Neap:

Trial Examination 2009

VCE Chemistry Unit 3

Written Examination

Suggested Solutions

SECTION A: MULTIPLE-CHOICE QUESTIONS

1	A	B	**C**	D
2	A	**B**	C	D
3	A	B	C	**D**
4	**A**	B	C	D
5	A	B	**C**	D
6	A	B	C	**D**
7	A	**B**	C	D
8	A	B	**C**	D
9	A	B	C	**D**
10	A	**B**	C	D

11	A	B	**C**	D
12	**A**	B	C	D
13	A	**B**	C	D
14	A	B	C	**D**
15	A	**B**	C	D
16	**A**	B	C	D
17	A	B	**C**	D
18	**A**	B	C	D
19	**A**	B	C	D
20	A	B	C	**D**

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Question 1 **C**

The errors listed in **A**, **B** and **D** all result in an over-estimation of the salt content. Insufficient precipitating agent results in less precipitate than expected, and so a lower calculated salt content.

Question 2 **B**

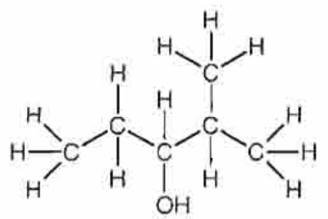
Rewriting the fatty acid formula as $C_{21}H_{41}COOH$ shows that it fits the general formula of a monounsaturated fatty acid, $C_nH_{2n-1}COOH$. The molecular formula does not provide information regarding the essential/non-essential nature of a fatty acid, hence **D** is not correct.

Question 3 **D**

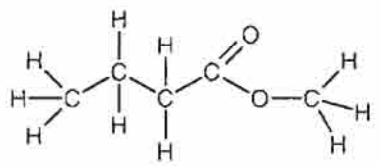
Infrared spectroscopy provides information about functional groups present in the molecule, so **A** is not the answer. ^{1}H NMR spectroscopy provides information about the arrangement of the hydrogen atoms within the molecule, so **B** is not the answer. The fragmentation pattern from the mass spectrometer provides structural information, so **C** is not the answer. HPLC is useful for the separation and identification of organic compounds, but not for the determination of the structure.

Question 4 **A**

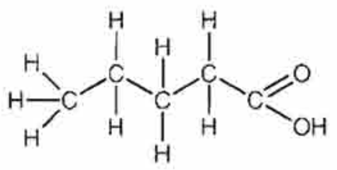
The relevant structures are shown below.



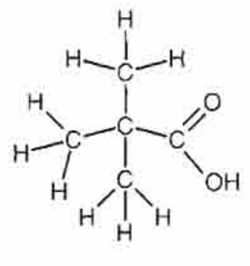
2-methylpentan-3-ol (6C)



methyl butanoate (5C)



pentanoic acid (5C)



2,2-dimethylpropanoic acid (5C)

Question 5 **C**

A. $32 \text{ mg L}^{-1} = 32 \times 10^{-3} \text{ g L}^{-1} = 0.032 \text{ g L}^{-1}$ ∴ **A** is incorrect

B. $32 \text{ mg L}^{-1} = \dfrac{32 \times 10^{-3}}{132} \text{ mol L}^{-1} = 2.4 \times 10^{-4} \text{ M}$ ∴ **B** is incorrect

C. $32 \text{ mg L}^{-1} = 32 \times 10^{-3} \text{ g L}^{-1} = 32 \times 10^{-4} \text{ g per 100 mL} = 0.0032\% \text{ m/V}$, **C** is correct

D. $32 \text{ mg L}^{-1} = 32 \times 10^{-3} \text{ mg mL}^{-1} = 3.2 \times 10^{-2} \text{ mg mL}^{-1}$ ∴ **D** is incorrect

Question 6 **D**

The conversion involves the gain of oxygen and the loss of hydrogen. This process is oxidation, and so the cinnamaldehyde is acting as a reductant.

