Suggested Answers VCE Chemistry 2008 Year 12 Trial Exam Unit 3

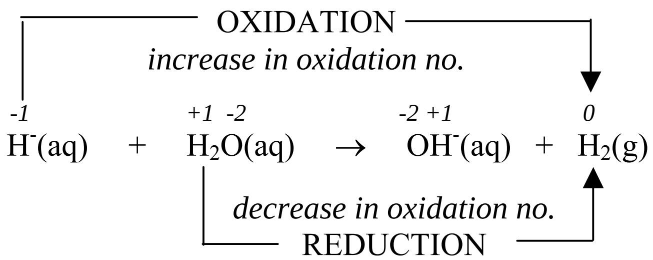
Multiple Choice Section

Section A

Q1 **C** Burettes are read from top to bottom and at the bottom of the meniscus (the slight concave curve formed at the top of the liquid.
Since the bottom of the meniscus is halfway between 17.6 and 17.7 the correctly recorded reading would be **17.65.**

Q2 **B** The reaction for the preparation of ethylamine from chloroethane is
$CH_3CH_2Cl + NH_3 \rightarrow CH_3CH_2NH_2 + HCl$
i.e. a maximum of 1 mol ethylamine can be produced for each 1 mol chloroethane reacting.
$n(CH_3CH_2Cl)$ reacting $= m / M$
$= 3.225\ g / 64.5\ g\ mol^{-1}$
$= 0.0500\ mol$
$n(CH_3CH_2NH_2)$ produced $= 0.0500\ mol$
$m(CH_3CH_2NH_2)$ produced $= n \times M$
$= 0.0500\ mol \times 45.0\ g\ mol^{-1}$
= **2.25 g**

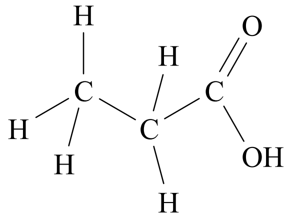
Q3 **D** The reaction $H^-(aq) + H_2O(aq) \rightarrow H_2(g) + OH^-(aq)$ is an acid-base reaction with H^- acting as a base, i.e. accepting a proton, and forming H_2, and H_2O acting as an acid, i.e. donating a proton and forming OH^-.
The redox nature of the reaction can be assessed by assigning oxidation numbers.



Hydrogen is both oxidised, from H^- to H_2, and reduced, from H_2O to H_2. So the reaction is a redox reaction as well as an acid-base reaction.

Q4 **C** Consider the reactions occurring
$CH_3CH_3 \rightarrow CH_3CH_2Cl$ – substitution
$CH_3CH_2Cl \rightarrow$ X, i.e. CH_3CH_2OH – substitution
$CH_3CH=CH_2 \rightarrow CH_3CH_2OH$ – addition
$CH_3CH_2CH_2OH \rightarrow$ Y, i.e. CH_3CH_2COOH – oxidation
(X) CH_3CH_2OH + (Y) $CH_3CH_2COOH \rightarrow$ (ESTER) $CH_3CH_2COOCH_2CH_3$ – condensation – using concentrated H_2SO_4 as a catalyst.
The conversion of 1-propanol, $CH_3CH_2CH_2OH$, to propanoic acid, CH_3CH_2COOH, is an oxidation reaction but requires an oxidant. Cu is a reductant, not an oxidant (see VCE Data Book Table 2)**.** The oxidant commonly used is an acidified solution of dichromate ions, i.e. $Cr_2O_7^{2-}(aq) / H^+(aq)$.

Q5 **C** Y is propanoic acid, CH_3CH_2COOH.
Propanoic acid will show **three peaks on its ^{13}C NMR spectrum** because it has **three different carbon environments.**



Propanoic acid will show **three peaks on its ^{1}H NMR spectrum** because it has **three different hydrogen environments.**

Q6 **B** According to Table 7 in the VCE Data Book, the **hydroxy group, O-H (in alcohols)** alcohols will produce an **IR absorption band in the range between 3200 and 3550 cm^{-1}.**
Whilst the OH group in carboxylic acids will produce an IR absorption band in the range between 2500 and 3300cm^{-1}, a particular acid may not produce its associated absorption band between 3200 and 3300 cm^{-1}.
There are **two alcohols** – ethanol (X), CH_3CH_2OH, and 1-propanol, $CH_3CH_2CH_2OH$, both of which show strong absorption between 3200 and 3550 cm^{-1} on their IR spectra.

