

CHEMISTRY VCE UNITS 3&4 DIAGNOSTIC TOPIC TESTS 2008

TEST 3: ORGANIC CHEMISTRY

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.

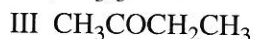
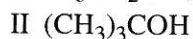
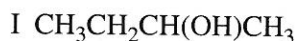
Question 1

When hexene is burnt in excess oxygen, carbon dioxide and water are produced in the mass ratio of approximately

- A. 1:1
- B. 1:2
- C. 5:2
- D. 2:1

Question 2

Consider the following formulas.



Which of the formulas represent isomers of butanol?

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

Question 3

Which of the following compounds would be expected to have the highest boiling point?

- A. 1-butene
- B. 1-butanol
- C. butane
- D. 1-chloropropane

Question 4

Which of the following does **not** contain six carbon atoms per molecule?

- A. hexanoic acid
- B. 2-methylpentan-1-ol
- C. ethyl butanoate
- D. 2,2-dimethylpropanoic acid

Question 5

Which of the following pairs of compounds can be used to prepare $\text{CH}_3\text{OOCCH}_3$?

- A. ethanol and ethanoic acid
- B. methanol and ethanoic acid
- C. ethanol and methanoic acid
- D. methanol and methanoic acid

Question 6

Which of the of the following compounds would **not** show three peaks on its low resolution ^1H NMR spectrum?

- A. propanoic acid
- B. 1-chloropropane
- C. 2-aminopropane
- D. 2-methylpropan-2-ol

Question 7

In which of the following reactions would you expect only one product to form?

- A. the reaction of HBr with 2-butene
- B. the condensation of ethanol and ethanoic acid to form ethyl ethanoate
- C. the hydrolysis of propene
- D. the chlorination of ethane in the presence of sunlight

Question 8

A saturated compound has the molecular formula $\text{C}_4\text{H}_{11}\text{Z}$.

'Z' is most likely to be

- A. a nitrogen atom.
- B. a hydrogen atom.
- C. an oxygen atom.
- D. a sulfur atom.

Question 9

Which of the following is **incorrect**?

- A. The chemical reactivity of chloroalkanes is greater than the chemical reactivity of alkanes.
- B. The degree of unsaturation in non-cyclic C_6H_{12} is less than the degree of unsaturation in non-cyclic C_5H_8 .
- C. The acidity of CH_3COOH is less than the acidity of $CH_3CH_2NH_2$.
- D. The boiling point of pentane is greater than the boiling point of propane.

Question 10

Which of the following hydrocarbons could be formed by the dehydration of 2-butanol?

- A. 1-butene
- B. butane
- C. 2-methylpropene
- D. 2-methylpropane

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 $\text{H}_2(\text{g})$; $\text{NaCl}(\text{s})$.

Question 1

Propane and propene react with bromine in different ways.

- a. i. Using structural formulas write an equation for the reaction between propane and bromine, showing the structure of a possible organic product.

- ii. State the type of reaction represented in part i.

1 + 1 = 2 marks

- b. i. Using structural formulas write an equation for the reaction between propene and bromine, showing the structure of the organic product.

- ii. State the type of reaction represented in part i.

1 + 1 = 2 marks

- c. Describe a simple test, including the expected results, that can be used to distinguish between samples of propane and propene.

1 mark
Total 5 marks

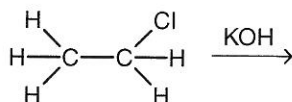
Question 2

a. Give the systematic names of the following organic compounds.



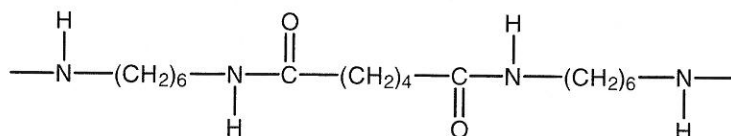
1 + 1 = 2 marks

b. Complete the following equation by drawing the major organic product.



1 mark

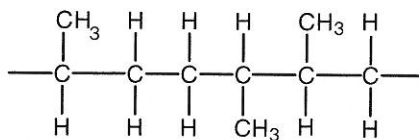
c. A representation of a section of a polymer chain is shown below.



