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Carbohydrates: Sugars as Macromolecules

Exam — Biochemistry

Pre-med/IB-style questions covering carbohydrate structure (mono/di/polysaccharides), glycosidic bonds, reducing sugars, alpha vs beta linkages, storage vs structural polysaccharides (starch, glycogen, cellulose, chitin), and cell biology roles (glycocalyx, glycoproteins/glycolipids, cell recognition, peptidoglycan).

40 items — Printable Exam

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1 **Why are large polysaccharides (e.g., glycogen, starch) better for intracellular glucose storage than storing the same number of glucose molecules as free monosaccharides?**

A Polysaccharides diffuse across membranes more easily than monosaccharides

B Polysaccharides create a much lower osmotic effect per glucose unit and can be stored compactly

C Polysaccharides are more reactive and therefore easier to mobilize instantly

D Polysaccharides are amphipathic and form bilayers around glucose

E Polysaccharides cannot be broken down back into glucose

2 **The formation of a glycosidic bond between two monosaccharides is best described as:**

A A hydrolysis reaction that consumes water

B A condensation (dehydration) reaction that releases water

C A redox reaction that transfers electrons

D A phosphorylation reaction that adds phosphate

E A reaction that forms peptide bonds

3 **Which description best defines a glycosidic bond in carbohydrates?**

A A covalent bond between two amino acids

B A covalent bond between sugar units, typically involving the anomeric carbon of one sugar

C A hydrogen bond between parallel -sheets

D An ionic bond between fatty acid heads and tails

E A phosphodiester bond linking nucleotides

4 **Which disaccharide is NON-reducing (i.e., cannot act as a reducing sugar)?**

A Maltose

B Lactose

C Sucrose

D Cellobiose

E All disaccharides are reducing

5 **A carbohydrate is called a "reducing sugar" mainly because it:**

A Has at least one free anomeric carbon that can open to a reactive aldehyde/ketone form

B Always contains a phosphate group

C Is always a polysaccharide

D Is always insoluble in water

E Can only be digested by bacteria

6 **Which disaccharide is composed of glucose + galactose and is typically a reducing sugar?**

A Sucrose

B Maltose

C Lactose

D Trehalose

E Cellulose

7 **The "anomeric carbon" of a monosaccharide is best described as the carbon that:**

A Always carries the phosphate group in the cell

B Was the carbonyl carbon (aldehyde/ketone) in the linear form and becomes a new stereocenter in the ring form

C Is always the terminal carbon farthest from oxygen

D Forms peptide bonds with amino acids

E Is the only carbon present in carbohydrates

8 **When a glycosidic bond forms using a sugar's anomeric carbon, what happens to that anomeric carbon?**

A It becomes unable to participate in ring opening (it is "locked" as an acetal/ketal)

B It becomes a phosphate group

C It becomes an amino acid

D It is removed from the molecule

E It turns into a peptide bond

9 **Cellulose differs from starch mainly because cellulose contains:**

A (1→4) glycosidic bonds that form a helix

B (1→4) glycosidic bonds that create straight chains

C Peptide bonds between glucose units

D Phosphodiester bonds between glucose units

E Only fructose units

10 **Humans cannot digest cellulose efficiently because humans lack:**

A Enzymes that break (1→4) glycosidic bonds

B Enzymes that break (1→4) glycosidic bonds between glucose units (cellulase)

C The ability to absorb glucose from the intestine

D Hydrochloric acid in the stomach

E Any enzymes that digest carbohydrates at all

11 **Which statement best explains why cellulose fibers are mechanically strong?**

A Cellulose chains are highly branched, trapping large amounts of water

B Straight cellulose chains align and form extensive hydrogen bonds between chains

C Cellulose contains many disulfide bonds between chains

D Cellulose is made of lipid bilayers stacked together

E Cellulose is a protein with -helices

12 **Which polysaccharide is the primary glucose storage polymer in animals?**

A Cellulose

B Chitin

C Glycogen

D Amylose

E Pectin

13 **Compared with amylopectin (starch), glycogen typically has:**

A Fewer branches (fewer $(1\rightarrow6)$ linkages)

B More frequent branching (more $(1\rightarrow6)$ linkages)

C $(1\rightarrow4)$ linkages instead of linkages

D No glucose units

E Only fructose units

14 **A key advantage of glycogen's branching for rapid energy release is that branching:**

