Biomolecules – Class 12

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1. Introduction

- Living systems grow, sustain, and reproduce itself.
- A life-defining property is the harmonious and synchronous progress of chemical reactions in the body.
- The field is called Biochemistry.
- Complex biomolecules like carbohydrates, proteins, nucleic acids, lipids, etc., are the molecular logic of life processes.

2. Key Definitions

- **Biomolecules:** "Complex molecules that form the structural and functional units of living systems.
- **Biochemistry:** "The pursuit of knowledge of what goes on chemically within a living system.
- **Carbohydrates:** "Optically active polyhydroxy aldehydes or ketones, or compounds that produce such units on hydrolysis.
- **Exception Highlight:** 'Does Formula = Carbohydrate?'
  (1) Fits formula but NO carb (Acetic acid CH_3COOH is $C_2(H_2O)_2$)
  (2) Does NOT fit formula but IS carb (Rhamnose $C_6H_{12}O_5$)

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3. Hydrates of Carbon Concept

- Name 'Carbohydrates' is derived from 'Hydrates of Carbon'.
- Original general formula $C_x(H_2O)_y$ was the basis, where 'H_2O' represents hydrates and 'C' carbon.

4. Classification of Carbohydrates (Exam-Focused)

Class	Hydrolysis behavior	Examples	Properties
Monosaccharides	Cannot be hydrolysed	~20 in nature	Glucose/Fructose/ Ribose
Oligosaccharides	Yield 2-10 monosacc units		Sucrose/Maltose/ Lactose
Polysaccharides	Yield large number units	non-sweet, non-sugars	Starch/Cellulose/ Glycogen

Note: Reducing vs not-rocarences on reducing Tollen's/Fehling's reagent,
→ vs non-reducing sugars base non-reducing sugars

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Glucose: Preparation & Structure Elucidation (6 Key Proofs)

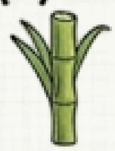
1. Glucose: Elucidation (Title and brief intro)

- An Aldohexose (6C, aldehyde).
- Found free in nature (sweet fruits, honey).
- Combined form (sucrose, starch).

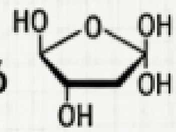
Structure assigned based on 6 proofs...Let's study its production.

2. Preparation of Glucose

(1) From Sucrose (Cane sugar):



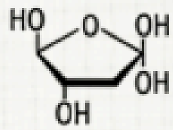
$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{H^+,\ heat} C_6H_{12}O_6 + C_6H_{12}O_6$$



Write names.

(2) From Starch:

$$(C_6H_{10}O_5)_n + nH_2O \xrightarrow{(H^+/393K,\ 2\text{-}3\ atm)} nC_6H_{12}O_6$$



Reagents and conditions clearly marked

3. Structure Elucidation: 6 Proofs (Table) ★ High-value

Property	Reagent/Reaction	Evidence/Conclusion	
1. Molecular Formula	Found to be	$C_6H_{12}O_6$	$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$  CH_3
2. Straight Chain	HI / Heat ⚠	*n*-Hexane →	
3. Carbonyl Group (>C=O)	NH_2OH OR HCN	Oxime OR Cyanohydrin	$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$ (>C=O proof)
4. Aldehyde Group (-CHO)	Br_2 water → (mild oxidising agent)	Gluconic Acid	$CH_2OH\text{-}(CHOH)_4\text{-}COOH$ Gluconic Acid
5. Five -OH Groups	Acetic Anhydride	Pentaacetate formation	Stable compound means -OH on different carbons
6. Primary Alcoholic Group ($-CH_2OH$)	Nitric Acid (strong oxidising agent)	Saccharic Acid (dicarboxylic)	$HOOC\text{-}(CHOH)_4\text{-}COOH$ Saccharic Acid

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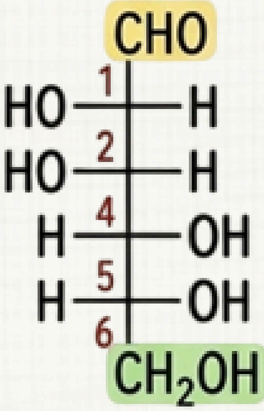
Glucose Stereochemistry & D/L Notation – Class 12

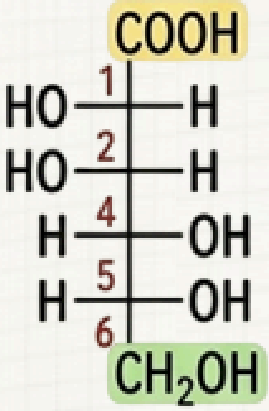
1. Glucose Stereochemistry (Relative Configuration)

I.



