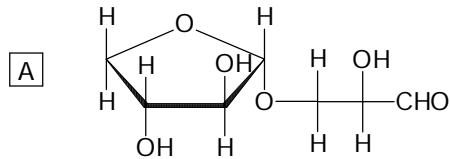


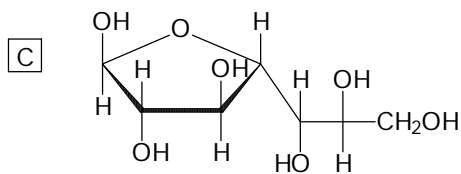
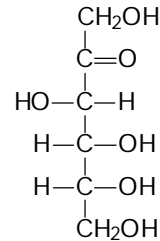
Practice Problems on Carbohydrates

1. Which one of the following is a heptulose?

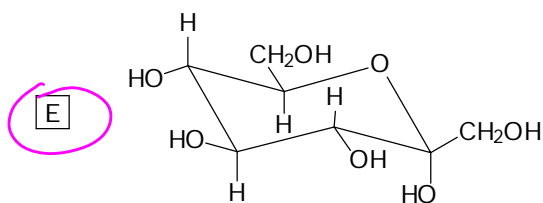
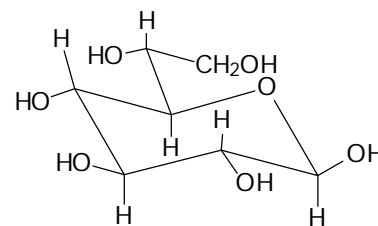
← must have a 7-carbon chain and a ketone



[B]



[D]



2. Based on the names, which one of the following does NOT have an aldehyde?

- A) Idose
- B) Tagose
- C) Fucose
- D) Sedoheptulose ← ketose
- E) Cellobiose

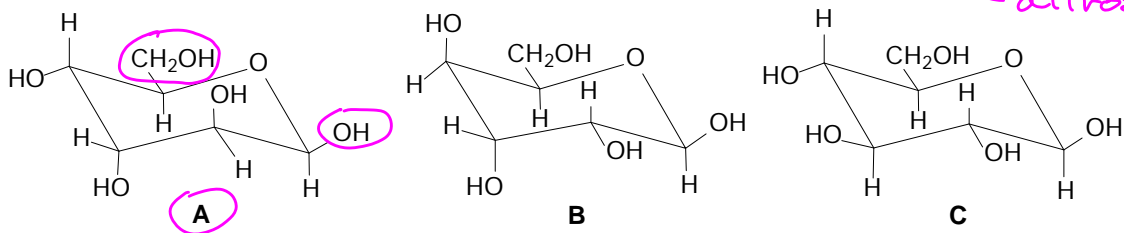
3. Which formula correctly represents a simple monosaccharide?

- A) $C_5H_5O_5$
- B) $C_5H_5O_{10}$
- C) $C_4H_8O_4$
- D) $C_6H_{10}O_6$
- E) $C_4H_{12}O_6$

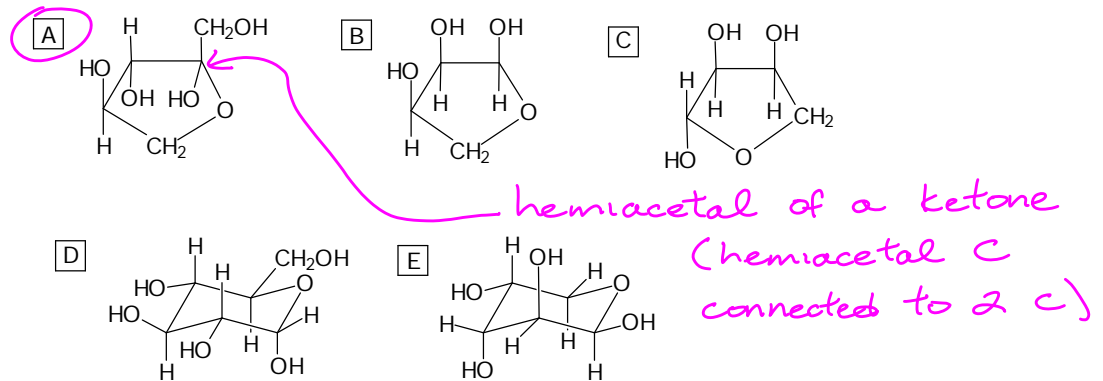
$C_nH_{2n}O$

note: one unit of unsaturation due to $C=O$

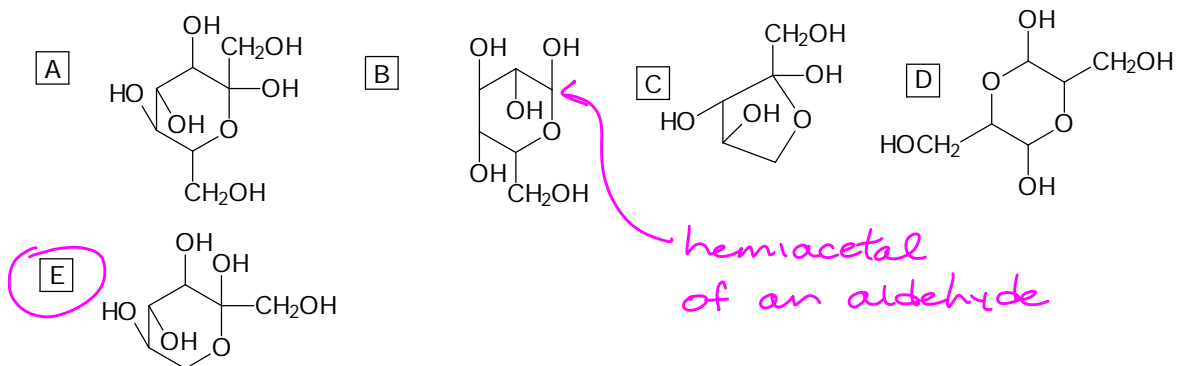
4. Which one of the following structures correctly represents β -D-altropyranose?