Draw the structures of the two different monomers needed to make this polymer.

2 marks

d. A representation of a section of a polymer chain is shown below.



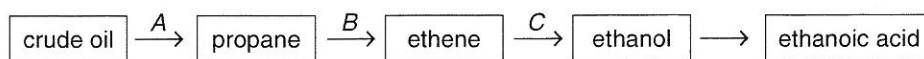
Name the monomer from which the polymer is made.

1 mark

Total 6 marks

Question 3

Ethene gas is used in the production of many industrial chemicals, including ethanol and ethanoic acid. Production of these compounds is shown in the flowchart below.



- a. Briefly describe process A.

2 marks

- b. Reaction B occurs under conditions of high temperature and pressure. Write an equation for the conversion of propane to ethene.

1 mark

- c. Using structural formulas, write an equation for reaction C. Include the formulas of any inorganic reagents required.

1 mark

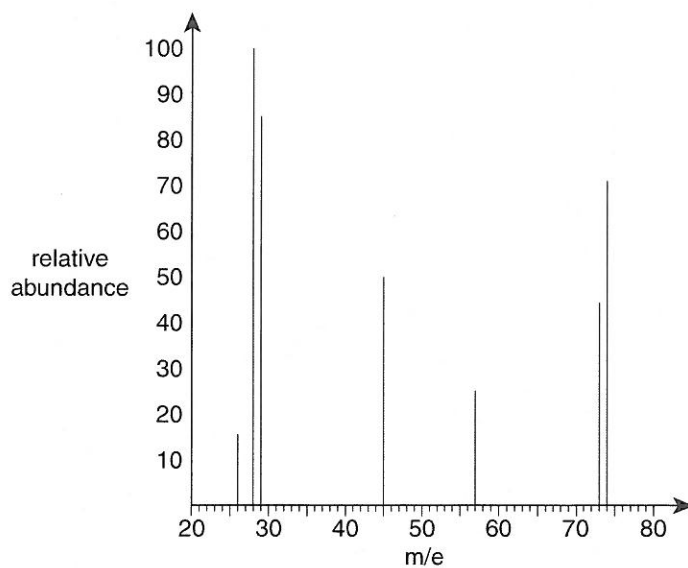
- d. Write the half-equation for the conversion of ethanol to ethanoic acid in acidic solution.

1 mark

Total 5 marks

Question 4

A sweet-smelling liquid (*X*) undergoes hydrolysis in acidic conditions to give two organic products (*Y* and *Z*). Product *Y* was found to be a water soluble carboxylic acid. The mass spectrum of *Y* is shown below.



- a. i. Determine the molar mass of *Y*.
-
- ii. Suggest a fragment ion responsible for the peak at *m/e* value of 29.
-
- iii. Deduce the structural formula of compound *Y*.

1 + 1 + 1 = 3 marks

b. Product Z was found to have a relative molecular mass of 60, and was found to contain 60.0% carbon, 13.3% hydrogen and 26.7% oxygen by mass.

i. Determine the empirical formula of Z.

ii. Determine the molecular formula of Z.

iii. The infrared spectrum of compound Z shows a prominent band at a wave number of approximately 3400 cm^{-1} .

Draw **two** possible structural formulas for the isomers of compound Z.

iv. The low resolution ^1H NMR spectrum of compound Z shows four peaks.

Determine which of the isomers drawn in part **iii** is compound Z, and hence draw a structural diagram for compound X (the original sweet-smelling liquid).

2 + 1 + 2 + 1 = 6 marks
Total 9 marks

b. Product *Z* was found to have a relative molecular mass of 60, and was found to contain 60.0% carbon, 13.3% hydrogen and 26.7% oxygen by mass.

i. Determine the empirical formula of *Z*.

ii. Determine the molecular formula of *Z*.

iii. The infrared spectrum of compound *Z* shows a prominent band at a wave number of approximately 3400 cm^{-1} .

Draw **two** possible structural formulas for the isomers of compound *Z*.

iv. The low resolution ^1H NMR spectrum of compound *Z* shows four peaks.

