Neap:

CHEMISTRY VCE UNITS 3&4
DIAGNOSTIC TOPIC TESTS 2008

TEST 4: BIOCHEMISTRY

TOTAL 35 MARKS (45 MINUTES)

Student's Name: _____ Teacher's Name: _____

Directions to students

Write your name and your teacher's name in the spaces provided above.
Answer all questions in the spaces provided.

SECTION A: MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

For each question in Section A, choose the response that is correct and circle your choice.
Choose the response that is **correct** or **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

Question 1

Consider the following statements.

I – Enzymes are proteins.
II – Enzymes operate efficiently over a wide range of temperatures and acidity levels.
III – Enzymes increase the rate of specific biochemical reactions.

Which of the statements is/are correct?

A. I only
B. I and II only
C. I and III only
D. I, II and III

Question 2

A pure sample of a compound is analysed and found to contain 40.6% carbon, 52.6% oxygen and 6.8% hydrogen by mass.

Which of the following is the compound most likely to be?

A. a fat
B. a carbohydrate
C. a protein
D. DNA

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Question 3

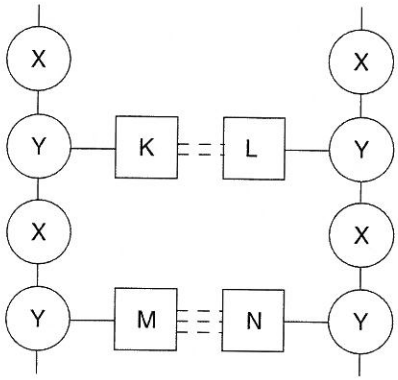
Benzene is found in many drug molecules.

Which of the following reaction types does benzene typically undergo?

A. combustion and substitution
B. condensation and substitution
C. combustion and addition
D. condensation and addition

Question 4

A segment of DNA is represented in the diagram below.



Which of the following correctly identifies the components labelled Y and K?

	Component Y	Component K
A.	deoxyribose	adenine
B.	deoxyribose	cytosine
C.	phosphate	adenine
D.	phosphate	cytosine

Question 5

Prostate-specific antigen (PSA) is a protein disease marker present in blood plasma. A high PSA level is an indication of inflammation of the prostate and could be a sign of prostate cancer.

A person with elevated PSA levels

A. will develop cancer of the prostate.
B. will exhibit external symptoms of disease.
C. has damaged prostate tissue.
D. carries a gene predisposing them to prostate cancer.

Question 6

Which of the following types of bonding is largely responsible for the maintenance of the secondary structure of proteins and DNA?

A. covalent bonding
B. hydrogen bonding
C. ionic bonding
D. ion–dipole bonding

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Question 7

When a triglyceride forms by reaction between stearic acid molecules and glycerol, which of the following functional groups react?

A. hydroxyl only
B. ester and hydroxyl
C. hydroxyl and carboxyl
D. carboxyl and amino

Question 8

Which of the following pairs of compounds are isomers?

A. the sugars glucose and sucrose
B. the nitrogenous bases adenine and thymine
C. the fatty acids linolenic and linoleic
D. the amino acids leucine and isoleucine

Question 9

The production of bioethanol may be outlined as a two-stage process.

$$CO_2 \xrightarrow{x} C_6H_{12}O_6 \xrightarrow{y} C_2H_6O$$

Which of the following statements concerning this two-stage process is correct?

A. *x* represents oxidation of carbon in the photosynthesis reaction.
B. *x* represents reduction of carbon in an aerobic respiration reaction.
C. *y* represents oxidation of carbon in the fermentation reaction.
D. *y* represents reduction of carbon in an anaerobic respiration reaction.

Question 10

The nitrogenous base composition of a nucleic acid was analysed and found to be 25% adenine, 38% cytosine and the remainder composed of guanine and thymine.

Based on this information, it can be concluded that the nucleic acid was

A. single-stranded DNA.
B. single-stranded RNA.
C. double-stranded DNA.
D. double-stranded RNA.

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SECTION B: SHORT-ANSWER QUESTIONS

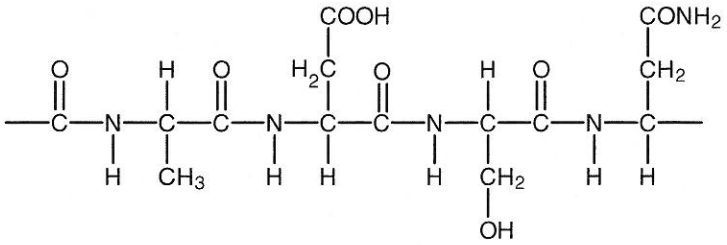
Instructions for Section B

Answer **all** questions in the spaces provided.
To obtain full marks you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example $H_2(g)$; NaCl(s).