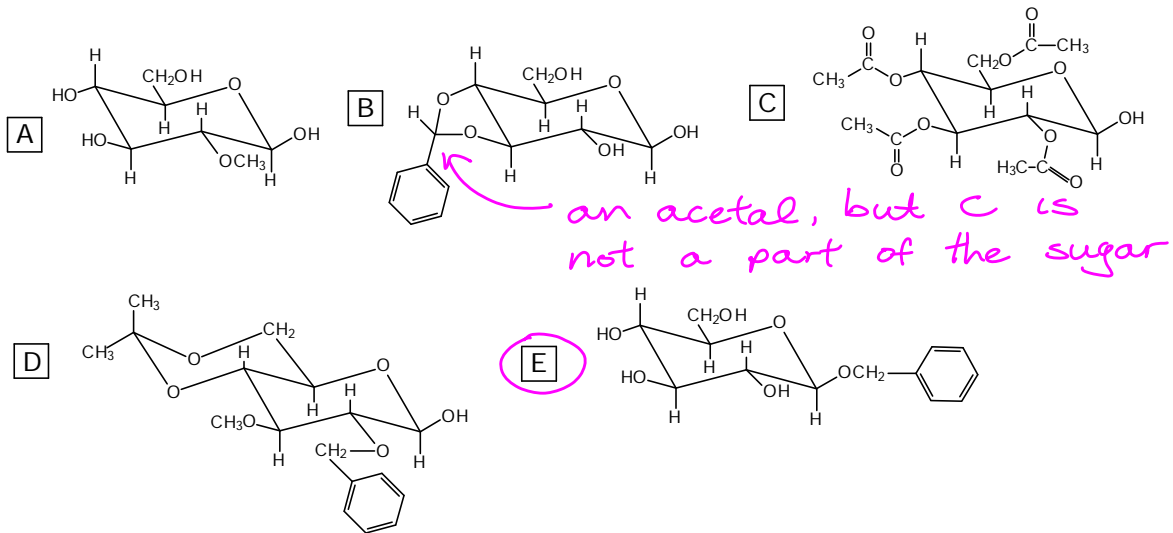
5. Which one of the following is not an aldose? *o* must be ketose



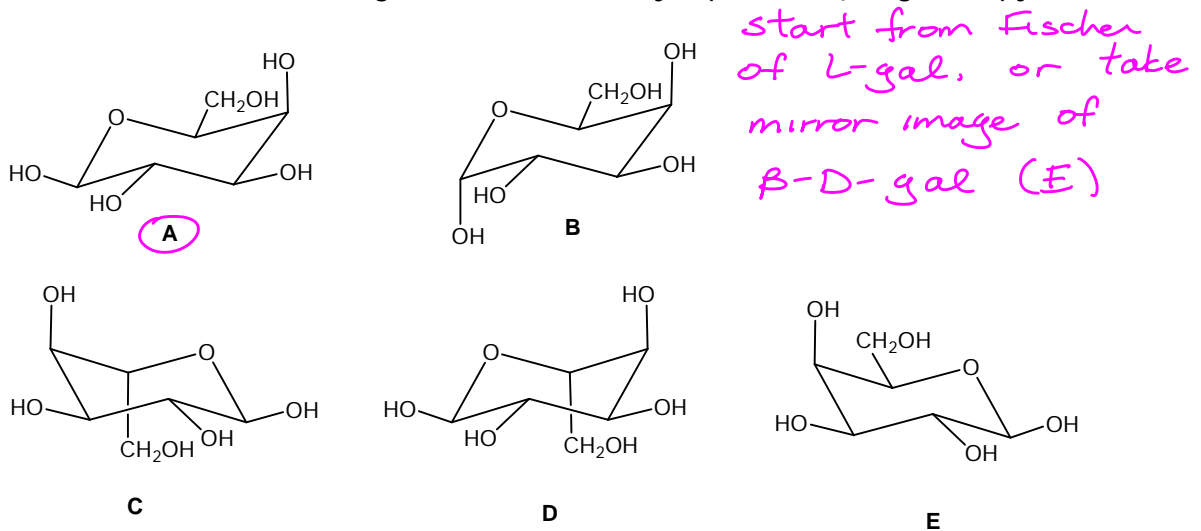
6. Which one of the following is a ketohexose?



7. Which one of the following compounds is a glycoside?



8. Which one of the following structures correctly represents β -L-galactopyranose?



remember, L-gal = enantiomer of D-gal

9. How many hexoses (aldohexoses and 2-ketohexoses) are possible?

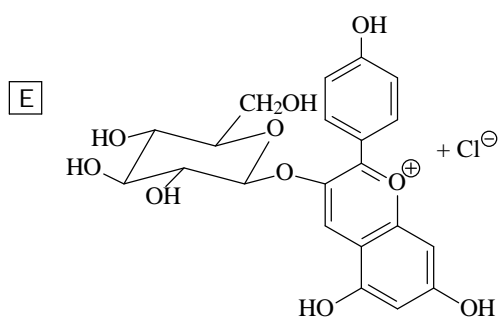
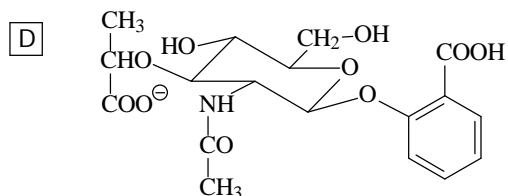
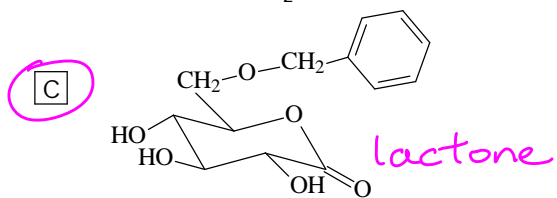
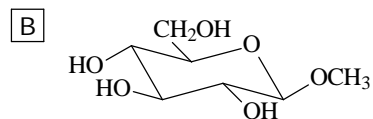
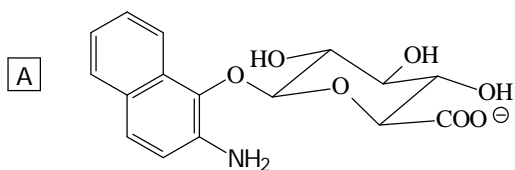
- A) 8
B) 12
C) 16
D) **24**
E) 46