Question 7 B

The OH group in cinnamic acid produces a broad peak in the 3100–3300 cm^{-1} range. This group is absent from the cinnamaldehyde. Thus **B** is a correct statement. Both compounds produce many peaks in the fingerprint region, and both contain the C=O and C=C groups, producing peaks at approximately 1700 cm^{-1} and 1620 cm^{-1} respectively. The statements in **A**, **C** and **D** are therefore incorrect.

Question 8 C

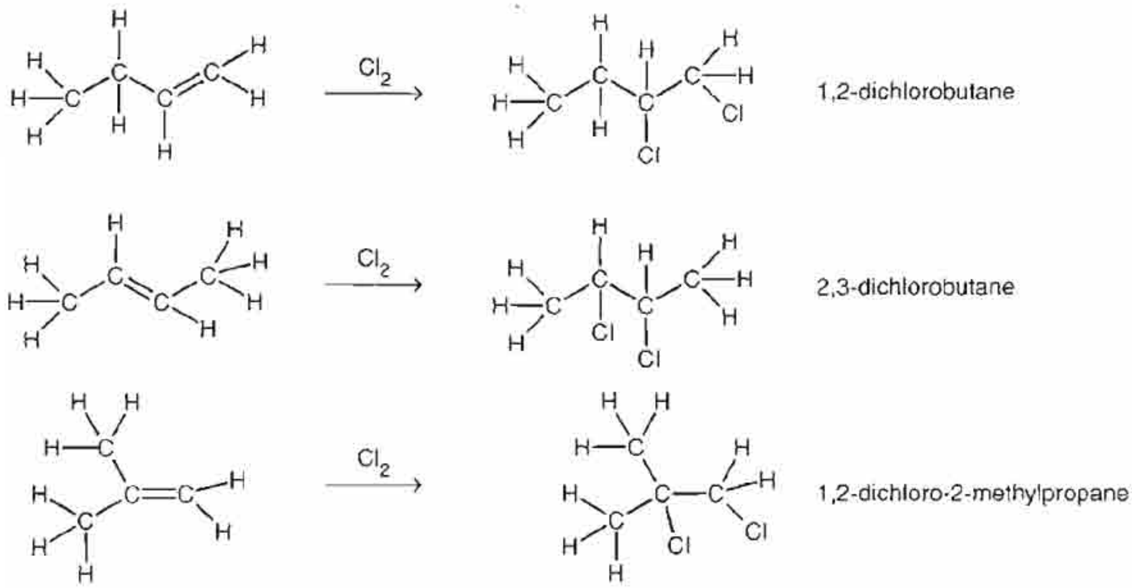
The filament produces a beam of electrons, which ionise the sample. The magnetic field separates the moving positively charged particles on the basis that those with the highest mass-to-charge ratio are deflected the least.

Question 9 D

Due to the complementary base pairing, A = T and C = G. Hence A + C = T + G.

Question 10 B

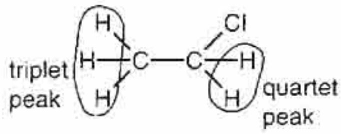
Butene undergoes addition reactions with chlorine. The chlorine atoms must therefore be on adjacent carbon atoms, and so the 1,3-dichloro product is not possible. The relevant reactions are shown below.



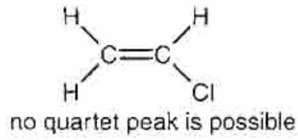
Question 11 C

The doublet at 2 ppm represents a ^{1}H nucleus with a single nearest ^{1}H neighbour. The quartet at 7 ppm represents a ^{1}H nucleus with three nearest ^{1}H neighbours. 1,1-dichloroethane is the only molecule listed that fits this pattern. Relevant structures and peak splitting patterns are shown below.