Question 1

a. A section of a protein chain is shown below with four side groups.



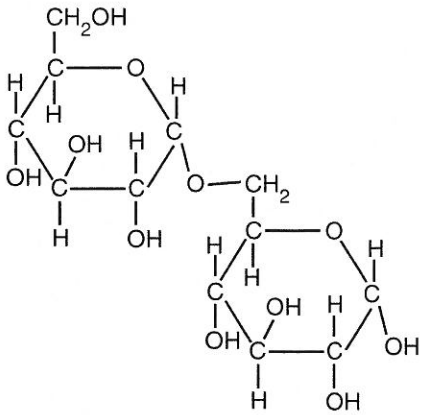
i. On the diagram, circle one complete peptide link. Label the circle with the letter '*x*'.

ii. On the diagram, circle a side group that would carry a negative charge when in a solution of pH 10. Label the circle with the letter '*y*'.

iii. On the diagram, circle a hydrophobic side group. Label the circle with the letter '*z*'.

1 + 1 + 1 = 3 marks

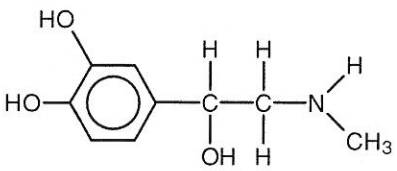
b. Isomaltose is a disaccharide that is produced during the hydrolysis of certain polysaccharides. The structure of isomaltose is shown below.



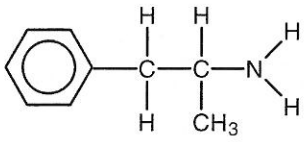
Draw the structure of the monosaccharide that would be produced by the enzyme catalysed hydrolysis of isomaltose.

1 mark

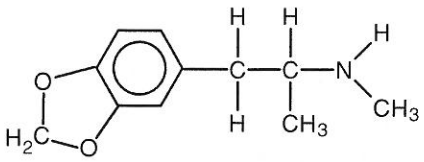
c. Amphetamine is chemically related to adrenalin (ephinephrine), the 'fight or flight' hormone. Amphetamines were used initially as a treatment for sleep disorders. Their short-term effects include an increase in heart rate and breathing rate. Long term effects include emotional instability. A related compound is methylenedioxymethamphetamine, MDMA (ecstasy). The structures of adrenaline, amphetamine and MDMA are shown below.



adrenaline



amphetamine



MDMA

i. Name one functional group that is found in adrenaline, but is not found in amphetamine or MDMA.

_____

ii. Name one functional group that is found in MDMA, but is not found in adrenaline or amphetamine.

_____

iii. Explain why these three compounds might be expected to show similar pharmacological effects.

_____

_____

_____

1 + 1 + 2 = 4 marks

d. Electrophoresis is a technique which may be used to separate mixtures of various biological molecules.

i. During the electrophoresis of a mixture of amino acids, the components are separated on the basis of their charge and mass.

If a solution containing leucine undergoes electrophoresis at a solution pH of 2, to which electrode (+ or –) will the leucine migrate?

_____

ii. Draw the structure of the leucine ion at pH 2 that explains your choice in part **i**.

iii. When a mixture of DNA fragments is separated by electrophoresis as part of the DNA fingerprinting process, to which electrode (+ or –) do the fragments migrate?

_____

1 + 1 + 1 = 3 marks
Total 11 marks

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Question 2

a. **i.** How many hydrogen atoms are there in one molecule of a saturated fatty acid containing seventeen carbon atoms?

_____

ii. What is the minimum number of nucleotides needed to code for a protein segment containing fifteen amino acids?

_____

iii. How many sugar–phosphate bonds are formed when six nucleotides join to form a single strand of DNA?

_____

1 + 1 + 1 = 3 marks

b. Give the molecular formula of

i. the trisaccharide formed when three glucose molecules undergo a condensation reaction.

_____

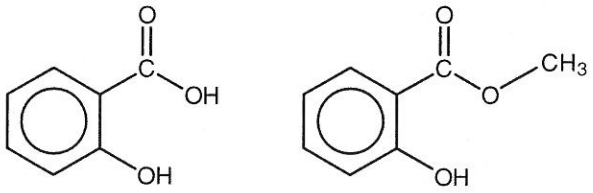
ii. the dipeptide formed when two alanine molecules undergo a condensation reaction.

_____

1 + 1 = 2 marks
Total 5 marks

Question 3

The structures of salicylic acid and methyl salicylate (oil of wintergreen) are shown below.



salicylic acid methyl salicylate

a. Name the type of reaction occurring when salicylic acid reacts with methanol to produce methyl salicylate.