A Eliminates the need for enzymes

B Creates many non-reducing ends where enzymes can add/remove glucose quickly

C Makes glycogen able to cross membranes directly

D Creates $(1\rightarrow4)$ bonds that are harder to break

E Turns glycogen into a lipid

15 **Which statement correctly matches amylose and amylopectin?**

A Amylose is highly branched; amylopectin is unbranched

B Amylose is mostly unbranched ($1\rightarrow4$); amylopectin is branched ($1\rightarrow4$ with $1\rightarrow6$)

C Amylose contains $(1\rightarrow4)$ bonds; amylopectin contains peptide bonds

D Amylose is made of fructose; amylopectin is made of galactose

E Both are structural components of insect exoskeleton

16 **Which pair of monosaccharides are epimers (differ at exactly one chiral carbon)?**

A Glucose and fructose

B Glucose and galactose

C Glucose and sucrose

D Starch and cellulose

E Glycine and alanine

17 **Which monosaccharide is a ketose (rather than an aldose)?**

A Glucose

B Galactose

C Fructose

D Ribose

E Deoxyribose

18 **Most biologically common sugars are in the D-configuration. This statement refers primarily to:**

A Whether the sugar can be digested by humans

B Whether the sugar is a reducing sugar

C The stereochemistry around the chiral carbon farthest from the carbonyl group (relative to D-glyceraldehyde)

D Whether the sugar forms or anomers

E The number of carbons in the sugar

19 **Chitin is best described as:**

A A branched $(1\rightarrow6)$ glucose polymer used for animal energy storage

B A $(1\rightarrow4)$ polymer of N-acetylglucosamine found in arthropod exoskeletons and fungal cell walls

C A disaccharide of glucose + fructose

D A lipid used to form membranes

E A nucleic acid sugar found only in DNA

20 **In animal cells, carbohydrates on the external surface of the plasma membrane are most commonly found as part of:**

A Free polysaccharides floating in the cytosol

B Glycoproteins and glycolipids forming the glycocalyx

C DNA and RNA projecting through the membrane

D Triglycerides embedded as the main bilayer component

E Cellulose microfibrils anchored in the membrane

21 **Which is a key function of the glycocalyx on animal cells?**

A ATP production via oxidative phosphorylation

B Cell–cell recognition and adhesion through specific carbohydrate patterns

C DNA replication during S phase

D Protein synthesis on ribosomes

E Direct pumping of Na^+ out of the cell

22 **Glycolipids involved in cell recognition are most commonly oriented so that their carbohydrate chains face:**

A The cytosol

B The nucleus

C The extracellular space

D The mitochondrial matrix

E The inside of lysosomes

23 **Which statement best distinguishes proteoglycans from typical glycoproteins?**

A Proteoglycans have short, branched oligosaccharides; glycoproteins have long unbranched chains

B Proteoglycans have long, often unbranched glycosaminoglycan chains and a high carbohydrate content

C Proteoglycans are made entirely of lipids; glycoproteins are made entirely of sugars

D Proteoglycans are found only in the nucleus

E Glycoproteins cannot be part of membranes

24 A major reason glycosaminoglycans (GAGs) attract water and resist compression in tissues is that they often:

A Contain many positively charged groups that repel water

B Are strongly negatively charged (e.g., sulfate/carboxyl groups), attracting cations and water

C Are made only of hydrophobic amino acids

D Form peptide bonds with collagen

E Are stored inside mitochondria to regulate ATP

25 Which statement about N-linked versus O-linked glycosylation is MOST accurate (basic cell biology level)?

A N-linked glycosylation attaches sugars to lysine in the nucleus; O-linked attaches to DNA in mitochondria

B N-linked glycosylation attaches to asparagine and begins in the ER; O-linked often attaches to serine/threonine and is commonly processed in the Golgi

C Both occur only in the cytosol after translation

D O-linked glycosylation always forms cellulose fibers

E Glycosylation can only happen in prokaryotes

26 ABO blood group differences are primarily determined by variation in:

A The amino acid sequence of hemoglobin

B Carbohydrate structures on glycoproteins/glycolipids at the red blood cell surface

C The number of mitochondria in red blood cells

D The length of DNA in the red blood cell nucleus

E The fatty acid saturation level of red blood cell membranes

27 **Peptidoglycan in bacterial cell walls contains repeating units of:**

A Glucose and fructose

B N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM)

C Ribose and deoxyribose

D Cellulose and chitin

E Amino acids only, no sugars

28 **Lysozyme (found in tears and saliva) helps defend against bacteria by cleaving:**