Determine which of the isomers drawn in part **iii** is compound *Z*, and hence draw a structural diagram for compound *X* (the original sweet-smelling liquid).

2 + 1 + 2 + 1 = 6 marks
Total 9 marks

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TEST 3: ORGANIC CHEMISTRY

SUGGESTED SOLUTIONS AND MARKING SCHEME

SECTION A: MULTIPLE-CHOICE QUESTIONS

Question 1 C

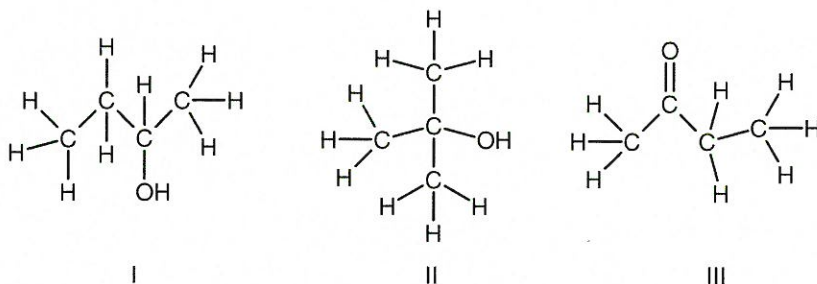
The relevant equation is $C_6H_{12}(g) + 9O_2(g) \rightarrow 6CO_2(g) + 6H_2O(g)$.

$$n(CO_2) : n(H_2O) = 1:1$$

$$m(CO_2) : m(H_2O) = 44:18 = 2.44:1 \approx 5:2$$

Question 2 C

Draw the structures first.



I and II both represent butanol, $C_4H_{10}O$. III does not contain the $-OH$ group, and has fewer hydrogen atoms per molecule than butanol. III is a ketone, not an alkanol.

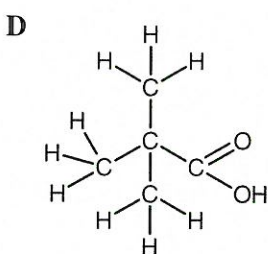
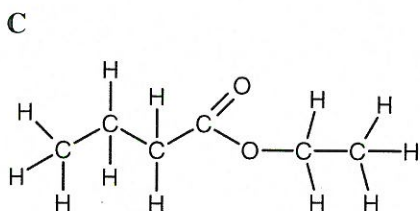
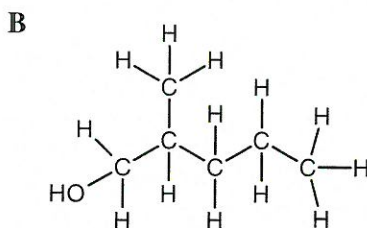
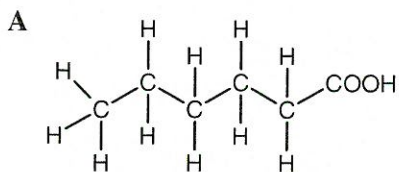
Question 3 B

Butane and butene are non-polar and so have only weak dispersion forces between their molecules.

1-chloropropane is polar and so will exhibit stronger dipole-dipole bonding (and increased dispersion forces due to a larger molecular size). 1-butanol will exhibit hydrogen bonding between molecules, leading to the highest boiling point for these compounds. (The actual boiling points are $118^\circ C$ for 1-butanol, $46.7^\circ C$ for 1-chloropropane, $-0.5^\circ C$ for butane and $-6^\circ C$ for 1-butene.)

Question 4 D

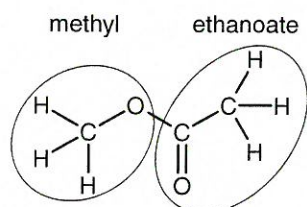
If you cannot 'see' the answer, try drawing the structures.



2,2-dimethylpropanoic acid has only five carbon atoms per molecule.

Question 5 B

It is helpful to draw the structure.

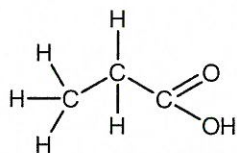


$\text{CH}_3\text{OOCCH}_3$ is methyl ethanoate. It is prepared using ethanoic acid, methanol and an acid catalyst.