↑ 3 stereocentres
4 stereocentres

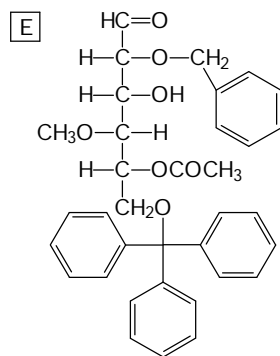
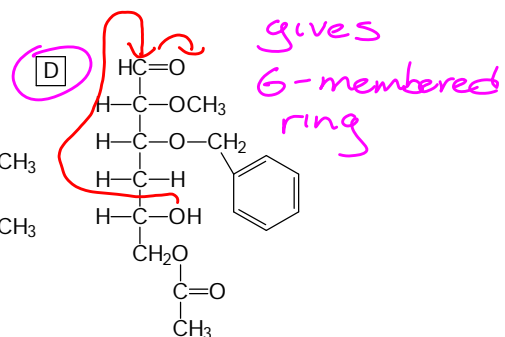
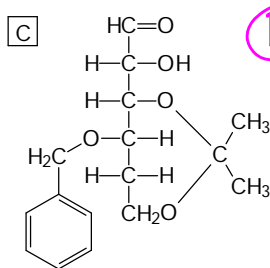
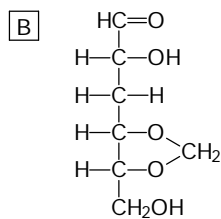
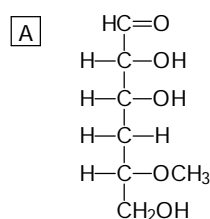
$$2^4 + 2^3 = 24$$

10. Which one of the following compounds is not a glycoside?

acetal of sugar



11. Which one of the following molecules is most likely to form a cyclic hemiacetal in neutral solution?



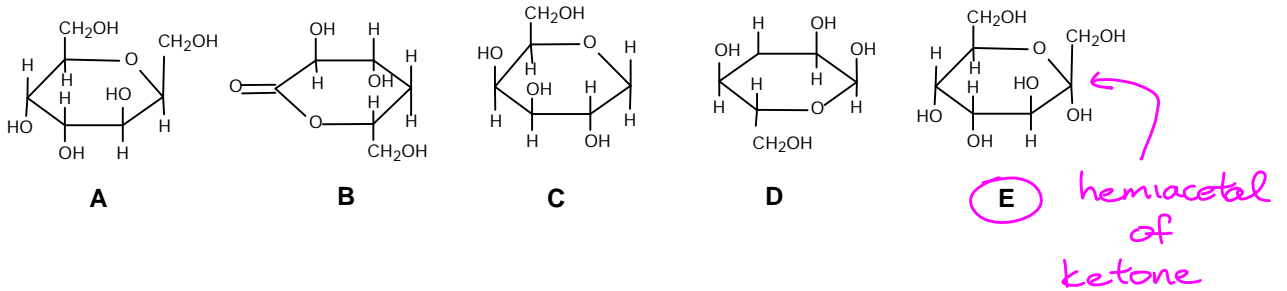
rings of 5/6 members best

A + B → 7 membered

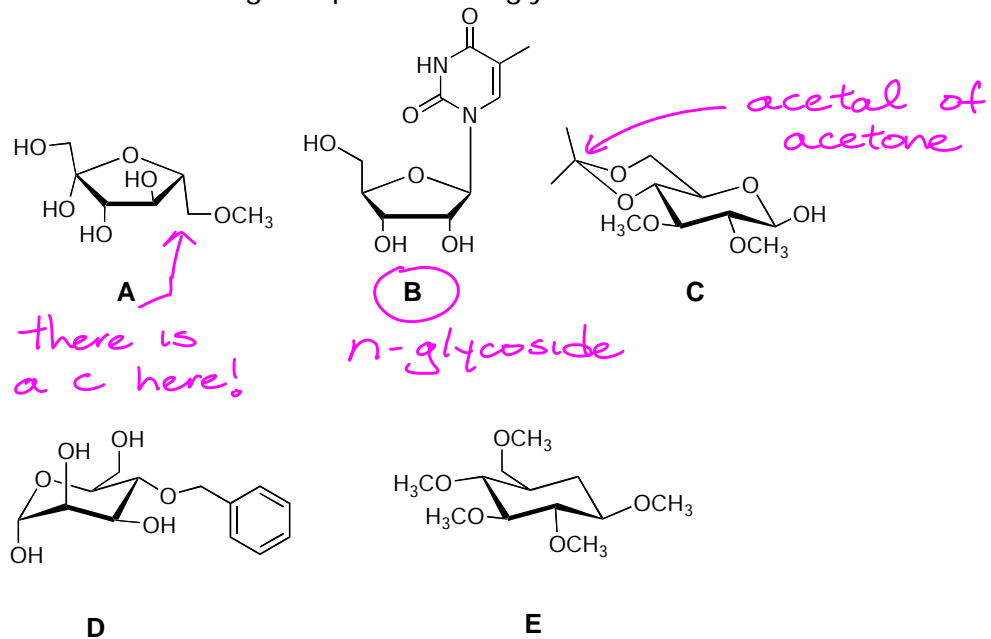
C → 3

E → 4

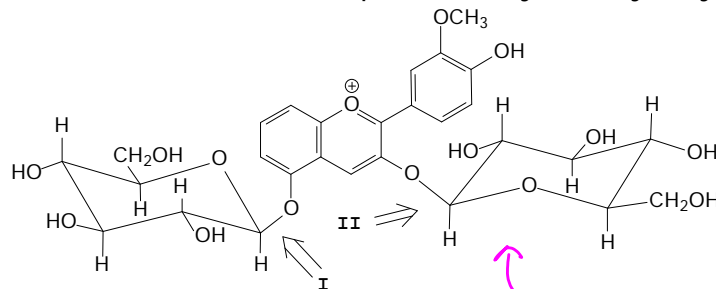
12. Which one of the following is a ketose?



