# 1.1 Biological Molecules: Test Pack

AQA 7402 · Calculator allowed · about 65 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

**Answer ALL questions. Show all your working.**

**1** This question tests core vocabulary used to describe biological macromolecules.

**(a)** State what is meant by the term monomer. **(1)**

**(b)** State what is meant by the term polymer. **(1)**

**(c)** Explain, in terms of atoms lost and gained, what happens during a condensation reaction between two monomers. **(2)**

**(d)** State the type of reaction that breaks a polymer back down into its monomers. **(1)**

**(Total for Question 1 is 5 marks)**


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**2** This question is based on the required practical involving the use of qualitative reagents to identify biological molecules. A student is given four unlabelled solutions, P, Q, R and S, each of which contains a different one of glucose, starch, egg albumen (protein), vegetable oil and sucrose (one of these five is not present), in no particular order.

**(a)** Describe how the student could use the iodine test to identify which tube contains starch, including the result that would confirm this. **(2)**

**(b)** Solution P gave a positive Biuret test. State what this indicates about the contents of tube P, and state the colour change that would have been observed. **(2)**

**(c)** The student then heated tube Q with Benedict's reagent and it remained blue (no colour change). Explain what this result indicates about tube Q, and describe the further test needed to check whether tube Q contains a non-reducing sugar. **(3)**

**(d)** Solution S was identified using the emulsion test. Describe the procedure for this test and the result that indicates a positive result for lipid. **(2)**

**(Total for Question 2 is 9 marks)**


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**3** Adenosine triphosphate (ATP) is described as the universal energy currency of cells.

**(a)** Describe the structure of an ATP molecule. **(2)**

**(b)** Explain why ATP is described as a useful, immediate source of energy for cells, referring to the hydrolysis of ATP. **(2)**

**(c)** State two cellular processes that require energy released from ATP hydrolysis. **(2)**

**(Total for Question 3 is 6 marks)**

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**4** Nucleic acids store and transmit genetic information.

**(a)** Describe the structure of a DNA nucleotide. **(3)**

**(b)** State two differences between the structure of DNA and RNA. **(2)**

**(c)** Explain how complementary base pairing and hydrogen bonding allow DNA to act as a stable store of genetic information. **(3)**

**(Total for Question 4 is 8 marks)**


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**5** ATP (adenosine triphosphate) is described as the immediate energy currency of cells.

**(a)** Describe the structure of an ATP molecule. **(2)**

**(b)** Explain why hydrolysis of the terminal phosphate bond of ATP releases usable energy. **(2)**

**(c)** A cell contains $5.0 \times 10^{-15}$ mol of ATP. Given that hydrolysis of one mole of ATP releases approximately 30.5 kJ of energy, calculate the total energy, in joules, available from hydrolysing all the ATP in this cell. Give your answer in standard form to 2 significant figures. **(2)**

**(d)** Explain why ATP, rather than the direct oxidation of glucose, is used to supply energy for most cellular processes. **(2)**

**(Total for Question 5 is 8 marks)**


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**6** A particular enzyme has a glutamate residue at position 76 of its primary structure, which forms part of its active site. A gene mutation changes the DNA triplet coding for this residue, altering the mRNA codon from GAA (glutamate) to GUA (valine).

**(a)** State what is meant by a gene mutation. **(1)**

**(b)** Explain how the change from glutamate to valine at position 76 could affect the enzyme's tertiary structure and its ability to catalyse its reaction. **(3)**

**(c)** A different base substitution in the same gene changes a codon from CGA to CGG. Using your knowledge of the genetic code, explain why this substitution is likely to have no effect on the enzyme's structure or function. **(2)**

**(d)** Under identical conditions, the normal enzyme has a reaction rate of 4.50 arbitrary units. The glutamate-to-valine mutant shows a 92% reduction in rate compared with the normal enzyme. Calculate the reaction rate of the mutant enzyme. **(2)**

**(Total for Question 6 is 8 marks)**


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# Mark scheme · 1.1 Biological Molecules: Test Pack

## Question 1

(a) a small, basic molecular unit that can join with others of a similar kind to form a larger molecule oe **B1**

**(a) Answer: A small molecule that is a basic monomeric unit of a larger molecule (polymer).**

(b) a large molecule made from many repeating monomer units joined together oe **B1**

**(b) Answer: A large molecule made of many monomers joined together.**

(c) a chemical bond forms between two monomers oe **B1**

(c) a molecule of water is released/eliminated in the process oe **B1**

**(c) Answer: A bond forms between the two monomers and a molecule of water is released.**

(d) hydrolysis (a molecule of water is added, breaking the bond between monomers) oe **B1**

**(d) Answer: Hydrolysis (a water molecule is added to break the bond).**

## Question 2

(a) add iodine dissolved in potassium iodide solution to a sample of each solution oe **M1**

(a) a positive result (starch present) is shown by a colour change from orange/brown to blue-black oe **A1**

**(a) Answer: Add iodine/potassium iodide solution; blue-black colour confirms starch.**

(b) tube P contains protein (peptide bonds present) **B1**

(b) colour change from blue to purple/lilac/violet oe **B1**

**(b) Answer: Tube P contains protein; colour changes blue to purple.**

(c) tube Q does not contain a reducing sugar, since no brick-red/orange precipitate formed oe **M1**

(c) to test for a non-reducing sugar, a fresh sample must first be boiled with dilute hydrochloric acid (to hydrolyse any glycosidic bonds), then neutralised with sodium hydrogencarbonate solution oe **M1**

(c) the sample is then retested with Benedict's reagent and heated; if a brick-red precipitate now forms, a non-reducing sugar (e.g. sucrose) is confirmed present oe (dependent on M1 hydrolysis step being described) **dM1**