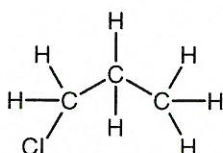
Question 6 D

Draw the structures first.

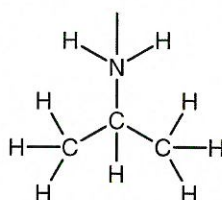
propanoic acid



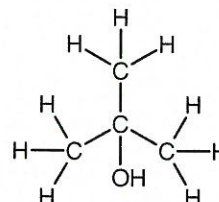
1-chloropropane



2-aminopropane



2-methylpropan-2-ol



2-methylpropan-2-ol has two ^1H environments and so would show two peaks on its ^1H NMR spectrum, not three. The nine methyl hydrogens are equivalent.

Question 7 **A**

The relevant products are shown below.

A 2-bromobutane only

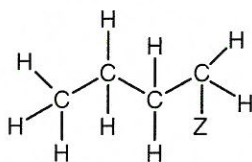
B $\text{CH}_3\text{COOH}(\text{l}) + \text{CH}_3\text{CH}_2\text{OH}(\text{l}) \rightarrow \text{CH}_3\text{COOCH}_2\text{CH}_3(\text{l}) + \text{H}_2\text{O}(\text{l})$

C $\text{CH}_3\text{CHCH}_2(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ and $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$

D $\text{CH}_3\text{CH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{Cl}, \text{CH}_3\text{CHCl}_2, \text{CH}_2\text{ClCH}_2\text{Cl}$ etc.

Note that in **A**, the same product forms whichever way the HBr adds across the double bond. In **C**, two products occur (though not in equal proportions).

Question 8 **A**

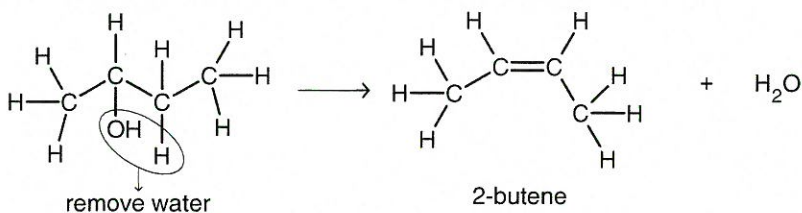


In saturated molecules, there are only single carbon-carbon bonds. Nine hydrogen atoms are used. The remaining position, including atom Z, must therefore hold two hydrogen atoms (so **B** is incorrect). Both oxygen and sulfur will only bond to one hydrogen atom, in addition to the hydrocarbon chain. Z must therefore be part of an amine group $-\text{NH}_2$, making Z a nitrogen atom.

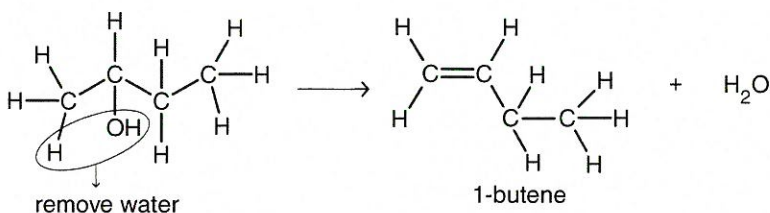
Question 9 **C**

The presence of the polar C-Cl bond in chloroalkanes makes them more reactive than alkanes (so **A** is not the required response). Non-cyclic C_6H_{12} contains one double carbon-carbon bond, while non-cyclic C_5H_8 contains two (so **B** is not the required response). CH_3COOH is a weak acid, while $\text{CH}_3\text{CH}_2\text{NH}_2$ is a weak base (so **C** is incorrect, and is the required response). The boiling point of alkanes increases with increasing size due to increased dispersion forces (so **D** is not the required response).