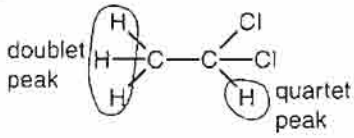
A



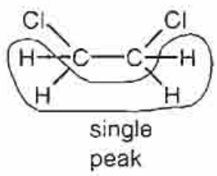
B



C



D



Question 12 A

The pH will be low (1 for a 0.10 M solution of HCl) at the start of the titration due to the acid in the conical flask. pH will rise as the base is added. At the equivalence point the pH will be less than 7 due to the presence of the weak conjugate acid, NH_4^+. Methyl red will change from its colour in acid (red) to its colour in base (yellow). Thymol blue would be an unsuitable indicator as its colour change would occur at a pH of approximately 2, well before the equivalence point had been reached.

Question 13 B

There are 20 alpha amino acids, hence **A** is not the required response. When 20 nucleotides combine to form a section of single stranded DNA, 19 sugar-phosphate bonds form, hence **B** is the required response (if the DNA is double stranded, only 18 sugar-phosphate bonds form). Each amino acid is coded for by three bases, so that a minimum of 21 bases will be needed to code for seven amino acids, hence **C** is not the required response. Each A–T base pair forms two hydrogen bonds. Each C–G base pair forms three hydrogen bonds. The total number of bonds for the section shown is 21, hence **D** is not the required response.

Question 14 D

Polymerisation occurs by condensation reaction between the OH groups on the C_1 and C_4 of adjacent molecules. When two molecules combine a water molecule is formed. When n molecules combine, $n - 1$ water molecules are formed.

The relevant calculation is therefore:

$M((C_8H_{13}O_5N)_n) = 317 \times M(C_8H_{15}O_6N) - 316 \times M(H_2O) = 64\ 369\ \text{g mol}^{-1}$

Question 15 B

$$M = \frac{mRT}{pV} = \frac{0.351 \times 8.31 \times 303 \times 760}{780 \times 101.3 \times 334 \times 10^{-3}} = 25.5\ \text{g mol}^{-1}$$

A. CH_4, $M = 16$ g mol^{-1}

B. C_2H_2, $M = 26$ g mol^{-1}

C. CO_2, $M = 44$ g mol^{-1}

D. BeO, $M = 25$ g mol^{-1}

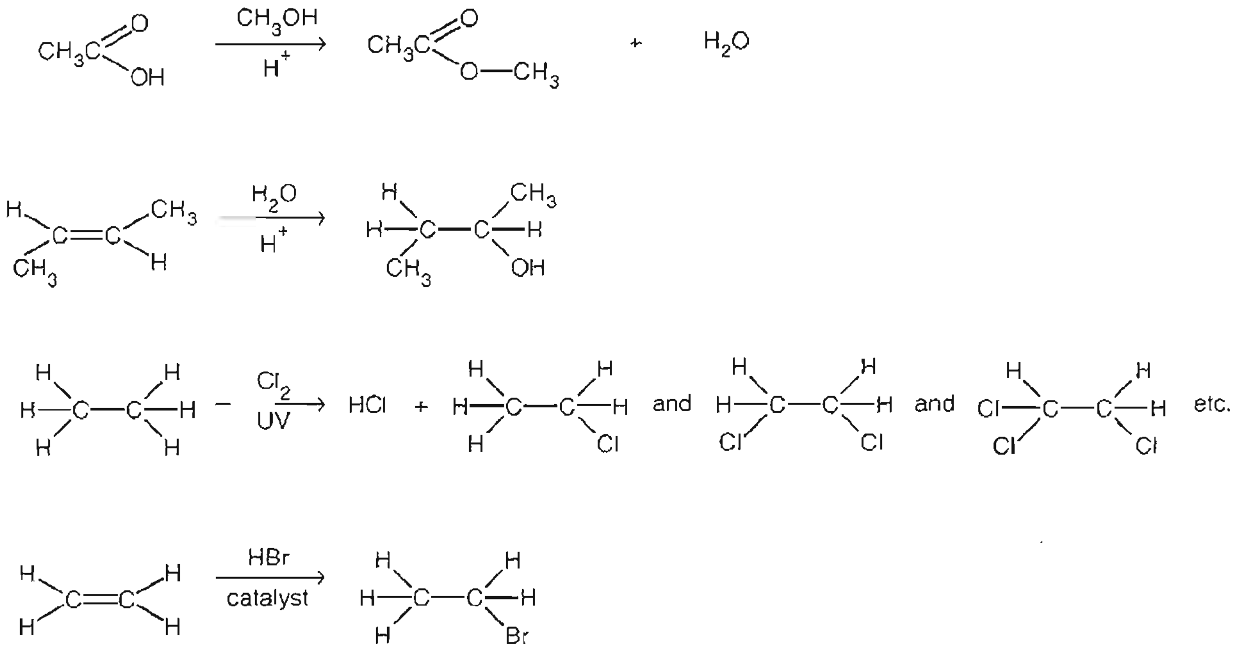
BeO is an ionic solid. It is not a gas at the conditions of the experiment, hence **D** is not correct.