_____

1 mark

b. Give the approximate wave number (in cm^{-1}) of an infrared spectral band present on the infrared spectrum of salicylic acid, but not present on the infrared spectrum of methyl salicylate.

_____

1 mark

c. State **one** difference expected in the chemical properties of salicylic acid and methyl salicylate.

_____

_____

1 mark

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d. 20.0 g of salicylic acid (M = 138 g mol^{-1}) was reacted with excess methanol to produce 14.9 g of methyl salicylate (M = 152 g mol^{-1}).

Calculate the percentage yield for the reaction.

2 marks
Total 5 marks

Question 4

Biomass can be used to produce the potentially useful fuels biodiesel and biogas.

a. Biodiesel can be manufactured by a condensation reaction between palmitic acid ($C_{15}H_{31}COOH$), derived from fats and oils, and methanol.

i. Write a balanced equation, using semi-structural formulas, for the production of biodiesel from methanol and palmitic acid. (States are not required.)

ii. The iodine number is defined as the number of grams of iodine that reacts with 100 g of a fatty acid in an addition reaction.

State the iodine number of palmitic acid (M = 256 g mol^{-1}).

1 + 1 = 2 marks

b. **i.** Identify the major organic component of biogas.

ii. Briefly explain how biogas is produced.

1 + 1 = 2 marks
Total 4 marks

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TEST 4: BIOCHEMISTRY

SUGGESTED SOLUTIONS AND MARKING SCHEME

SECTION A: MULTIPLE-CHOICE QUESTIONS

Question 1 **C**

Enzymes are proteins. They act as catalysts for biochemical reactions. Each reaction is catalysed by a specific enzyme. Enzymes operate within narrow ranges of temperature and pH due to their specific three-dimensional shape (which may be altered by changes in temperature or pH). Statements I and III are correct. Statement II is incorrect.

Question 2 **B**

Proteins and DNA contain elements in addition to carbon, hydrogen and oxygen (hence **C** and **D** cannot be correct).

$$\text{C:H:O} = \frac{40.6}{12.0} : \frac{6.8}{1.0} : \frac{52.6}{16.0} = 3.38:6.8:3.29 = 1:2:1$$

The empirical formula is CH_2O. This is characteristic of carbohydrates. Fats have a much lower proportion of oxygen.

Question 3 **A**

Benzene, like other hydrocarbons, undergoes combustion reactions. Benzene does not contain reactive functional groups and therefore does not undergo condensation reactions. The special ring structure of benzene with intermediate carbon–carbon bonds (between single and double) means that it undergoes substitution reactions, not addition reactions.

Question 4 **A**

Nitrogenous bases (A, C, T and G) are attached to the sugar unit on the DNA backbone (so the answer is **A** or **B**). Adenine and thymine (on opposite DNA strands) are linked by two hydrogen bonds (so **A** is correct). Cytosine and guanine are linked by three hydrogen bonds.

Question 5 **C**

The PSA marker indicates a problem, but does not necessarily mean that prostate cancer will follow (so **A** and **B** are incorrect). Protein markers are not necessarily genetically linked, so while the patient may have a gene predisposing them to prostate cancer, this is not certain based on an elevated PSA level (so **D** is incorrect).

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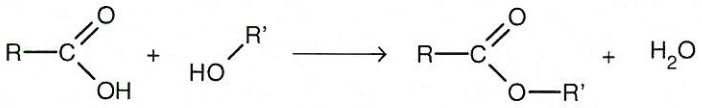
Question 6 **B**

In proteins, secondary structure involves the formation of a helices (or sheets) of the polypeptide chain stabilised by hydrogen bonds between non-adjacent amino acids. In DNA, the secondary structure involves a double helix held in place by hydrogen bonds between complementary base pairs on opposite strands of the structure. The primary structure (amino acid and nitrogenous base sequence) involves covalent bonding. The tertiary structure may involve all four types of bonding (covalent only in the special case of disulfide links in proteins).

Question 7 **C**

The carboxyl group of the acid reacts with the hydroxyl group of the glycerol to produce an ester link.



acid (carboxyl) glycerol (hydroxyl) ester

Question 8 **D**

Isoleucine and leucine have the same molecular formula but a different arrangement of the atoms in the side group. They are therefore structural isomers. In **A**, sucrose ($C_{12}H_{22}O_{11}$) and glucose ($C_6H_{12}O_6$) have different molecular formulas. Similarly in **B** and **C**, the molecules do not have the same molecular formulas and so cannot be structural isomers.

Question 9 **D**

Reaction *x*:

photosynthesis $6CO_2(g) + 6H_2O(l) \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6(aq) + 6O_2(g)$

Carbon's oxidation number changes from +4 to 0, and so undergoes reduction.