Q7 **B** The **molecular ion** is formed as a result of an electron being knocked off each of the ester molecules when bombarded by a stream of electrons in the mass spectrometer.
The ester produced is ethyl propanoate, **$CH_3CH_2COOCH_2CH_3$**
(X) CH_3CH_2OH + (Y) $CH_3CH_2COOH \rightarrow$ (ESTER) $CH_3CH_2COOCH_2CH_3 + H_2O$
$M_r(CH_3CH_2COOCH_2CH_3) = 102$, i.e. the relative molecular mass of the ester is 102.
In the mass spectrum of ethyl propanoate, **the peak for the unfragmented molecular ion would appear at the *m* / *e* ratio of 102**. This *m* / *e* assumes a charge of +1 on the molecular ion.

Q8 **A** When nitric acid acts as an oxidant, it oxidises another species and is itself reduced. As a result of being reduced there will be a decrease in the oxidation number of nitrogen.
In HNO_3 the oxidation number of N is +5
In NO_3^-, the oxidation number of N is +5
In N_2, the oxidation number of N is 0
In NO, the oxidation number of N is +2
In NO_2, the oxidation number of N is +4
Hence NO_3^- will not be produced when HNO_3 acts as an oxidant.

Q9 **A** $2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$

6.75 g *6.3 L at STP*

n(Al) reacting = 6.75 / 27.0
= 0.250 mol

$n(H_2)$ produced = $^3/_2$ x n(Al)
= 1.5 x 0.250
= 0.375 mol

$n(H_2)$ collected = $V(H_2)$ / V_m(STP)
= 6.3 L / 22.4 L mol^{-1}
= 0.281 mol

% H_2 collected = [$n(H_2)$ collected / $n(H_2)$ produced] x 100
= 75 %

% H_2 not collected = 100 – 75
= 25 %

Q10 **D** $n(CrO_4^{2-})$ initially = $n(K_2CrO_4)$ initially
= $c(K_2CrO_4)$ x $V(K_2CrO_4)$
= 0.05 x 20×10^{-3}
= 0.001 mol

$n(Ag^+)$ initially = $n(AgNO_3)$ initially
= 0.1 x 10×10^{-3}
= 0.001 mol

Since $Ag^+(aq)$ and $CrO_4^{2-}(aq)$ react in the ratio 2 : 1, i.e. 0.001 mol Ag^+ will react with 0.001 / 2 = 0.0005 mol CrO_4^{2-}, then CrO_4^{2-} is in excess and will not all of it will be precipitated.

Considering the reactants in the ratio indicated by the equation

	$2Ag^+(aq)$ +	$CrO_4^{2-}(aq)$	$\rightarrow$	$Ag_2CrO_4(s)$
initially (mol)	0.001	0.001		-
reacting	0.001	0.001 / 2		
	0.001	0.0005	$\rightarrow$	0.0005
finally	-	**0.0005**		0.0005

CrO_4^{2-} is in excess by 0.0005 mol and will remain unprecipitated at the end of the reaction.

Q11 **A** The equation for the reaction is

$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$

20.0 mL *17.5 mL*
0.0300 M

n(HCl) required = c(HCl) x V(HCl)
= 0.0300 x 17.5×10^{-3}
= 5.25×10^{-4} mol

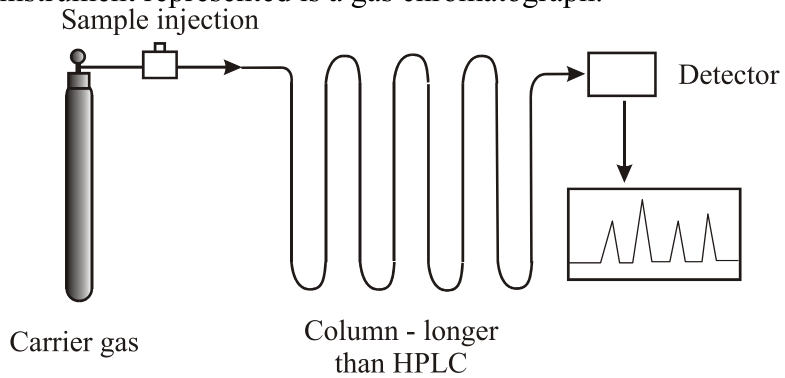
$n(Ca(OH)_2)$ reacting = ½ x n(HCl)
= ½ x 5.25×10^{-4}
= 2.63×10^{-4} mol

This was the amount of $Ca(OH)_2$ in a 20.0 mL aliquot.