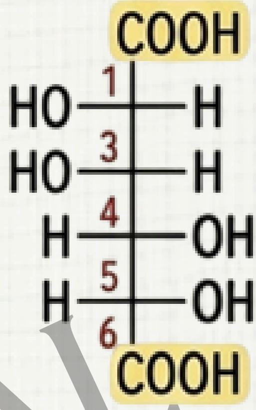
Glucose

II.



Gluconic Acid

III.



Saccharic Acid

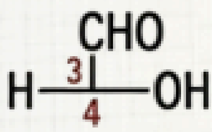
Key Points / Tricks (Clarifying D(+) vs. d/l)

- Glucose is D-(+)-glucose

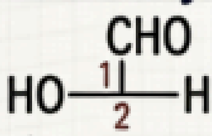
★ Remember! 'D' and 'L' have NO relation to the optical activity ('+' / d- and '–' / l-).

- (+) is dextrorotatory experimental result.
- D/L is a configuration notation based on Glyceraldehyde.

D/L Notation Rule (Based on Glyceraldehyde)

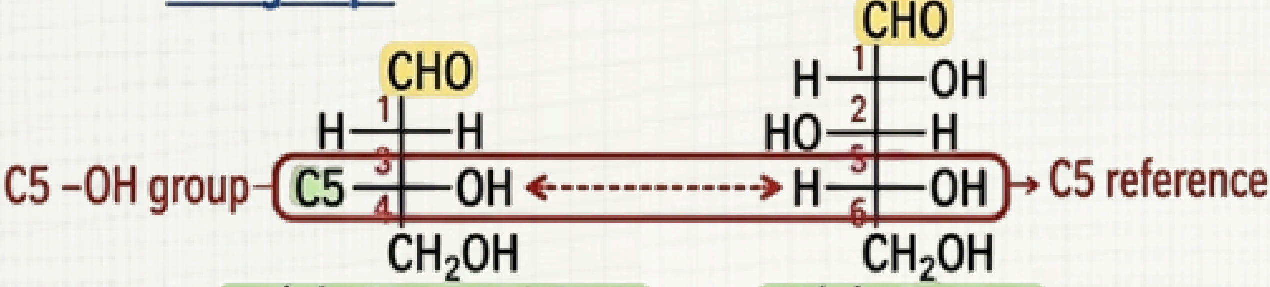


(+) - Glyceraldehyde



(–) - Glyceraldehyde

Based on lowest asymmetric carbon, l is dne by the asymmetric carbon of Low groups tn the lowest carbon.



D-(+)-Glyceraldehyde D-(+)-Glucose

* Glyceraldehyde D- and L- are tmiot asymmetric standards.

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Glucose Cyclic Structure (Ring Form) – Class 12