Question 16 **A**

The statements in **B**, **C** and **D** are correct. Only a small percentage of the total DNA sequence is compared in the DNA fingerprinting process. Much of the DNA sequence is common to all individuals.

Question 17 **C**

The relevant reactions are shown below.



Question 18 **A**

Benzene has a structure in which the bonds are intermediate between those of C–C and C=C bonds. Benzene undergoes substitution reactions, not the addition reactions of unsaturated molecules, hence **B** and **D** are incorrect. All hydrocarbons undergo combustion reactions. Condensation reactions required the presence of functional groups. These are absent from benzene, hence **C** is incorrect.

Question 19 **A**

W is glucose, the monomer of starch. *Y* is deoxyribose, a component of nucleotides of DNA. *X* is fructose. *Z* is ribose, a component of nucleotides of RNA.

Question 20 **D**

	n(C)	:	n(H)	:	n(N)	:	n(O)
=	$\frac{43.2}{12.0}$	:	$\frac{4.50}{1.0}$	:	$\frac{37.8}{14.0}$	:	$\frac{14.5}{16.0}$
=	3.60	:	4.50	:	2.70	:	0.91
=	4	:	5	:	3	:	1

$\therefore C_4H_5N_3O$

$\therefore$ cytosine

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. $n(SeO_2) = \frac{m}{M} = \frac{0.142}{111} = 0.001279$ mol — 1 mark

$n(Cr^{2+}) = c \times V = 0.100 \times 25.52 \times 10^{-3} = 0.00255$ mol — 1 mark

$n(SeO_2) : n(Cr^{2+}) = 0.001279 : 0.00255 = 1 : 2$

The Se was initially in a +4 oxidation state, and so must be reduced to a +2 state. — 1 mark

b. **i.** $n(H_2SeO_3) = c \times V = 0.0500 \times 25.00 \times 10^{-3} = 1.25 \times 10^{-3}$ mol

$n(NaOH) = 2 \times n(H_2SeO_3) = 0.00250$ mol — 1 mark

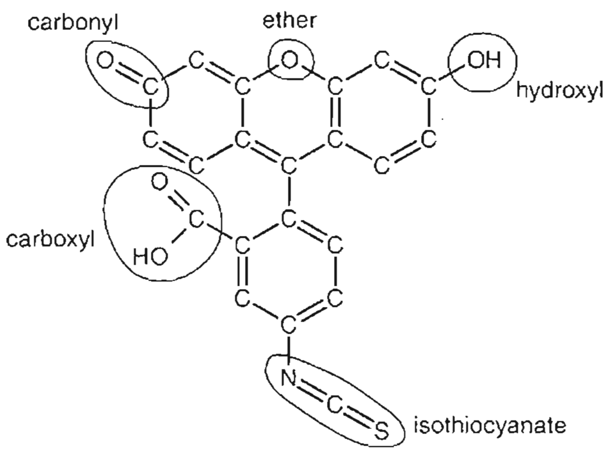
$V(NaOH) = \frac{n}{c} = \frac{0.00250}{0.100} = 0.0250 \text{ L} = 25.0 \text{ mL}$ — 1 mark

ii. The product, $SeO_3^{\ 2-}$ is a weak base. This produces a solution with a pH greater than 7. — 1 mark