Question 10 **A**



OR

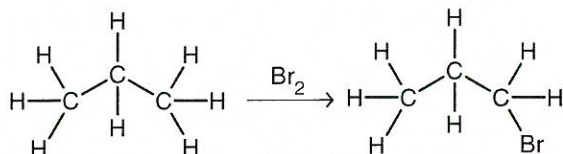


The possible products are 1-butene and 2-butene.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. i. For example:

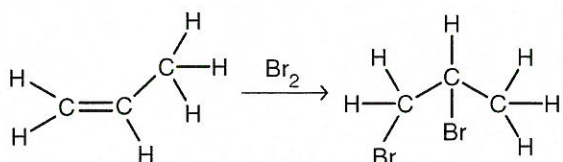


1 mark

ii. substitution

1 mark

b. i.



1 mark

ii. addition

1 mark

c. Propene will decolourise a bromine solution. Propane will not.

1 mark

Total 5 marks

Question 2

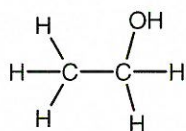
a. i. 2-aminobutane or 2-butanamine

1 mark

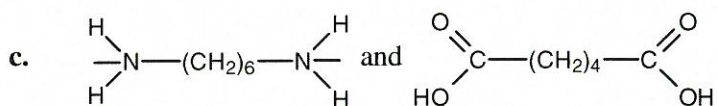
ii. 2-chlorobutan-1-ol

1 mark

b.



1 mark



2 marks

1 mark for each correct structure

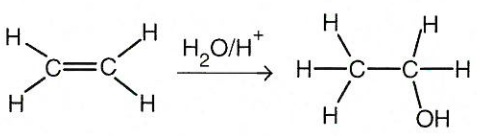
d. propene

1 mark

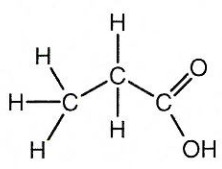
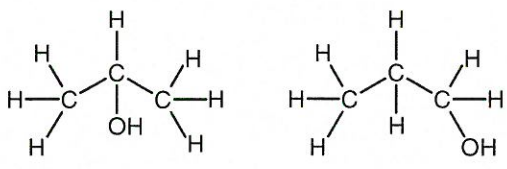
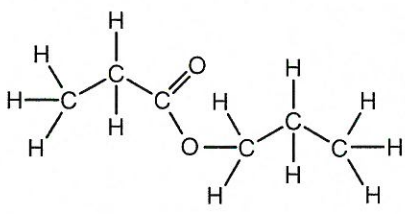
(Look for the repeating unit: $-(CH_3)CHCH_2-$.)

Total 6 marks

Question 3

- a. Process A is fractional distillation. 1 mark
The crude oil is heated to high temperatures. Vapours rise through a tower. As the vapours cool, hydrocarbons with progressively lower boiling points are collected as they condense. The lightest hydrocarbons (those with the lowest boiling points) are collected near the top of the fractionating tower. 1 mark
- b. $\text{CH}_3\text{CH}_2\text{CH}_3(\text{g}) \rightarrow \text{CH}_2\text{CH}_2(\text{g}) + \text{CH}_4(\text{g})$ 1 mark
- c.  1 mark
- d. $\text{CH}_3\text{CH}_2\text{OH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{CH}_3\text{COOH}(\text{aq}) + 4\text{H}^+(\text{aq}) + 4\text{e}^-$ 1 mark
- Total 5 marks

Question 4

- a. i. $M = 74 \text{ g mol}^{-1}$ 1 mark
ii. CH_3CH_2^+ 1 mark
iii.  1 mark
- b. i. $\text{C:H:O} = \frac{60.0}{12.0} : \frac{13.3}{1.0} : \frac{26.7}{16.0} = 5.0:13.3:1.67 = 3:8:1$ 1 mark
The empirical formula is $\text{C}_3\text{H}_8\text{O}$. 1 mark
- ii. $\text{MF} = (\text{C}_3\text{H}_8\text{O})_a$, where $a = \frac{\text{RMM}}{\text{EFM}} = \frac{60}{60} = 1$ 1 mark
The molecular formula is $\text{C}_3\text{H}_8\text{O}$. 1 mark
- iii.  2 marks
2-propanol 1-propanol
1 mark for each correct structure
- iv. The ^1H NMR data shows that Z is 1-propanol. 2-propanol would only show three peaks, as the six methyl hydrogens are equivalent. X is therefore propyl propanoate. 1 mark
- 
- Total 9 marks