$n(Ca(OH)_2)$ in one litre = [2.63×10^{-4} / 20] x 1000
= 0.013 mol

***m*(Ca(OH)$_2$) in one litre** = n x M
= 0.013 x 74.0
= **0.97 g**

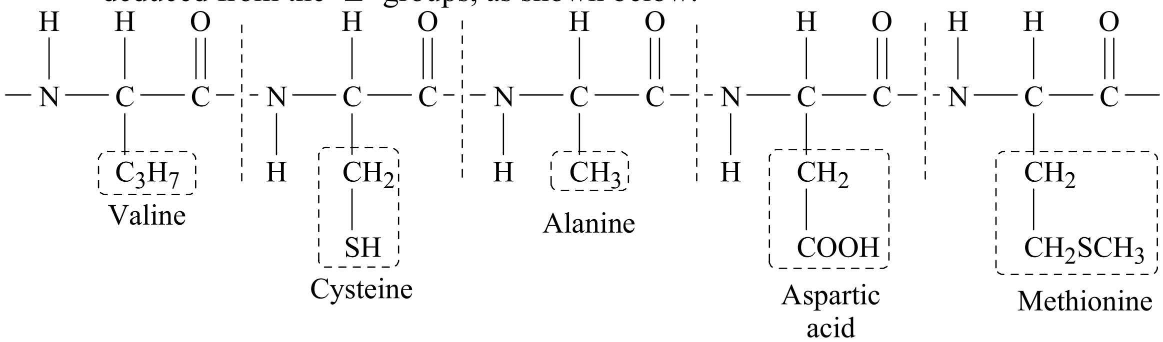
Q12 A The instrument represented is a gas chromatograph.



In modern analytical procedures gas chromatography is commonly combined with mass spectroscopy, GC-MS. A complex sample can be separated into its components by gas chromatography and the components then identified using mass spectroscopy.

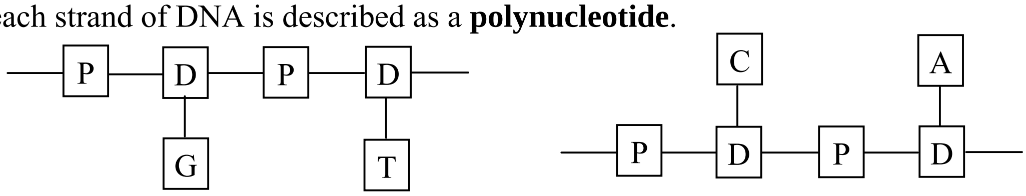
Q13 D **Table 8** in the VCE Data Book indicates that all amino acids contain C, H, O and N and some contain S.
Nucleic acids on the other hand all contain C, H, N, O and P.
Phosphorus is not present in amino acids.
Sulfur is not present in nucleic acids.

Q14 B **Table 8** in the VCE Data Book shows the structures of all the α-amino acids and should be used to identify the ones present (or missing) from the protein chain. The amino acids which reacted to form the section of protein chain shown can be deduced from the 'Z' groups, as shown below.

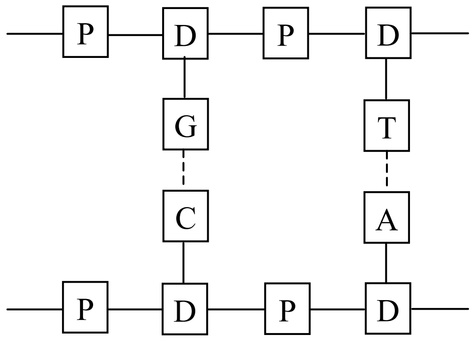


Glycine was not one of the amino acids used to produce this protein section. Alternatively you may recall that glycine, NH_2CH_2COOH, is the simplest amino acid, and inspection shows that it is not part of the protein chain.

Q15 D The **primary structure** of DNA consists of a backbone of **alternating units of deoxyribose and phosphate groups**. The bonds between the deoxyribose and phosphate groups are **covalent bonds**. A **base** – **adenine, guanine, cytosine or thymine** - is also **covalently bonded to each deoxyribose unit**. Each combination of phosphate group, deoxyribose and base is called a nucleotide and each strand of DNA is described as a **polynucleotide**.



The **secondary structure** of DNA and the **double helix** is due to the **attraction between two polynucleotide strands** by **hydrogen bonding between complementary bases.** To maintain the constant distance between the two strands **guanine on one strand is always bonded to cytosine on the other strand**, and **adenine on one strand is always bonded to thymine on the other strand.**



Alternative D is the best alternative.

