1.1 Water, carbohydrates and food tests

Name: _____ Class: _____ Date: _____ **Total: 21 marks**

KEY WORDS condensation • hydrolysis • glycosidic bond • amylose • glycogen • semi-quantitative

Objective

Practise the carbohydrate and water chemistry of Topic 1 statements 1.1–1.4: water as a polar solvent, condensation and hydrolysis of sugars, the storage polysaccharides, and Core Practical 1's semi-quantitative food tests. Original training tasks grounded in the specification.

1 Key knowledge and worked examples

■ Two reactions build and break every carbohydrate

Condensation joins two monosaccharides, removing a water molecule and forming a **glycosidic bond**. **Hydrolysis** adds water back across that bond. Maltose = glucose + glucose; sucrose = glucose + fructose; lactose = glucose + galactose.

■ Storage structure is release speed

Amylose: 1,4-linked straight chain that coils – compact. Amylopectin and glycogen add 1,6-branches every 24–30 residues – many chain ends, so hydrolases release glucose quickly. Glycogen is the animal store; starch (amylose + amylopectin) is the plant store.

■ Worked example: reading a Benedict's calibration

Colour standards of 0–4 % glucose are heated with equal volumes of Benedict's and read in a colourimeter (absorbance 0.02, 0.09, 0.18, 0.35, 0.64). The straight section runs to about 4 %; beyond it the reagent saturates. An unknown of absorbance 0.58 lies at $0.58/0.16 \approx 3.6\%$. Two working habits: compare like with like (equal volumes, same heating time), and read unknowns inside the calibrated range, not past it.

2 Practice

2.1 Explain, in terms of its dipole nature, why water dissolves sodium chloride but hexane does not. [3]

2.2 Name the bond formed when two glucose molecules join, state the molecule removed, and name the disaccharide produced. [3]

2.3 Explain one way in which the structure of glycogen suits its role as an animal energy store. [2]

3 Exam-style questions

3.1 A student heats equal volumes of Benedict's reagent with five glucose standards and a fruit-juice sample. The juice's colour matches the 2 % standard exactly, but the juice was diluted 1 part juice to 4 parts water before testing. Calculate the glucose concentration of the undiluted juice, showing your working, and state one reason why colour matching against standards is described as semi-quantitative. [4]

3.2 Amylose and cellulose are both polymers of glucose, yet only amylose serves as an energy store for the plant. Describe two structural differences between amylose and cellulose and explain why each difference makes cellulose unsuitable as an energy store. [4]

3.3 Lactose-intolerant people lack the enzyme that hydrolyses lactose. Name the products of lactose hydrolysis, name the bond broken, and explain why failing to hydrolyse lactose causes gut symptoms when gut bacteria ferment it instead. [5]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 Water is polar: oxygen pulls shared electrons, giving each O–H bond a negative and a positive end. Water molecules cluster around Na^+ with their negative ends and around Cl^- with their positive ends, so the lattice separates and dissolves. Hexane is non-polar, so it cannot surround ions and exerts no attractive forces comparable with the ionic lattice.

2.2 Glycosidic bond; a molecule of water is removed; maltose.

2.3 Any one: many 1,6-branch points give many chain ends, so glucose is released rapidly when energy is needed; or the polymer is insoluble, so it stores energy without changing cell water potential.

3.1 The diluted juice is 2 %. Dilution was 1 in 5 total (1 part juice + 4 parts water), so the original is $2\% \times 5 = 10\%$. Semi-quantitative because colour is judged by eye against a limited set of standards, giving a range rather than an exact value; or because the reaction's colour depends on heating time and volume, which vary between tubes.

3.2 Amylose has only 1,4-glycosidic bonds and coils into a compact helix; cellulose has 1,4-bonds with alternate glucose units inverted, giving straight, unbranched chains. Amylose's helix packs densely for storage; cellulose's straight chains hydrogen-bond into microfibrils, so hydrolytic enzymes (which the plant targets at starch) cannot rapidly attack it. Amylose is made of α-glucose, which the plant's amylases hydrolyse; cellulose's β-linkage needs different enzymes the plant does not use for mobilising store.

3.3 Glucose and galactose. The 1,4-glycosidic bond. Undigested lactose passes to the colon, where bacteria ferment it, producing gas and osmotically active products that draw water into the gut, causing bloating and diarrhoea.