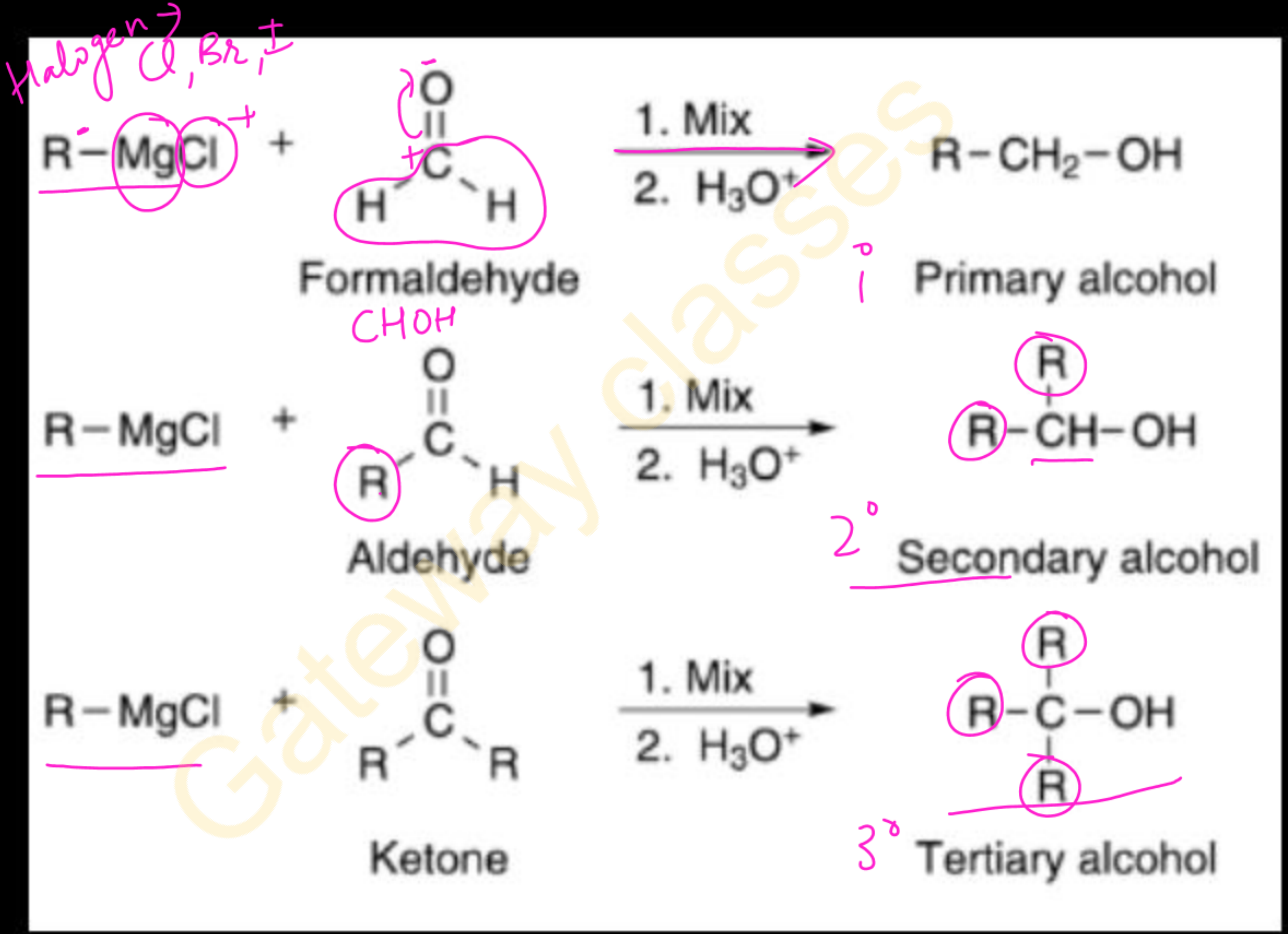
Organometallics involving π bonds: Have metal-ligand bonds between metal and π orbital of organic ligands. E.g. Ferrocene - $(C_5H_5)_2Fe$.

