Mark scheme - Biological Molecules: Carbohydrates

Question			Answer/Indicative content	Marks	Guidance
1			A ✓	1	
			Total	**1**	
2			D ✓	1	
			Total	**1**	
3			B ✓	1	
			Total	**1**	
4			C ✓	1	
			Total	**1**	
5			A ⟩	1	**Examiner's Comments** A large majority of candidates achieved the mark.
			Total	**1**	
6			B ✓	1	
			Total	**1**	
7			**D** ✓	1	**Examiner's Comments** The correct response was D, however, all the other options were selected by different candidates.
			Total	**1**	
8			**A** ✓	1	**Examiner's Comments** A, the correct response was selected by some All the other options were selected by candidates who perhaps had a lack of knowledge of this detail.
			Total	**1**	
9			**C** ✓	1	**Examiner's Comments** This question tested knowledge of molecular structure. Candidates should be aware that carbohydrates and lipids contain only C, H and O. Candidates should also know that insulin is a protein and therefore contains N. ATP being closely related to nucleotides must also contain N as

					well as P. It appears that many less able candidates became confused by the numbers of letters involved in each row and guessed at the correct response (C).
			Total	**1**	
10			**A** ✓	1	**Examiner's Comments** This question tests knowledge of carbohydrate structure and how candidates apply their knowledge to solubility. Most candidates apparently knew that glucose and ribose are the most soluble. Many candidates found it difficult to assess whether amylose or amylopectin is the least soluble.
			Total	**1**	
11			**A** ✓	1	**Examiner's Comments** This question tests knowledge of molecular structure and how bonds are named. Most candidates opted for answer D which is the type of bond found in maltose – the simple disaccharide composed of two alpha glucose units. Only the most able candidates looked closely at the diagram to see that this is actually a 1,6-glycosidic link rather than a 1,4−glycosidic link.
			Total	**1**	
12			**C ✓**	**1**	**Examiner's Comments** This was fairly well answered.
			Total	**1**	
13			**B ✓**	**1**	**Examiner's Comments** Many candidates got this one wrong with all distractors proving tempting.
			Total	**1**	
14			β / beta glucose	1	
			Total	**1**	
15			B	1	**Examiner's Comments** This was a straightforward question that candidates should have been able to answer by recalling the fact.

					This was answered correctlyby a high proportion of candidates.
			Total	**1**	
16		i	it contains, N / nitrogen **or** monosaccharide does not contain nitrogen ✓	1	**CREDIT** any correct ref to the nitrogen-containing group in Fig. 3.1 $NHCOCH_3$ **ACCEPT** 'OH is replaced with $NHCOCH_3$' **or** '$NHCOCH_3$ is replaced with OH' **ACCEPT** ref to H not being twice C / 15 H instead of 12 / 8 C instead of 6 **ACCEPT** has no OH on carbon 2 **ACCEPT** 'monosaccharide **only** contains C, H & O' **DO NOT CREDIT** 'it has a nitrogen molecule' **Examiner's Comments** Candidates' understanding of biochemistry was generally good. The mechanism of a condensation reaction was well known, although some candidates confused glycosidic and peptide bonds. The presence of the N in various forms was generally recognised.
		ii	beta / β ✓ glucose ✓	2	**IGNORE** alpha /**α** **DO NOT CREDIT** B / b / beta pleated sheet **Examiner's Comments** Many candidates correctly suggested beta glucose, although some failed to specify the type of glucose or incorrectly suggested alpha. If using the symbol for beta, rather than writing it in full, it should be stressed to candidates that the symbol must be unambiguous and clearly distinguishable from the letter B. Consequently, β needed to have a clear 'tail' so as not to be confused with B. (B or b were not acceptable