13. Which one of the following compounds is a glycoside?



14. Peonin (shown below) is a red pigment found in the petals of peony flowers. Which monosaccharide(s) would be produced by acid hydrolysis of peonin?



- A) D-glucose and D-mannose
- B) L-glucose and D-mannose
- C) D-glucose and D-galactose
- D) D-glucose only**
- E) L-galactose only

15. Referring to the previous question, what is the stereochemistry of the two glycosidic bonds denoted by I and II?

A) I: α and II: α

B) I: α and II: β

C) I: β and II: α

D) I: β and II: β

16. Which one of the following statements is NOT correct?

A) D-Glucose and D-gulose have the same configuration at the penultimate carbon but different configurations at carbon 4.

B) D-Glucose and D-gulose are diastereomers, but D-glucose and L-glucose are enantiomers.

C) D-Gulose and D-glyceraldehyde have the same configuration at the penultimate carbon.

D) D-Glucose and D-gulose both must be dextrorotatory because they are both D sugars.

E) D-Glyceraldehyde is dextrorotatory, and L-glyceraldehyde is levorotatory.

D/L and +/- do not correlate unless it is glyceraldehyde

17. Which of the following statements about D-2-deoxyribose (the monosaccharide in DNA) is/are most likely to be correct?

a. it can exist as two furanose anomers

b. it can exist as two pyranose anomers

c. reaction of it with NaBH_4 gives an optically inactive product

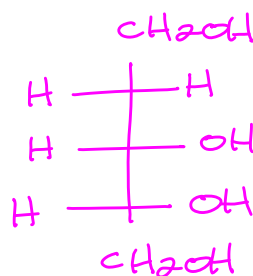
A) b only

B) c only

C) a and b only

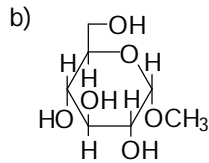
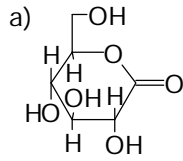
D) a and c only

E) all three statements are correct

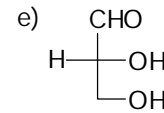
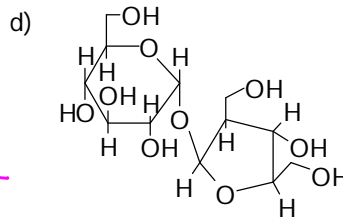
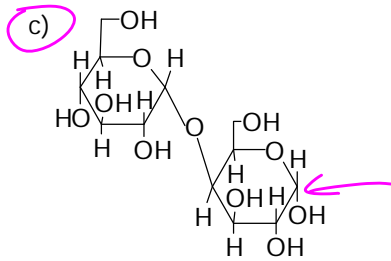


not meso, so optically active

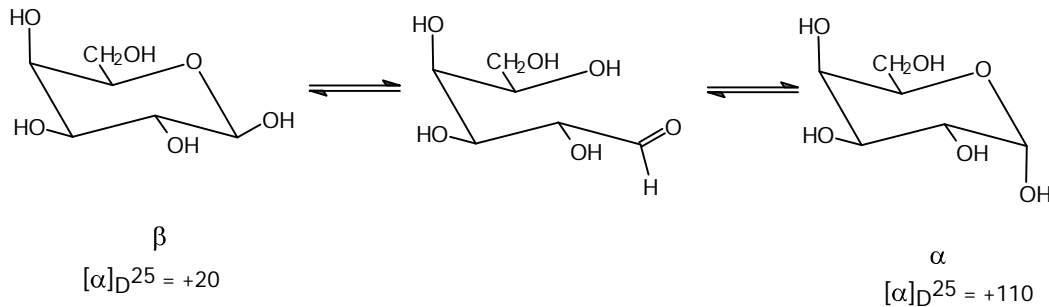
18. Which one of the following would show mutarotation when dissolved in water?



must have a hemiacetal



19. Consider the equilibrium shown below; the optical rotation values are given for each of the cyclic molecules. Which one of the following statements is true?



diaster.

A) The α and β anomers are enantiomers, related by inversion of stereochemistry at C1.

B) The process of interconversion is termed racemization

mutarotation

C) The acyclic intermediate is achiral

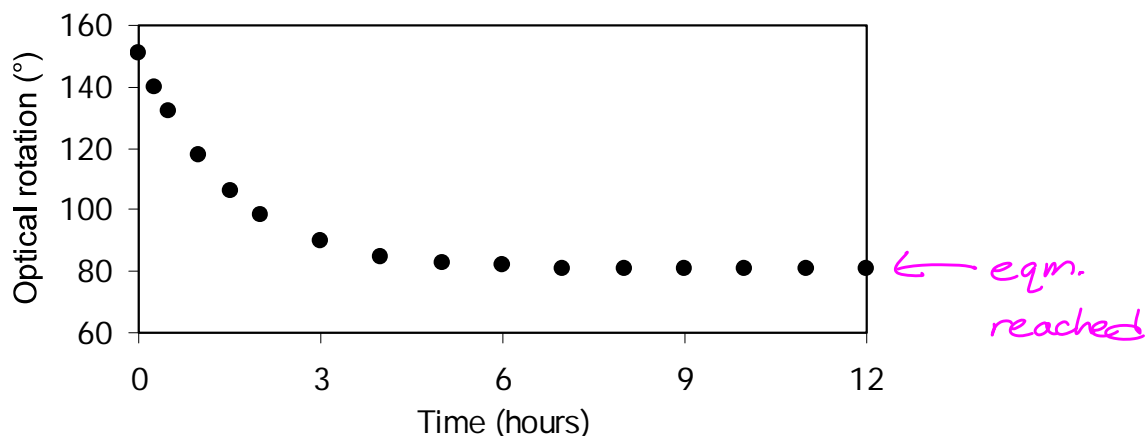
no

D) The α and β anomers are diastereomers

E) Mutarotation occurs for aldose monosaccharides only

ketoses also mutarotate

20. A student dissolved α -D-galactose in acid, placed the solution in a sealed tube, and then monitored the optical activity of the solution in a polarimeter over time. Which statement best explains the data collected below?