**(c) Answer: No reducing sugar in Q; must hydrolyse with acid, neutralise, then retest with Benedict's for a non-reducing sugar.**

(d) add ethanol to the sample, shake/mix thoroughly, then pour the resulting solution into a separate tube of water oe **M1**

(d) a positive result is shown by a white/cloudy emulsion forming (in the water) oe **A1**

**(d) Answer: Mix with ethanol, then add to water; white emulsion confirms lipid.**

## Question 3

(a) adenine (base) attached to a ribose sugar, forming adenosine **B1**

(a) with three phosphate groups attached in a chain oe **B1**

**(a) Answer: Adenine + ribose (adenosine) with three phosphate groups attached.**

(b) hydrolysis of ATP (catalysed by ATP hydrolase) removes the terminal phosphate group, forming ADP and inorganic phosphate (Pi), releasing energy oe **M1**

(b) this single-step, rapid, reversible reaction releases a relatively small, manageable quantity of energy exactly when and where it is needed in the cell oe **A1**

**(b) Answer: ATP hydrolysis to ADP + Pi in one rapid step releases small, manageable amounts of energy on demand.**

(c) active transport (across membranes) **B1**

(c) any other valid named energy-requiring process, e.g. muscle contraction, DNA replication, protein synthesis, cell division/mitosis oe **B1**

**(c) Answer: Active transport; and one of muscle contraction / DNA replication / protein synthesis / cell division.**

## Question 4

(a) a pentose sugar (deoxyribose) **B1**

(a) a phosphate group **B1**

(a) a nitrogen-containing (organic) base, one of adenine, thymine, cytosine or guanine **B1**

**(a) Answer: Deoxyribose sugar, phosphate group and a nitrogenous base.**

(b) DNA contains deoxyribose sugar; RNA contains ribose sugar **B1**

(b) DNA is usually double-stranded; RNA is usually single-stranded (allow: DNA contains thymine, RNA contains uracil instead) **B1**

**(b) Answer: DNA has deoxyribose and is double-stranded; RNA has ribose and is single-stranded.**

(c) adenine always pairs with thymine (by 2 hydrogen bonds) and cytosine always pairs with guanine (by 3 hydrogen bonds) oe **M1**

(c) the large number of hydrogen bonds between the two strands, together with the double helix structure, makes the DNA molecule chemically stable oe **M1**

(c) so the genetic information (base sequence) is protected from damage and can be copied/replicated accurately (semi-conservatively) oe **A1**

**(c) Answer: Fixed base pairing and many hydrogen bonds give DNA a stable structure that protects and allows accurate copying of genetic information.**


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## Question 5

(a) adenine (a nitrogen-containing base) attached to a ribose sugar oe **B1**

(a) a chain of three phosphate groups attached to the ribose oe **B1**

**(a) Answer: ATP is made of adenine bonded to a ribose sugar, which is bonded to a chain of three phosphate groups.**

(b) hydrolysis of the bond between the terminal (third) phosphate group and the rest of the molecule, catalysed by ATP hydrolase, forms ADP and inorganic phosphate (Pi) oe **B1**

(b) the products (ADP + Pi) have a lower energy content than ATP, so energy is released that can be transferred to do cellular work oe **B1**

**(b) Answer: Hydrolysing the terminal phosphate bond of ATP produces ADP and inorganic phosphate; because these products have lower energy content than ATP, energy is released for cellular work.**

(c) correct substitution: $5.0 \times 10^{-15} \times 30.5 \times 10^{3}$ J **M1**

(c) $1.5 \times 10^{-10}$ J, cao **A1**

**(c) Answer: $1.5 \times 10^{-10}$ J**

(d) ATP releases energy in small, manageable packets suited to individual reactions, whereas oxidising glucose directly releases a much larger amount of energy at once, most of which would be wasted (e.g. as heat) oe **B1**

(d) ATP hydrolysis is a single-step, rapidly reversible reaction that can be coupled directly to energy-requiring reactions in the cell, providing energy immediately when and where it is needed oe **B1**

**(d) Answer: ATP releases energy in small, immediately usable amounts through a single, rapidly reversible reaction that can be coupled directly to cellular processes, unlike the large, less controllable release of energy from directly oxidising glucose.**

## Question 6

(a) a change in the base sequence of DNA (e.g. a base substitution, insertion or deletion) oe **B1**

**(a) Answer: A change in the base sequence of a gene's DNA.**

(b) glutamate has an acidic (negatively charged, polar) R group, whereas valine has a non-polar (hydrophobic) R group, so the chemical properties of the R group at position 76 change oe **B1**

(b) this can disrupt ionic or hydrogen bonds that this R group previously formed, altering the folding/tertiary structure around the active site oe **B1**

(b) if the active site shape is changed, it may no longer be complementary to the substrate, so fewer or no enzyme-substrate complexes can form, reducing or abolishing catalytic activity oe **B1**

**(b) Answer: Glutamate's charged R group is replaced by valine's non-polar R group, which can disrupt the ionic/hydrogen bonds that shaped the active site region; if the active site is no longer complementary to the substrate, fewer enzyme-substrate complexes form and catalytic activity falls.**

(c) the genetic code is degenerate, so more than one codon can code for the same amino acid; CGA and CGG both code for arginine oe **B1**

(c) because the same amino acid is still incorporated, the primary structure (and therefore tertiary structure and function) of the enzyme is unchanged - this is a silent mutation oe **B1**

**(c) Answer: CGA and CGG both code for arginine because the genetic code is degenerate, so the amino acid sequence (and hence the enzyme's structure and function) is unchanged - this is a silent mutation.**

(d) correct method: 4.50 x (1 - 0.92), oe **M1**

(d) 0.36 arbitrary units, cao **A1**

**(d) Answer: 0.36 arbitrary units**


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