					answers because of the potential confusion with protein structure.)
		iii	*four from* 1 (in chitin glycosidic bond(s) formed by) condensation ✓ 2 (molecule of) H_2O / water, produced / released ✓ 3 alternate monomers are, upside-down / flipped / rotated through 180° ✓ 4 because of the position of the, OH / H, on carbon 1 ✓ 5 forms a, straight / linear / unbranched, chain / molecule / polymer ✓ 6 similar to cellulose ✓	4	**IGNORE** ref to 1-4 linkage & glycosidic (as given in Q) **ACCEPT** shown on a diagram 3 **ACCEPT** sugars / units / residues / molecules **DO NOT CREDIT** glucose 4 Must be a clear statement **ACCEPT** the 2 OH groups cannot, line up / bond 5 **IGNORE** ref to branching **IGNORE** ref to polysaccharide 6 **ACCEPT** ref to H bonds crosslinking between, molecules / chains **Examiner's Comments** Many candidates gained 2 out of the 4 possible marks. These tended to be the mark points for condensation reaction and the water released. There were some excellent answers from candidates who applied their scientific knowledge and explained fully how chitin could be formed to gain all 4 marks. The need to 'flip' alternate monomers was recognised but few managed to clearly explain why this was necessary. The similarity to cellulose was identified but some were unable to distinguish between the monomer and polymer, stating that chitin molecules are joined to each other by glycosidic bonds. Weaker answers strayed into descriptions of alpha helixes and beta pleated sheets.
			Total	**7**	

17	a		starch **AND** glycogen✓	1	**ALLOW** amylose , amylopectin
	b		***Please refer to the marking instructions on page 3 of this mark scheme for guidance on how to mark this question. In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.) Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1****,* ***Level 2*** *or* ***Level 3****, best describes the overall quality of the answer. Then award the higher, middle or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* • *award the higher mark where the Communication Statement has been met.* • *award the middle mark where aspects of the Communication Statement are missing.* • *award the lower mark where the Communication Statement has not been met.* • ***science content determines the level.*** • ***Communication Statement determines the mark within a level.*** **Level 3 (7−9 marks)** A good range of structural details and properties are provided including reference to fats and carbohydrates in both plants and animals. Explanations are provided for each structural comment.	• Max 9	**Indicative scientific points may include: Structures (S), Properties (P) and Explanations (E):** Carbohydrates: S1. Polymers of glucose E1. Glucose can be used in

			The explanations are clearly linked to the structure of the molecules and the use of scientific terminology is at an appropriate level. All the information presented is relevant and forms a continuous narrative. **Level 2 (4−6 marks)** Some structural details and properties are provided including reference to molecules in both plants and animals. Explanations are provided for each structural comment. *The explanations are clearly linked to the structure of the molecules but may not fully explain how the structure suits the role and use of scientific terminology may not always be appropriate. The information presented is mostly relevant.* **Level 1 (1−3 marks)** A limited number of structural details are provided. The explanations do not clearly show how the molecules are suited to their role. *There is a logical structure to the answer. The explanations, though basic, are clear.* 0 marks No response or no response worthy of credit		respiration to release energy S2. Large molecules P2. Insoluble E2. Do not affect water potential of cell S3. 1−4 glycosidic bonds E3. Easy to make and break to release glucose / monomers S4. Coiled shape / compact E4. Take up less space in cell S5. Amylose unbranched / amylopectin with few branches E5. No need for rapid release of monomers in plants S6. Glycogen more branched E6. Allows more rapid release of monomers in animals Lipids (**ACCEPT** lipids or fats): S7. Fats have more carbon-carbon bonds / carbon-hydrogen bonds P7. Fats are energy rich / contain more energy per molecule E7. More energy stored in less space P8. Fats are insoluble E8. Do not affect water potential of cell S9. Fatty acids are long carbon chains E9. Can be broken down to release two carbon / acetyl groups (which enter Krebs cycle) S10. Animal fats saturated / harder E10. Have role in protection / insulation as well as energy storage.
			Total	**10**	
18		i		**2 max**	**Mark the first 2 answers** **IGNORE** properties e.g. solubility **IGNORE** ref to hexagons / rings **IGNORE** hydrocarbon