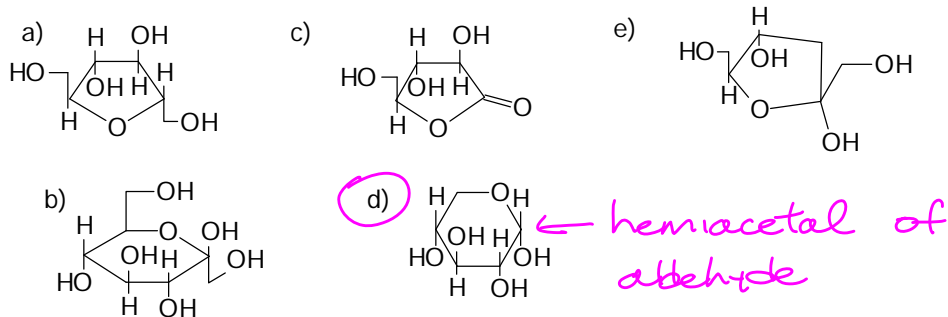
- A) A portion of the α -D-galactose was converted to α -D-fructose *no base*
- B) A portion of the α -D-galactose was hydrolyzed to two smaller sugars *already a monosacc.*
- C) A portion of the α -D-galactose was converted to α -D-glucose *no base*
- D) The solution of α -D-galactose evaporated over time *X sealed tube*
- E) α -D-galactose formed an equilibrium mixture with β -D-galactose**
21. Which one of the following statements is *not* correct?
- A) Individual units of sugars are typically linked by O-glycoside bonds to form oligomers and polymers.
- B) In the acid-catalyzed formation of a hemiacetal from an aldehyde and an alcohol, the carbonyl group is protonated to make it better nucleophile.** *X electrophile*
- C) Acetals are resistant to alkaline (basic) conditions.
- D) Hemiacetals readily revert to their aldehyde and alcohol components under neutral, acidic, or basic conditions.
- E) Bases of nucleic acids are linked to sugars via N-glycoside bonds.

22. Bromine water can be used to oxidize aldoses to aldonic acids. What is the reduction product formed in this reaction?

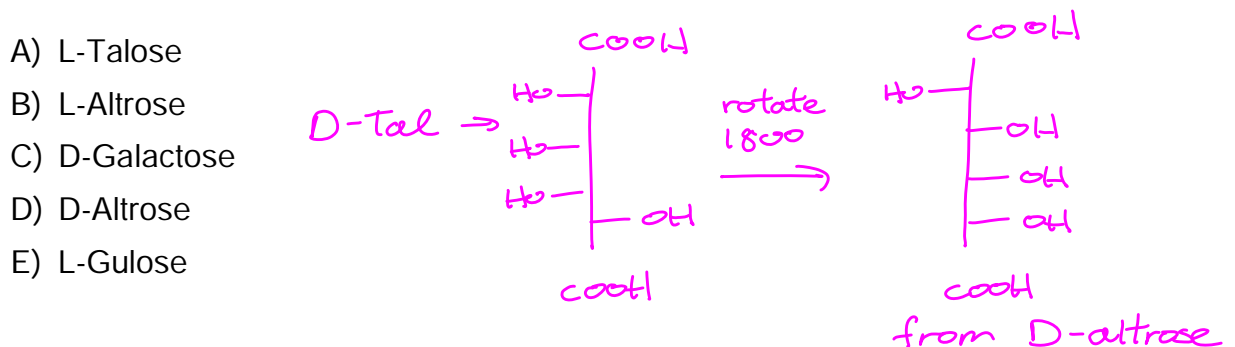
A) HBrO_3
 B) Br_3^+
 C) HBr
 D) HOBr
 E) Br_2

*Br₂ reduced to Br⁻
 (-1 ox. state)*

23. Which one of the following compounds can be readily oxidized by $\text{Br}_2/\text{H}_2\text{O}$?



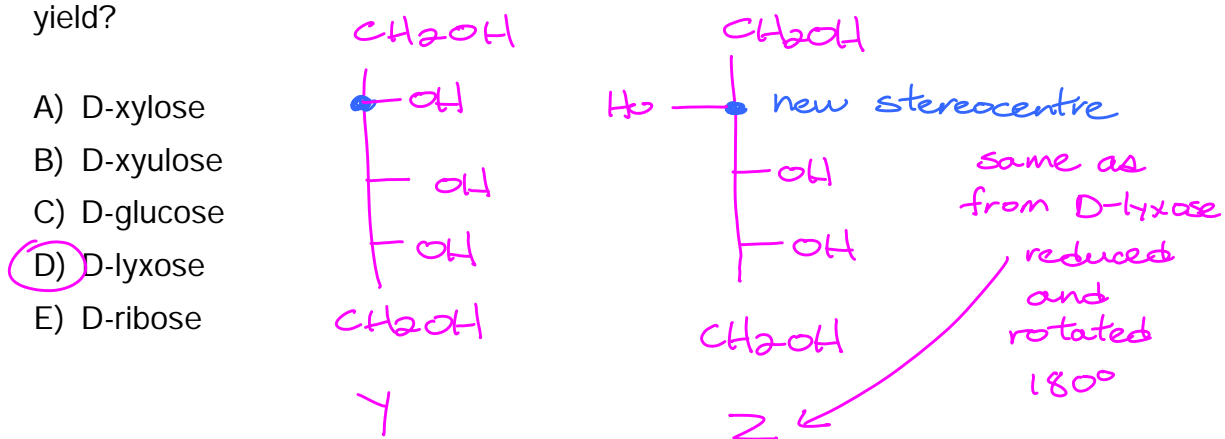
24. The oxidation of D-talose by nitric acid gives the same optically active diacid as the oxidation of which other sugar?