Q16 D Substances that increase the rate of a chemical reaction are generally described as catalysts. However **enzymes are a specific type of catalyst**, in that they are **proteins** and depend on a specific structural aspect, the active site for their catalytic action,

Not all proteins are enzymes, but all enzymes are proteins.

An enzyme **increases the rate of a specific biological reaction.**

Enzymes, like other proteins are prone to denaturation when exposed to changes in pH or temperature.

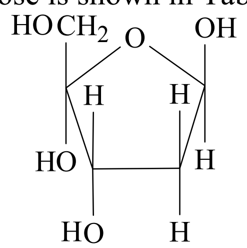
D is the best alternative.

Q17 B The diagram shown in the question is representative of the secondary structure of a protein, which is held together by **hydrogen bonds between different peptide groups on the protein chain**. The hydrogen bonds, indicated by **1.,** occur between the H atom on one peptide group and the O atom on another peptide group.

The bond indicated by **2.** is the **bond between the N and C atoms in the peptide links**. This is a **covalent bond.**

Q18 A **Glucose** has the molecular formula $\mathbf{C_6H_{12}O_6}$.

The structure of deoxyribose is shown in Table 10. of the VCE Data Book.



Recognising that there are four C atoms in the ring, the molecular formula of deoxyribose can be deduced as $\mathbf{C_5H_{10}O_4}$.

Hence a molecule of deoxyribose has **one less C** atom, two fewer H atoms, and two fewer O atoms than a molecule of glucose.

Q19 **A** The analytical process referred to is Atomic Absorption Spectroscopy (AAS), which is most suitable for measuring amounts of metals extracted into or present in solution.

Consider the techniques most suited to analyses described in the alternatives.

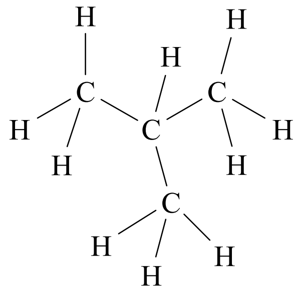
A. Atomic absorption spectroscopy.

B. IR spectroscopy

C. ^{13}C NMR spectroscopy

D. Gas chromatography or redox titration.

Q20 **A** The structural formula of 2- methylpropane indicates that there are only **two different hydrogen environments**.



The **9 H atoms in the three CH_3 groups are all equivalent**, i.e. in similar environments in that all 9 are bonded to a C atom which is bonded to two other H atoms and one other C atom.

There is **one other H atom which is bonded to a C atom which is bonded to three other C atoms**.

This also emphasised in the semi-structural formula $(CH_3)_3CH$.

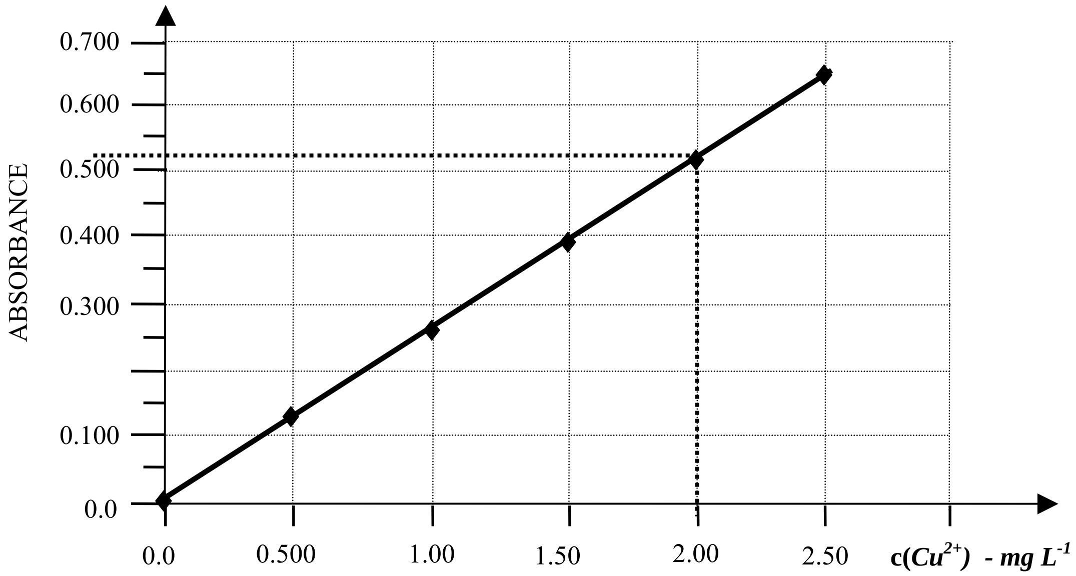
Because there are **9 H atoms in one environment and 1 H atom in the other environment**, the **ratio of the areas under the peaks** for the two environments on the ^1H NMR spectrum will be **9 : 1 or 1 : 9.**

Section B

Question 1

a. The **absorbances** of series of **standards of known concentration of $Cu(NH_3)_4^{2+}$(aq)** obtained at **600 nm.** ❶

b.