			both contain, C / carbon (atoms) **and** H / hydrogen (atoms) ✓ contain, O / oxygen (atoms) ✓ have, OH / hydroxyl / hydroxide (groups) ✓		**DO NOT ACCEPT** hexose **DO NOT ACCEPT** ions **DO NOT ACCEPT** molecules / groups **DO NOT ACCEPT** molecules / groups **ACCEPT** alcohol group **DO NOT ACCEPT** molecules **Examiner's Comments** Poor exam technique meant that some answers did not focus on cholesterol's *similarities* with glucose but simply described features shown on the cholesterol molecule. Ideally points should have begun with 'both', as in 'both contain carbon and hydrogen' or 'both include hydroxyl groups'. Elementary flaws in candidates' understanding of chemistry lost marks when atoms, elements or organic groups like the hydroxyl group were referred to as 'molecules'. Incorrect lines of thought took candidates to discussions of hexose, glycosidic bonds and branched and unbranched polysaccharide structures
		ii	(glucose is) soluble (in water) ✓	**1**	**ACCEPT** polar / dissolves (in water) **Examiner's Comments** The correct answer was very commonly given. Sometimes the wording was that glucose is polar or able to dissolve in water or plasma. A few candidates stated that glucose was insoluble and some simply wrote the one word 'solubility' without stating how this concept applied to glucose. Some, referring back to a question on paper 1, described it as small and compact rather than homing in on its solubility.
			Total	**3**	

19			*glycogen is* **1** insoluble, so has no effect on, water potential / Ψ (of cell) ✓ **2** metabolically inactive ✓ **3** compact / lots can be stored in a small space ✓ **4** able to store, large amounts / lots, of energy ✓ **5** (highly branched so) has lots of ends for, adding / removing, glucose (when needed) **or** can be broken down, fast / quickly / rapidly, to release glucose ✓	**3**	**ACCEPT** ORA for glucose for **mps 1, 2 3 & 4 only** **1 ACCEPT** insoluble so has no osmotic effect (on cell) **5 IGNORE** ref to surface area **Note:** 'compact so can store large amounts of energy' = 2 marks (mps 3 & 4) **Examiner's Comments** Candidates understood that glycogen is more compact than glucose, but didn't usually go on to explain that it stores large amounts of energy. Many commented that glycogen is insoluble, but didn't explain that it can be stored without any water potential implications for cells. A large number of candidates substituted 'energy' for 'glucose' when describing how the structure of glycogen allows a rapid release of glucose. There was a tendency to describe removal of glucose as 'easy' rather than 'fast'. The highly branched structure was noted but not explained further in terms of the idea of lots of 'ends' for rapid hydrolysis. A significant minority of candidates appeared to have little understanding of glucose and glycogen structure, e.g. seeming to be unaware that

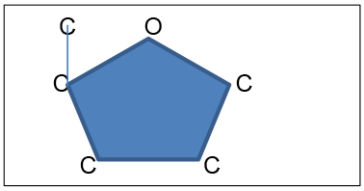
					glycogen was a polymer of glucose or making statements about the number of branches in glucose molecules.
			Total	**3**	
20	a	i	two, 6-membered rings / hexoses ⟩ (1-4) glycosidic bond ⟩ two CH^2OH (groups) ⟩ rings contain one, oxygen atom / O ⟩	**2 max**	**IGNORE** 6-carbon ring **ALLOW** two 5C-rings **IGNORE** molecule **IGNORE** oxygen / 0, molecule **Examiner's Comments** Around half of candidates got one mark for identifying glycosidic bonds as a common feature. Where candidates incorrectly identified the bond as 1,6 glycosidic, the mark was not awarded. Many candidates correctly identified hexose sugars but, of these, only a minority said there were two of them (in each molecule). The question asked for structural similarities, so frequent answers about condensation reactions were not credited.
		ii	lactose maltose (contains) beta / β-glucose (contains) alpha / α-glucose ⟩ β-glycosidic bond α-glycosidic bond ⟩ sugars in opposing orientation / flipped / AW both (monomers) in same direction / AW ⟩	**3**	**IGNORE** description of structural difference between glucose and galactose **IGNORE** refs to inversion of, e.g. CH^2OH **Examiner's Comments** This was a challenging question and 3 marks were rarely awarded. A relatively high number of candidates omitted it altogether or did not fill all the available boxes. Around half of candidates gained one mark for recognising either β-glucose and α-glucose or describing the alternating orientation of sugar residues in lactose. Some candidates achieved both of these marks. Very few candidates attached the prefixes, α and β, to the glycosidic bonds. There