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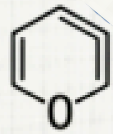
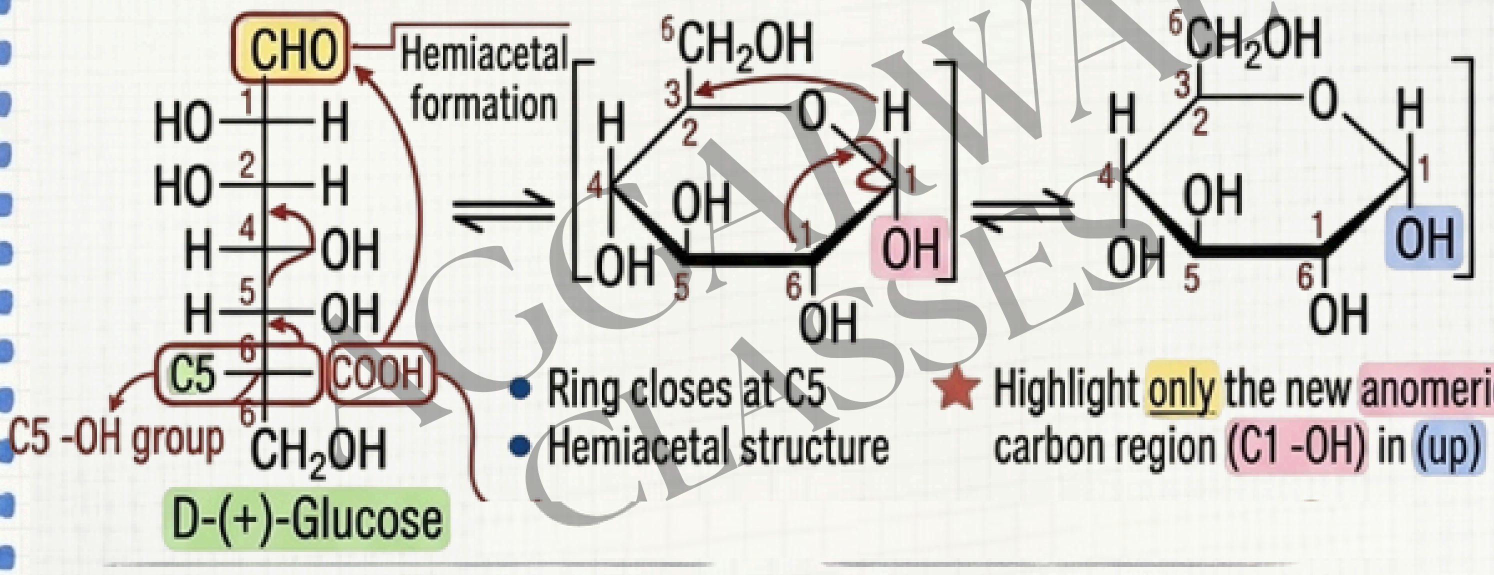
1. Limitations of Open-Chain (Proof for Ring):



Precise based on NCERT page 285:

- Does not give Schiff's test, and no addition product with $NaHSO_3$
- Glucose pentaacetate doesn't react with hydroxylamine doesn't react with hydroxylamine (NH_2OH) – Proves NO free -CHO group
- Exists in two crystalline forms: α and β

2. Core Concepts Breakdown: Cyclization (Hemiacetal Mechanism):



- Ring closes at C5
- Hemiacetal structure

★ Highlight only the new anomeric carbon region (C1 -OH) in (up)

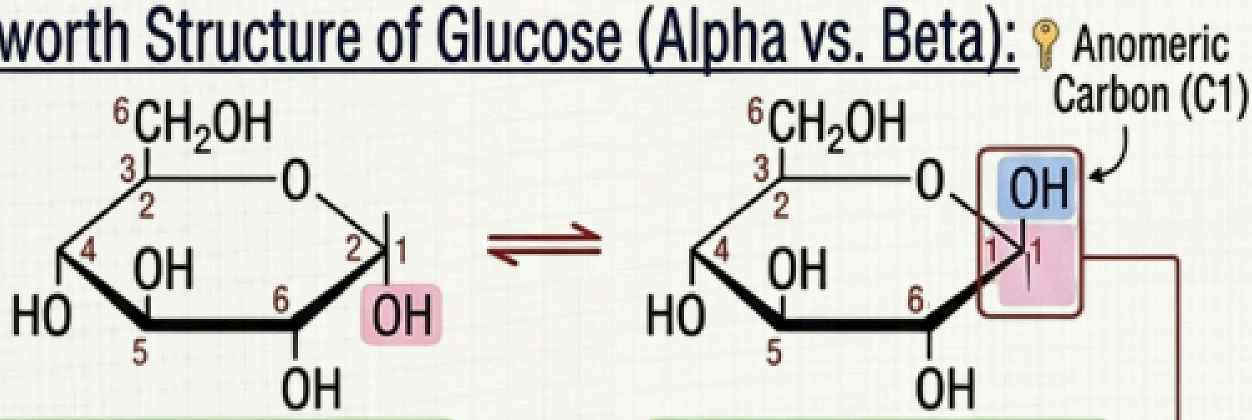
1. Haworth Structure & Pyran Anadgy (vs. Ring):

- These 6-membered rings are called pyranose forms (like pyran).