Reaction *y*:

fermentation (anaerobic respiration) $C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(aq) + 2CO_2(g)$

Carbon's oxidation number changes from 0 in $C_6H_{12}O_6$ to –2 in H_3CH_2OH (C_2H_6O), and so undergoes reduction.

Question 10 **A**

The nucleic acid contains thymine and so cannot be RNA (uracil replaces thymine in RNA). In double-stranded DNA, each adenine is hydrogen bonded to its complementary base thymine on the opposite strand. Similarly, each cytosine is bonded to a guanine molecule. To be double stranded the nucleic acid would have the composition 25% adenine, 25% thymine, 38% cytosine and 38% guanine: an impossible total of more than 100%. The nucleic acid must therefore be single-stranded.

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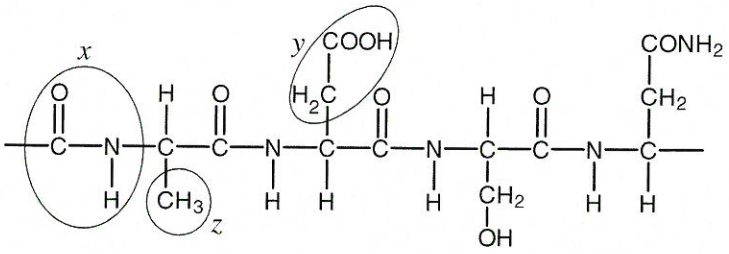
SECTION B: SHORT-ANSWER QUESTIONS

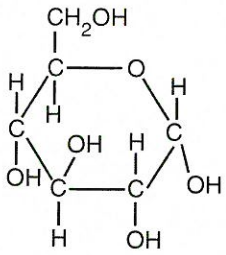
Question 1

a.



3 marks
1 mark for each correct circle

b.



1 mark

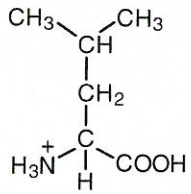
c. **i.** hydroxyl (OH) 1 mark

ii. ether (C–O–C) 1 mark

iii. The common structure of all three compounds leads to similar effects in the body. 1 mark
The exact shape of the common fragment may bind to a receptor site and alter electrical or chemical transmission signals. 1 mark

d. **i.** negative (–) 1 mark

ii.



Leucine acts as a base at pH 2, accepting a proton to form a cation.

1 mark

iii. positive (+) 1 mark
The fragments are negatively charged due to the phosphate groups.

Total 11 marks

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Question 2

a. i. 34 — 1 mark

The fatty acid formula must be $C_{16}H_{33}COOH$ to be a saturated fatty acid of general formula $C_nH_{2n+1}COOH$.

ii. 45 — 1 mark

Each codon (a set of three bases) codes for an amino acid. A minimum of 15 × 3 = 45 bases is therefore needed. In reality, more would be needed to provide the stop and start codons.

iii. 5 — 1 mark

Each nucleotide joins to the next by a sugar–phosphate bond. Six nucleotides will form 6 – 1 = 5 sugar–phosphate bonds when they join. (Note that 6 sugar–phosphate bonds already exist within the nucleotides.)

b. i. $C_{18}H_{32}O_{16}$ — 1 mark

($C_6H_{12}O_6 \times 3 - 2 \times H_2O$)

ii. $C_6H_{12}O_3N_2$ — 1 mark

($C_3H_7O_2N \times 2 - H_2O$)

Total 5 marks

Question 3

a. esterification or condensation — 1 mark

b. 2500–3300 cm^{-1} — 1 mark

The –OH (acid) group is present in salicylic acid but not present in methyl salicylate.

c. Salicylic acid is acidic and would be expected to react with a base such as sodium carbonate to release carbon dioxide gas. Methyl salicylate would not produce this result. — 1 mark

d. $n(\text{salicylic acid}) = \frac{m}{M} = \frac{20.0}{138}$ mol

$n(\text{methyl salicylate}) = n(\text{salicylic acid})$

$m(\text{methyl salicylate}) = n \times M = \frac{20.0}{138} \times 152 = 22.03$ g — 1 mark

$\%\text{ yield} = \frac{m(\text{obtained})}{m(\text{expected})} \times \frac{100}{1} = \frac{14.9}{22.03} \times \frac{100}{1} = 67.6\%$ — 1 mark

Total 5 marks

Question 4

a. i. $C_{15}H_{31}COOH + CH_3OH \rightarrow C_{15}H_{31}COOCH_3 + H_2O$ — 1 mark

ii. 0 — 1 mark

There are no double carbon–carbon bonds in palmitic acid. It does not therefore undergo an addition reaction with iodine.

b. i. methane (CH_4) — 1 mark

ii. Biogas forms by the bacterial decomposition of organic matter under anaerobic conditions. — 1 mark

Total 4 marks

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