					were a large number of incorrect references to 1,6 glycosidic bonds for either disaccharide. A common error was to comment on properties, such as solubility or polarity, rather than structure.
	b	i	bonds contain energy ⟩ (bonds) can be broken by (respiratory) enzymes ⟩ soluble so, can move (within cell) ⟩ H / OH, (groups) can form H bonds with water / allow solubility ⟩ AVP ⟩	**3 max**	**CREDIT** used in glycolysis / converted to pyruvate / phosphorylated / (easily) converted to glucose **Examiner's Comments** Few candidates achieved full marks for this question, many candidates focused on their knowledge of respiration rather than applying their knowledge of the structure and function of glucose from module 2 and so were only awarded the AVP as respiration is not directly tested in this paper. All other marking points were seen, but not particularly often. Some candidates who wrote about bond energy were unable to gain the first marking point because they said that that hydrogen or glycosidic bonds were the source of energy. References to energy being produced, made or created were not credited. Many candidates confused galactose with glycogen – perhaps as a result of having studied mark schemes on previous papers. A significant number wrote about glucose and galactose having similar structures but then failed to gain more marks by stating explicitly how the structure of glucose is related to its function, which they ought to have learned when studying module 2.
		ii	(too) big ⟩	**2**	**IGNORE** charged / polar

			unable to pass between phospholipids ⟩ **OR** no / small, concentration gradient ⟩ needs, carrier protein / pump ⟩		**CREDIT** needs, channel / (lactose) permease **IGNORE** phospholipid bilayer **DO NOT CREDIT** channel **ALLOW** needs <u>active</u> transport protein **Examiner's Comments** This question could be answered in two ways. A large majority of candidates correctly suggested that lactose was too big to cross the membrane. Fewer followed this up with the correct explanation in terms of fitting between phospholipids or needing the presence of a channel. A less common suggestion was the idea of the lack of a concentration gradient, but again few went on to talk about the need for a carrier protein or pump. Many candidates were unable to express the concept of a low concentration gradient well enough to be awarded the mark. Many candidates suggested both explanations but failed to explain them as directed and so received only one mark.
		iii	(mammal diet high in milk, so) high lactose concentration ⟩ (structural) gene for protein channel / lactose permease gene / lac Y, is, transcribed / expressed switched on ⟩ (protein is) lactose permease ⟩	**2 max**	**ORA** for older mammals **ALLOW** lactose is present **ALLOW** description of lactose causing repressor protein to leave operator **ALLOW** *lac* operon is switched on **Examiner's Comments** This question was intended to be challenging but fewer than half of candidates gained even one mark. Although E. coli was mentioned three times in the question, around half of candidates discussed the use of lactose by mammals, the presence of proteins in mammalian cell membranes, ageing in mammals or lactose intolerance, without any reference to E. coli. Some candidates

					realised that the question was about the lac operon but still discussed this in terms of the young mammals rather than E. coli. Very few candidates were awarded both available marks.
			Total	**12**	
21			insoluble ✓ unreactive / inert ✓ high <u>tensile</u> strength ✓ flexible ✓ can form hydrogen bonds with neighbouring chains ✓	3 max	**<u>List Rule</u>** If all **three** prompt lines used and more than one property is on prompt line mark the **first** one on each line. If only **one** or **two** lines used but there is more than one property listed mark the first three properties given. **IGNORE** detail about structure or cell walls **IGNORE** permeable **IGNORE** rigid **IGNORE** strong **<u>Examiner's Comments</u>** Many candidates gained one mark here with the most common response being 'insoluble'. However, few candidates gained three marks. Many candidates gave structural details rather than properties of cellulose or described properties of the cellulose cell wall rather than the polymer, cellulose. Responses that were not credited for these reasons included permeable, rigid and strong (without mention of tensile strength).
			Total	**3**	
22			*Similarities* ***Any two from:*** polymers / polysaccharides ✓ have , 6 carbon / C6 , sugars ✓ have 1-4 glycosidic bonds ✓ have CH_2OH side group (in monomers) ✓ *Differences* ***Any two from:*** chitin has β-glycosidic bonds ✓ chitin contains , nitrogen / N / amide / $NH\text{-}CO\text{-}CH_3$ ✓	4 max	**ALLOW** have hexose(s) **ALLOW** glycogen has α-glycosidic bonds **ALLOW ORA** for glycogen