Pyran

Rule of: Right groups on Fischer are belowt: below the plane in Haworth

2. Haworth Structure of Glucose (Alpha vs. Beta):



α-D-(+)-Glucopyranose β-D-(+)-Glucopyranose

* Critical distinction (C1 -OH): highlight ★ only difference in (up ws down)!

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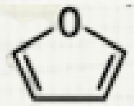
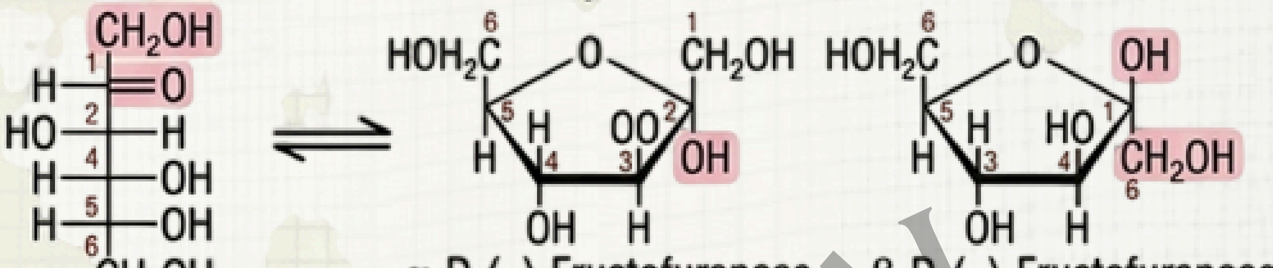
Glucose & Fructose Conclusion – Class 12

[1] Fructose Structure & Properties:

- A ketohexose (6C, ketone group), found in sweet fruits & honey.
- Levorotatory form (D-(–)-fructose).
- Exists in five-membered furanose cyclic form.



Furan



α-D-(–)-Fructofuranose β-D-(–)-Fructofuranose

[2] Real-Life Applications:

- Important constituents of our food (e.g., starch, cellulose).
- Essential energy source: provides energy to the brain (glucose).
- Structural support: Cellulose in plants, glycogen in animals.
- Component of genetic material: RNA and DNA.

[3] Key Points / Tricks:

	Glucose	Fructose
Type	Aldohexose	Ketohexose
Functional Group	Aldehyde (-CHO)	Ketone (C=O)
Optical Activity	Dextrorotatory (+)	Levorotatory (–)
Ring Size (Cyclic)	6-membered Pyranose	5-membered Furanose
Reducing Nature	Reducing	Reducing

High-Value Tautomerism Trick:

"How is Fructose a Reducing Sugar despite the Ketone Group?"

- Keto-enol tautomerism in basic medium.
  Fructose (Ketone) → Enediol → Glucose/Mannose (Aldehyde).
  (Only aldehydes reduce Tollen's/Fehling's).

[4] Common Exam Questions:

1. Define Anomers. Show alpha-D-Glucose and beta-D-Glucose anomeric differences.
2. Write reactions to prove presence of aldehyde and five -OH groups in Glucose.
3. Explain why Sucrose is a non-reducing sugar. (Rewritten info, no diagram).

[5] Quick Revision Section:

- ☑ **Carbs**: Optically active polyhydroxy. Classified by hydrolysis.
- ☑ **Monos** (Glucose, Fructose) & **Dis** (Sucrose, etc.): Sugar units.
- ☑ **Glucose**: Aldohexose, forms 6-membered Pyranose ring. Alpha vs Beta at C1 anomeric.
- ☑ **Fructose**: Ketohexose, forms 5-membered Furanose ring. Alpha vs Beta at C2 anomeric.
- ☑ **Reducing:** All monos (including Fructose via basic tautomerization) & di except Sucrose.

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