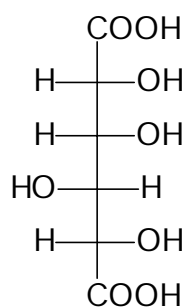
25. D-Arabinose is converted by nitric acid into the same aldaric acid as that obtained from the reaction of which other sugar with nitric acid?



26. Reduction of D-ribulose with NaBH_4 forms equal amounts of two products, **Y** and **Z**, i.e. 50% yield of each. Product **Y** does not rotate plane-polarized light. Similar reduction of which one of the following sugars would give product **Z** in 100% yield?



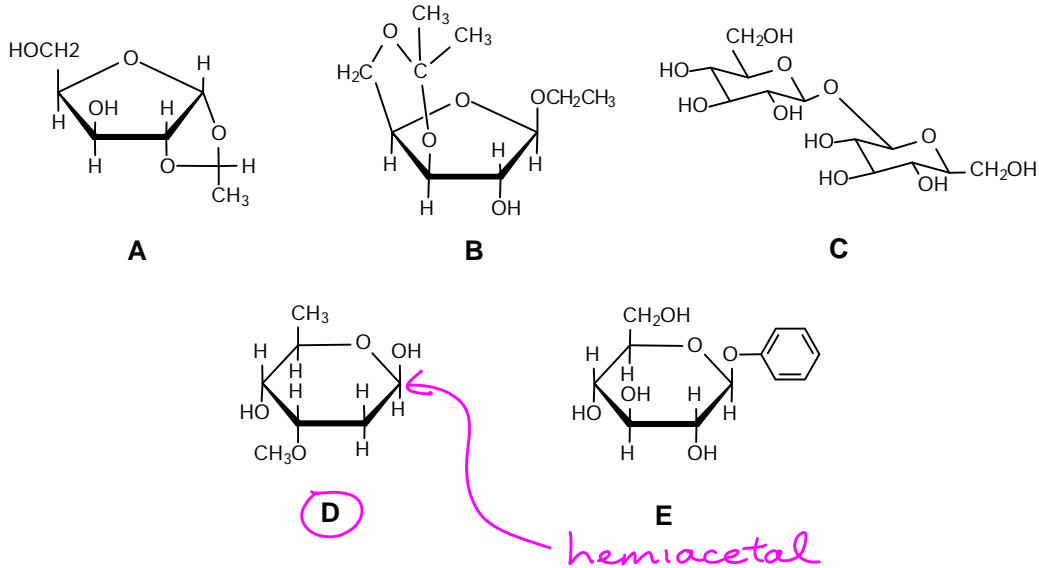
27. An aldohexose was oxidized with nitric acid, and the product was found to be the structure shown below. The original sugar could have been which one of A - E?



either top or bottom could have been aldehyde

- A) D-glucose or L-glucose
B) D-glucose or D-talose
C) D-altrose or L-talose
D) L-idose or D-galactose
E) D-idose or L-gulose

28. Which one of the following molecules gives a positive Tollens' or Benedict's test?



29. A positive Benedict's test is indicated by the precipitation of a brick-red solid from the blue solution. Which one of the following compounds is the brick-red solid?

- Cu²⁺ reduced to Cu⁺*
- A) Cu₂O
 B) CuSO₄
 C) CuCl₂
 D) Ag₂O
 E) Ag metal

30. Acid-catalyzed hydrolysis of one mole of sucrose gives one mole of glucose and one mole of fructose. Which compound(s) is (are) responsible for the positive Benedict's Test that one obtains after hydrolysis of sucrose?

- ← the actual sugar reacting with Cu²⁺*
- A) Glucose
 B) Fructose
 C) Glucose and fructose
 D) Sucrose
 E) Sucrose, glucose, and fructose

aldose
or
ketose

31. A monosaccharide was treated with Benedict's reagent, which produced a red precipitate. When the resulting solution was acidified, two aldonic acids, D-allonic acid and D-altronic acid, were isolated. Bromine water had no effect on the monosaccharide. What is the most likely identity of the monosaccharide?

is not
aldehyde

- A) D-allose
B) D-altrose
C) D-idose
D) D-tagulose
E) D-psicose

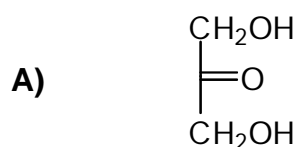
Benedict's is basic, Br₂ is not
↑
ketoses isomerize
to aldoses

32. A reducing monosaccharide is heated in dry methanol with catalytic hydrochloric acid. The carbohydrate product of this reaction is now a nonreducing sugar. What has *most likely* happened?

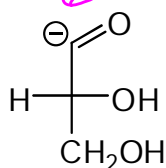
- A) glycoside formation
B) lactone formation
C) hydrolysis
D) oxidation
E) reduction

aldehyde + CH₃OH
↓ cat acid
acetal

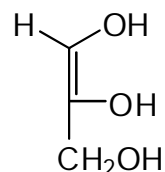
33. Which one of A – E is least likely to be formed when D-glyceraldehyde is treated with sodium hydroxide?



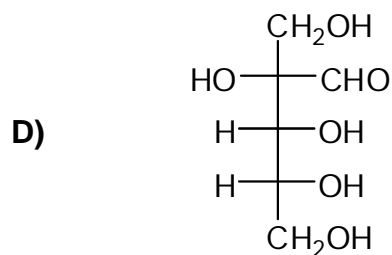
B)



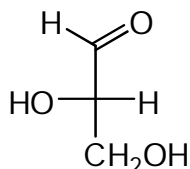
C)