Total 6 marks

Question 2

a. Any two of:



2 marks

b. **i.** 500 nm (*the wavelength of maximum absorbance*) — 1 mark

ii. To allow for any absorbance by the solvent and/or the silica cell. — 1 mark

iii. An absorbance of 0.34 corresponds to a concentration of 6.8 ng L^{-1}.

The dilution factor was 1 in 100.

The concentration of the original solution is therefore 680 ng L^{-1}. — 1 mark

iv. 680 ng in 1 L

$\therefore 680 \times \frac{2.00}{1000}$ ng in 2.00 mL

1 mark

$\therefore \frac{680}{389.1} \times \frac{2.00}{1000} \times 10^{-9}$ mol in 2.00 mL

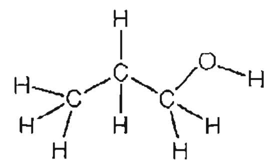
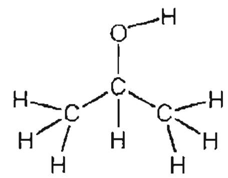
$\therefore \frac{680}{389.1} \times \frac{2.00}{1000} \times 10^{-9} \times 6.02 \times 10^{23}$ molecules $= 2.10 \times 10^{12}$ molecules — 1 mark

Total 7 marks

Question 3

a. **i.** addition or hydrolysis — 1 mark

ii.

Structure A	Structure B
Name: 1-propanol	Name: 2-propanol
	

Note: the O–H bond must be shown for full marks to be awarded. — 2 marks

b. The region above 1500 cm^{-1} shows peaks related to the functional groups present in a molecule. — 1 mark

Both molecules contain the same OH functional group, hence both show the same peaks at 3000–3500 cm^{-1}. — 1 mark

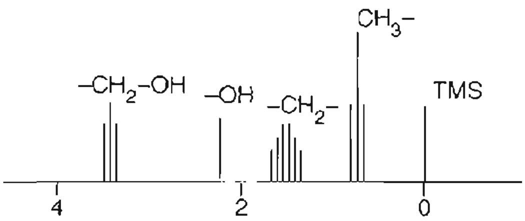
c. $CH_3CH_2^+$ — 1 mark

from structure A — 1 mark

d. i. 3 — 1 mark

ii. 2 — 1 mark

e.



high resolution ¹H NMR spectrum — 2 marks

Total 11 marks

Question 4

a. oxidant *(oxygen in H_2O_2 changes its oxidation number from –1 to –2, i.e. it is reduced. Sulfur changes its oxidation number from +4 to +6, i.e. it is oxidised by H_2O_2)* — 1 mark

b. **i.** $n(MnO_4^-) = c \times V = 0.0250 \times 23.90 \times 10^{-3} = 5.98 \times 10^{-4}$ mol — 1 mark

ii. $n(H_2O_2) = \frac{5}{2} \times n(MnO_4^-) = 1.49 \times 10^{-3}$ mol — 1 mark

iii. $n(H_2O_2)_i = c \times V = 0.0879 \times 50.0 \times 10^{-3} = 4.40 \times 10^{-3}$ mol — 1 mark

iv. $n(H_2O_2)_{consumed} = n(H_2O_2)_i - n(H_2O_2)_{in\ excess} = (4.395 - 1.494) \times 10^{-3}$