A Peptide bonds in bacterial enzymes

B (1→4) glycosidic bonds between NAG and NAM in peptidoglycan

C (1→6) glycosidic bonds in glycogen

D Phosphodiester bonds in bacterial DNA

E Disulfide bonds in membrane proteins

29 **Which polysaccharide is a structural component of plant cell walls?**

A Glycogen

B Cellulose

C Amylopectin

D Sucrose

E Lactose

30 **If two glucose molecules form maltose, which type of bond is most characteristic of maltose?**

A (1→4) glycosidic bond

B (1→4) glycosidic bond

C (1→6) glycosidic bond

D Peptide bond

E Phosphodiester bond

31 **Which polymer is a homopolysaccharide of glucose with (1→4) and (1→6) linkages and is typically MORE highly branched than plant starch?**

A Cellulose

B Chitin

C Glycogen

D Pectin

E Hyaluronan

32 **A student claims: "Starch and cellulose are both made of glucose, so they must have the same properties." What is the best rebuttal?**

A Correct—if monomers are the same, polymers must be identical

B Incorrect—different glycosidic bond geometry (vs) changes 3D structure and properties dramatically

C Incorrect—cellulose is made of fructose, not glucose

D Correct—cellulose differs from starch only because it contains more water

E Correct—cellulose and starch are both proteins that fold differently

33 **A polymer has one reducing end and many non-reducing ends. Which polymer most fits this description and why?**

A Cellulose, because it is highly branched

B Glycogen, because branching creates many non-reducing ends while the polymer still has only one reducing end

C Sucrose, because it contains two reducing ends

D Lactose, because it contains no reducing end

E Triglyceride, because it is a carbohydrate polymer

34 **A common lab test uses iodine to produce a blue-black color with certain carbohydrates. Which carbohydrate is most associated with this classic blue-black iodine reaction?**

A Amylose (a component of starch)

B Cellulose

C Glucose

D Sucrose

E Chitin

35 **Many cell-surface carbohydrates serve as 'ID tags' for recognition. Which statement best explains why carbohydrate-based ID tags are so information-rich?**

A Carbohydrates can form many different branching patterns and linkage positions, increasing diversity

B Carbohydrates can only form one type of bond, making them easy to distinguish

C Carbohydrates have only one possible stereochemistry

D Carbohydrates always form double helices like DNA

E Carbohydrates cannot be modified after synthesis

36 **A virus binds a specific carbohydrate residue on host cell glycoproteins to attach and enter. Where must that carbohydrate residue be located to allow binding?**

A On the cytosolic side of the plasma membrane

B In the mitochondrial matrix

C On the extracellular side of the plasma membrane

D Inside the nucleus

E Only on the inner leaflet of the Golgi membrane

37 **Which statement about monosaccharides in solution is most accurate?**

A They exist only in the linear form

B They exist only in the cyclic form and can never open

C They can interconvert between linear and cyclic forms, allowing and anomers to exist

D They are always non-reducing in water

E They form peptide bonds spontaneously

38 **A sugar is reducing even when most molecules are in the ring form because:**

A The ring form contains a free aldehyde group

B The ring can open to a linear form that contains a reactive carbonyl (aldehyde/ketone)

C All rings are nonpolar and donate electrons easily

D The sugar has a phosphate group that reduces other molecules

E Reducing sugars must be polysaccharides

39 **Which sugar is the key pentose component of RNA (but not DNA)?**

A Ribose

B Deoxyribose

C Glucose

D Fructose

E Galactose

40 **A lysosomal enzyme in an animal cell is tagged for delivery to lysosomes using a carbohydrate-based signal. Which signal is most associated with this targeting mechanism?**

A A cellulose microfibril attached to the enzyme

B Mannose-6-phosphate on an N-linked oligosaccharide

C Sucrose attached to the enzyme's active site

D Glycogen branching at $(1\rightarrow6)$ points

E A phosphodiester bond added to serine

#	Ans	Answer Text
	B	
2	B	A condensation (dehydration) reaction that releases water
	B	
4	C	Sucrose
	A	
6	C	Lactose
	B	
8	A	It becomes unable to participate in ring opening (it is "locked" as an a…
	B	
10	B	Enzymes that break (1→4) glycosidic bonds between glucose units (cellul…
	B	
12	C	Glycogen
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	C	
18	C	The stereochemistry around the chiral carbon farthest from the carbonyl …
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20	B	Glycoproteins and glycolipids forming the glycocalyx
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22	C	The extracellular space
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24	B	Are strongly negatively charged (e.g., sulfate/carboxyl groups), attract…
	B	
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32	B	Incorrect—different glycosidic bond geometry (vs) changes 3D structu…
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34	A	Amylose (a component of starch)
	A	
36	C	On the extracellular side of the plasma membrane
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