GRIGNARD REAGENT

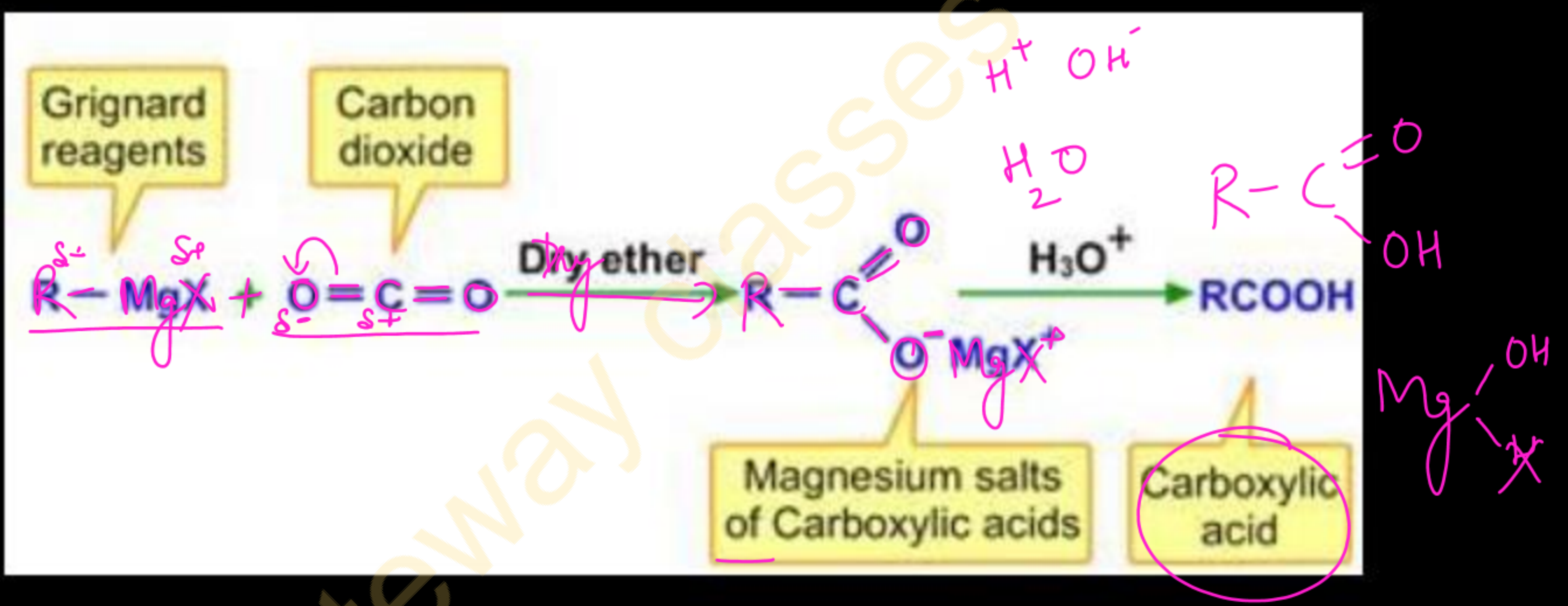
It is a type of organometallic compound formula RMgX where X is a halogen, and R is an alkyl or aryl (based on a benzene ring) group. A typical Grignard reagent might be CH_3MgBr

Prepared by the action of organic halide and Mg metal in ether or tetra hydro furan.