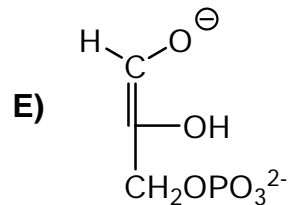
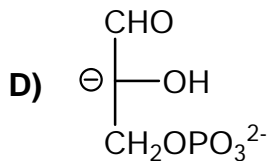
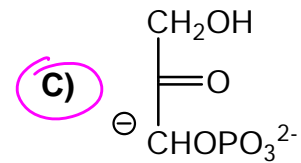
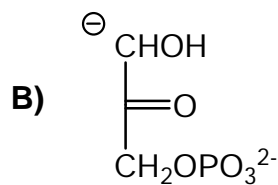
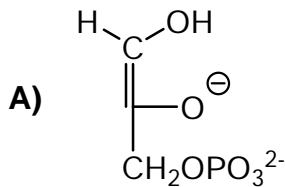
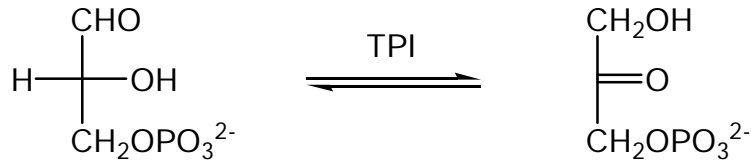
not here



E)



34. The glucose-metabolism enzyme TPI catalyzes the reversible conversion of glyceraldehyde-3-phosphate and dihydroxyacetone phosphate, as shown below. Which one of A-E is *least* likely to be an intermediate along the conversion pathway?



The next three questions refer to the following information: Kiliani Fischer extension of D-lyxose gives rise to two aldohexoses, **X** and **Y**. - see chart

aldehyde of lyxose becomes C-2 of Gal + Tal

35. What is the stereochemical relationship between the two aldohexoses **X** and **Y**?
- A) anomers
 - B) enantiomers
 - C) structural isomers
 - D) diastereomers
 - E) identical compounds

36. When the two aldohexoses **X** and **Y** are treated separately with NaBH_4 , **X** gives rise to an optically inactive product. Why is the product optically inactive?

- A) Treatment with NaBH_4 destroys the stereocentres so it is no longer chiral
- B) The product is a meso compound ← can only arise from Gal
- C) The experimentalist made a mistake – it has to be chiral.
- D) The starting aldohexose was not chiral, so the product should not be either
- E) A racemic mixture was formed



37. What is the identity of the optically active product from the reaction of **Y** with NaBH_4 ?



- A) D-talitol
- B) D-glucitol
- C) D-mannitol
- D) D-galactitol
- E) D-lyxitol

see chart - could only be allose or galactose

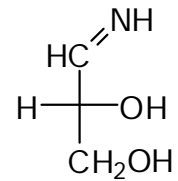
38. A hexose gave an optically inactive product when treated with HNO_3 . When the same hexose was treated with $\text{NaCN}/\text{H}_2\text{O}$ followed by hot aqueous acid, $\text{NaOH}/\text{H}_2\text{O}$, aqueous acid again and finally $\text{Na}(\text{Hg})$ at pH 3, two monosaccharides were produced. One of these gave an optically inactive product on treatment with HNO_3 , while the other gave an optically active product under the same conditions. What is the most likely identity of the original hexose?

} K.F. extension

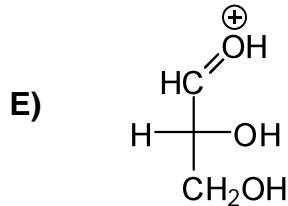
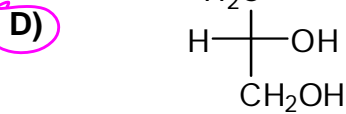
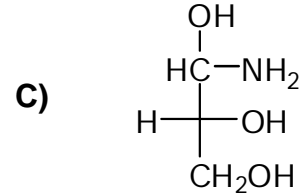
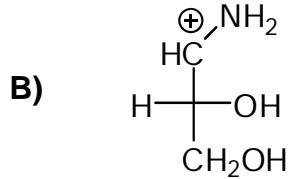
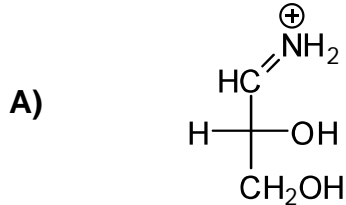
- A) D-galactose
- B) D-altrose
- C) D-mannose
- D) D-allose
- E) D-sorbose

if Gal underwent extension, none of the two products formed could be oxidized to a meso aldaric acid

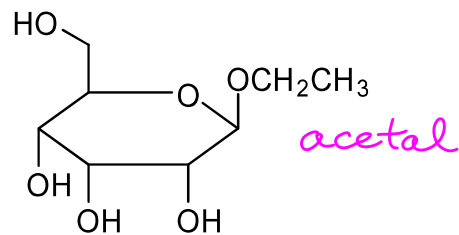
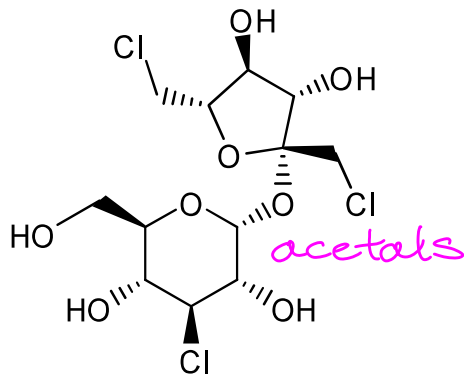
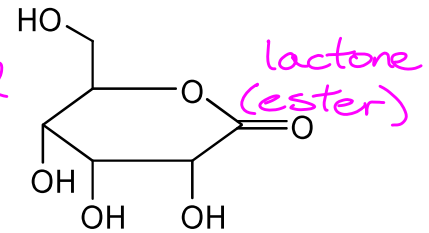
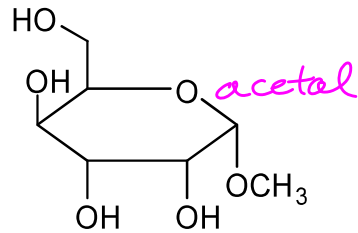
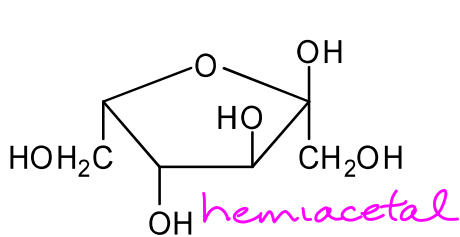
39. Which one of A – E is least likely to be involved in the acid-catalyzed hydrolysis of the compound on the right?