$= 2.90 \times 10^{-3}$ mol — 1 mark

v. $n(SO_2) = n(H_2O_2)_{consumed} = 2.90 \times 10^{-3}$ mol — 1 mark

$m(SO_2) = n \times M = 2.90 \times 10^{-3} \times 64.1 = 0.186$ g — 1 mark

vi. We have 0.186 g of SO_2 in (3 × 1200) g of air — 1 mark

$\therefore \frac{0.186 \times 10^6}{3 \times 1200}$ g in 10^6 g of air

$\therefore$ 51.6 ppm — 1 mark

Total 9 marks

Question 5

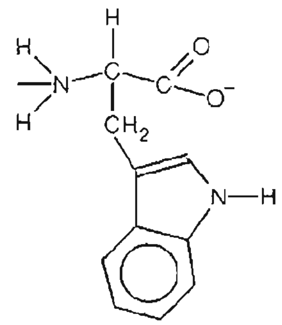
a. RAM(Zn) = Σ(RIM × abundance fraction)

$$= \frac{(63.93 \times 48.89) + (65.93 \times 27.81) + (66.93 \times 4.11) + (67.93 \times 18.57) + (69.93 \times 0.62)}{100}$$

= 65.39 — 2 marks

b. i. $C_{11}H_{12}O_2N_2$ — 1 mark

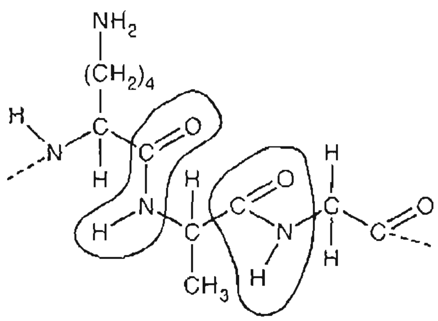
ii.



1 mark

c. i. Enzymes act as catalysts to increase the rate of reactions. — 1 mark

ii.



1 mark

iii. Changes in temperature and pH alter the secondary and tertiary structures of the protein by altering the bonding between different sections of the polypeptide chain. — 1 mark

The secondary and tertiary structures of an enzyme are critical to its functioning, hence changes in pH and temperature will alter this functioning. — 1 mark

d. atomic absorption spectroscopy — 1 mark

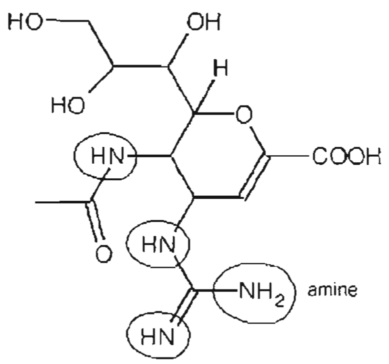
Total 9 marks

Question 6

a. This structural knowledge enables identification of the active site of the protein. Drugs can then be designed to match the shape and size of this active site. 1 mark

b. The drug may be broken down by the digestive enzymes in the mouth and/or the stomach and so will not reach the site of its action. 1 mark

c. i.

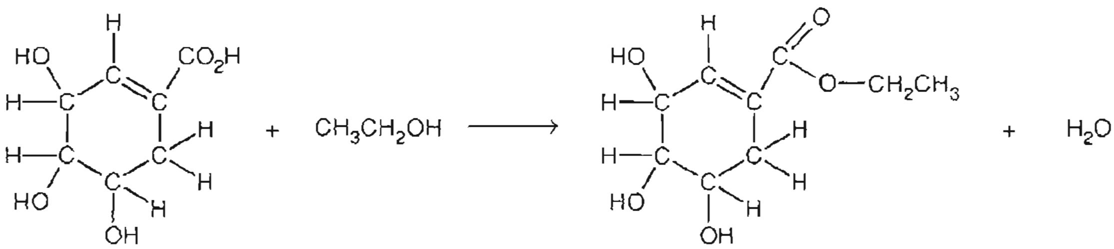


1 mark

ii. There are several functional groups (OH, NH_2, COOH) in the molecule which are able to hydrogen bond with water molecules and so enable the molecule to be soluble in water. 1 mark

d. i. The molecule is split by reaction with water. 1 mark

ii.



3 marks

1 mark for H_2O

1 mark for correct ester group

1 mark for correct copying of the remainder of the molecule

Total 8 marks