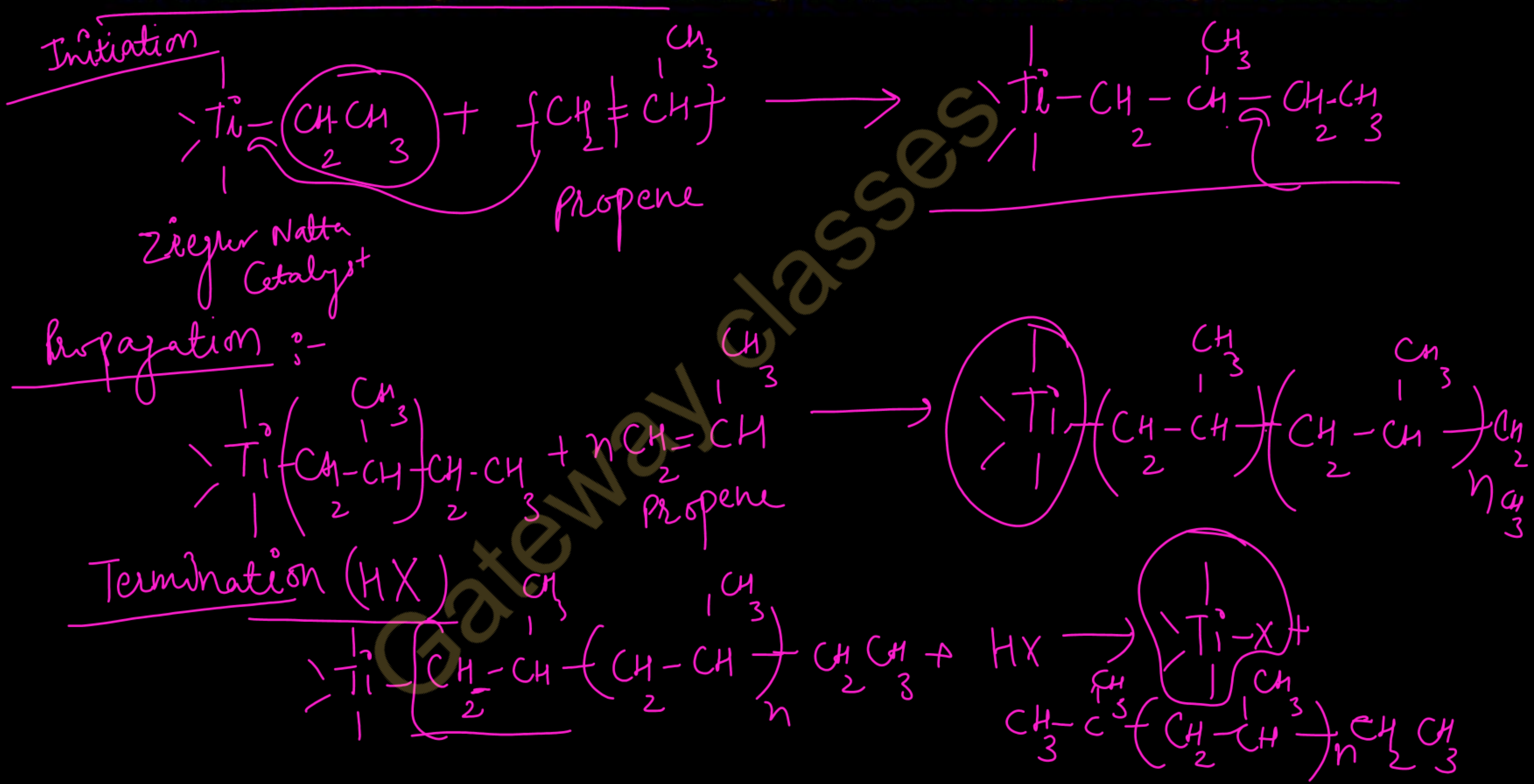
FORMATION OF PRIMARY, SECONDARY AND TERTIARY ALCOHO



FORMATION OF CARBOXYLIC ACID



Co-ordination Polymerisation or Ziegler-Natta Catalytic Polymerization



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Thank You