			no 1-6 glycosidic bonds in chitin ✓ no branching in chitin ✓		**ALLOW ORA** for glycogen **ALLOW ORA** for glycogen **Examiner's Comments** Many candidates were able to achieve at least two to three marks in this part of the question which was assessing AO2. Some candidates were not credited due to using terms incorrectly such as stating that 'they are hexose sugars' instead of 'contain' or 'have hexose sugars.' Many candidates recognised the fact that both contained glycosidic bonds, but this was not sufficient to gain credit. Good responses gave required detail and referred to the type of bonds present i.e. 1-4 or 1-6. For differences, some candidates did not specify which polymer they were referring to so could not be credited for certain mark points.
			Total	**4**	
23	a	i	soluble / polar ✓	1 (AO1.1)	
		ii	*any three from:* *glycogen (compared to amylopectin)* more branched ✓ more coiled ✓ (so is) more compact / less space needed (for storage) ✓ (branching gives) many / more, free ends ✓ where glucose can be added or removed ✓ (so) speeds up glucose, release / hydrolysis ✓	3 max (AO2.1)	*ORA for amylopectin throughout*
		iii	OH / H, group on C1 is in opposite position to, beta glucose / Fig 1.1 OR in alpha glucose -H is at top and -OH is at bottom on C1 ✓	1 (AO1.1)	**ALLOW** C1 position to be shown on diagram

	b		diagram completed to show correct position of all **5** carbon atoms in a pentose ✓	1 (AO1.1)	 **IGNORE** additional H, OH, H_2OH
			Total	**6**	
24			*callose…* (has) 1-3 and 1-6 glycosidic bonds ✓ (is) branched ✓ (is) helical ✓ *idea of* alternate glucose molecules are not rotated 180° ✓	2 max (AO2.1)	**ALLOW** cellulose (has only) 1-4 glycosidic bonds **ALLOW** cellulose is, not branched / straight chains **ALLOW** cellulose is not helical **IGNORE** callose is more compact **ALLOW** *idea of* alternate glucose molecules rotated 180° in cellulose **Examiner's Comments** Most candidates scored well on this question, showing a good understanding of plant diseases and examples of defences against herbivory. In (a), many candidates recognised that callose was branched and that the alternate glucose molecules were not rotated 180o.Others confused the types of glycosidic bonds found between the monomers in cellulose and callose. Some candidates gave examples of human viral diseases in (c) which did not gain credit. Likewise, the suggestion that insects develop immunity to insecticides in (e) was not credited.
			Total	**2**	
25					**Examiner's Comments** Most candidates were able to describe the habitat of *D. antarctica* as having lower light levels in (b), although few could suggest reasons for this. Some responses ignored the evidence of the graph and incorrectly focused on temperature differences between the two habitats.

					Few candidates scored full marks for the calculation of Spearman's Rank Correlation Coefficient in (c)(i). This was because most squared the absolute differences between the values rather than squaring the differences in rank. The importance of writing down the steps in the calculation was shown by the fact that often candidates gained marks for these steps as error carry forward (ECF). Candidates confused this statistical test with other tests such as the student's t-test or chi squared test, when answering (c)(ii) and (c)(iii). Very few concluded that the value worked out for (c)(i) showed a significant positive correlation and the value given for (c)(ii) would show no significant correlation. Many candidates' answers referred to null hypotheses being accepted or rejected or to there being a significant difference between the water content of soil and the mean rate of photosynthesis. Most candidates could suggest an advantage for (d)(i) and could correctly identify the letter representing fucoxanthin in (d)(ii). **AfL** Give candidates opportunities to select and use the full range of statistical tests, and to interpret the significance of those tests. Mathematical skills statistics booklet Maths Skills Handbook
				1 (AO1.1)	

Statement about amylose	**True or False?**
Amylose is soluble	False

			<table><tr><td>Amylose is branched</td><td>False</td></tr><tr><td>Amylose is formed by condensation reactions</td><td>True</td></tr></table> All 3 correct = ✓		
			Total	**1**	