reverse of imine formation



40. How many of the following compounds can form an acyclic (non-cyclic) structure when treated with a base, such as aqueous NaOH? 2



Splenda

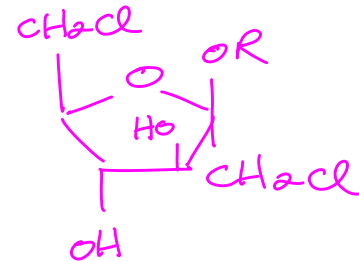
- acetals are base-stable
- lactones can be hydrolyzed

box says "made from sugar so it tastes like sugar" sugar = sucrose
 °° glucose + fructose

41. Refer to the structure of Splenda in the previous question. What is the sugar corresponding to the furanose ring?

- A) 1,6-dideoxy-1,6-dichloro-D-sorbose
- B) 1,6-dideoxy-1,6-dichloro-L-fructose
- C) 3-deoxy-3-chloro-D-glucose
- D) 3-deoxy-3-chloro-L-mannose
- E) 1,6-dideoxy-1,6-dichloro-D-fructose

redraw as:



42. Which one of the following best explains the origin of the term *invert sugar*?

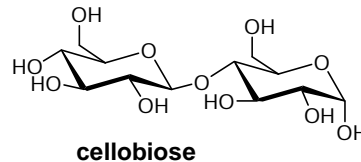
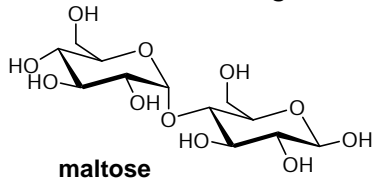
- A) Sucrose, when dissolves in water, mutarotates to an equilibrium specific rotation of the opposite sign
- B) The sign of the specific rotation of sucrose is opposite to that of a solution of hydrolyzed sucrose
- C) Upon dissolution, each stereocentre in sucrose undergoes inversion
- D) Upon dissolution, the anomeric carbon in the glucose fragment of sucrose undergoes inversion
- E) Upon treatment with acid, a racemic mixture of sucrose is obtained.

43. When a solution of sucrose is treated with an enzyme from the stomach of the bee, the optical rotation is observed to change from +66 to -40 degrees. This phenomenon is best described as?

- A) Racemization
- B) Oxidation
- C) Mutarotation
- D) Hydrolysis
- E) Isomerization

hydrolysis

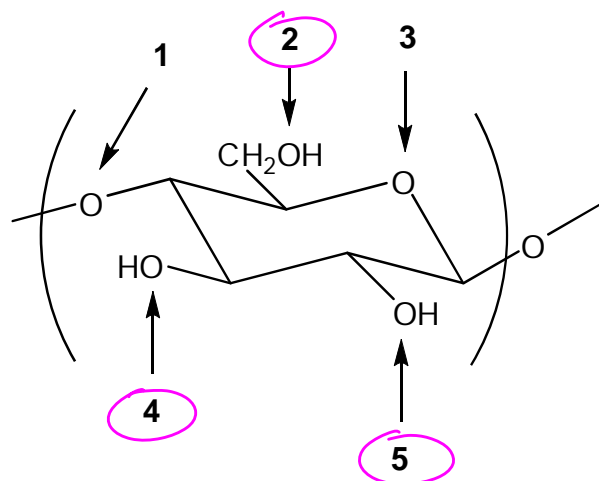
44. Which one of the following statements about cellulose is true?
- A) Cellulose is fermented to ethanol by numerous microorganisms
 - B) Ruminants can synthesize a cellulase enzyme
 - C) Cellulose and starch are constitutional isomers *x stereoisomers*
 - D) Cellulases invariably act outside the cell that synthesized them**
 - E) Cellulose represents 10% of the world's total biomass carbon
45. Why must the enzyme cellulase work outside the organism that hosts it?
- A) Cellulose is too highly charged to pass through the cell wall
 - B) Cellulose is too insoluble to pass through the cell wall**
 - C) Cellulose is too non-polar to pass through the cell wall
 - D) Cellulose is too soluble to pass through the cell wall
 - E) Amylose is too soluble to pass through the cell wall
46. Why is maltose a source of glucose for human nutrition, but cellobiose is not?



- A) Human enzymes require the β -anomer at the reducing end of the sugar.
- B) Cellobiose is too insoluble to be attacked by human enzymes which only work in solution
- C) Cleavage of cellobiose gives a monosaccharide which is not glucose
- D) The cellobiose acetal link is inherently resistant to acid hydrolysis.
- E) Humans only possess the enzyme to catalyze the hydrolysis the α -glycosides, and cellobiose has the β -geometry.**

51. Write a mechanism for the conversion of pyruvate to acetyl CoA. Assume all of the required coenzymes are present. *see class notes*
52. The mechanism of transaminase uses which coenzyme as a carrier of an amino group?
- A) Alanine
 - B) Coenzyme A
 - C) NAD⁺
 - D) Vitamin B₆ *pyridoxal phosphate*
 - E) Vitamin C
52. *← reacts with ald + ket*
Benedict's test could be used to differentiate which of the following sugars?
- A) Psicose and galactose
 - B) Fructose and tagulose
 - C) Sorbitol and sorbose *alcohol + ketone*
 - D) Ribose and glucose
 - E) Erythrose and glyceraldehyde

54. Below is a monomeric unit of cellulose. When cellulose is treated with excess acetic anhydride in the presence of acid, which oxygen atoms are acetylated?



- A) **1, 2, 4, and 5** only
B) **1** and **3** only
C) **2** only
D) **2, 4, and 5** only
E) All of them
55. In the preparation of the cellulose acetate film, what was the purpose of dibutyl phthalate?
- A) It aided in the dissolution of the cellulose (cotton)
B) It functioned as a drying agent that removes residual water from the solution
C) It makes the cellulose acetate more soluble in water
D) It softens the cellulose acetate to prevent from becoming brittle
E) It neutralizes the residual H_2SO_4