Absorbance 0.520 → $c(Cu^{2+})$ = 2.00 mg L^{-1} ❶

This is the concentration of the solution after the second dilution.

The first dilution was by a **factor of 10**,

i.e. 10 mL of original solution → 100 mL of first diluted solution.

The second dilution was by a **factor of 20**

i.e. 5 mL of first diluted solution → 100 mL of second diluted solution.

So the solution analysed (second diluted solution) was $^1/_{200}$ th (one-two hundredth) as concentrated as the original solution, i.e. ($^1/_{10}$ x $^1/_{20}$), i.e. the original solution was 200 times as concentrated as the second dilute solution.

$c(Cu^{2+})$ in original solution = 200 x 2.00 mg L^{-1} ❶
= 400 mg L^{-1}

$n(Cu^{2+})$ in one L of original solution = 400×10^{-3} g / 63.6 g mol^{-1}
= 6.29×10^{-3} mol

$c(Cu^{2+})$ in original solution = **6.29×10^{-3} mol L^{-1}** ❶

c. Yellow is the complementary colour of dark blue. Aqueous solutions of $Cu(NH_3)_4^{2+}$ ions appear dark blue because they absorb yellow wavelengths from incident white light and transmit blue light. ❶ The higher the concentration of $Cu(NH_3)_4^{2+}$(aq) the greater the absorbance of yellow light. ❶

d. Atomic absorption spectroscopy (AAS) ❶
Light source is a copper cathode lamp. ❶

Question 2

a. Table 11 of the VCE Data Book provides information about indicator colours.
Colour change: **red to colourless** ❶
[For the reaction $HCl(aq) + Na_2CO_3(aq) \rightarrow NaHCO_3(aq) + NaCl(aq)$ the original solution in the titration flask was basic due to $Na_2CO_3(aq)$. $Na_2CO_3(aq)$ contains the strongly basic $CO_3^{2-}(aq)$. [$Na_2CO_3(aq) \rightarrow 2Na^+(aq) + CO_3^{2-}(aq)$. So the original bath salts solution is of high pH [$CO_3^{2-}(aq) + H_2O(l) \rightarrow HCO_3^-(aq) + OH^-(aq)$] and the phenolphthalein is red (pH > 10)
The addition of HCl(aq) converts $CO_3^{2-}(aq)$ to $HCO_3^-(aq)$ [$CO_3^{2-}(aq) + H^+(aq) \rightarrow HCO_3^-(aq)$].
*When all the $CO_3^{2-}(aq)$ has been converted to the **slightly basic $HCO_3^-(aq)$**, the pH drops below 10 and the colour of the phenolphthalein indicator fades through pink to colourless.]*

b. According to $HCl(aq) + Na_2CO_3(aq) \rightarrow NaHCO_3(aq) + NaCl(aq)$
***n*(Na_2CO_3) present** = *n*(HCl) required to reach phenolphthalein endpoint. ❶
= *c*(HCl) x *V*(HCl)
= 0.1020 mol L^{-1} x 10.25×10^{-3} L
= **1.046×10^{-3} mol** ❶

c. *n*(HCl) used is based on the volume added after the phenolphthalein endpoint.
***n*(HCl)** = *c*(HCl) x *V*(HCl)
= 0.1020 x 25.35×10^{-3}
= **2.586×10^{-3} mol** ❶

d. Table 11 of the VCE Data Book provides information about indicator colours.
Colour change: **yellow to red** ❶
[For the reaction $HCl(aq) + NaHCO_3(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$ the original solution in the titration flask was basic due to $NaHCO_3(aq)$, the pH was above 7 (and 4.4) so methyl orange was yellow. When all the basic $HCO_3^-(aq)$ has reacted with HCl, the indicator colour changes when the solution becomes slightly acidic and pH drops below 4.4. The colour passes quickly through orange to red.]

e. According to $HCl(aq) + NaHCO_3(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$
***n*($NaHCO_3$)** reacting = *n*(HCl) added between endpoints.
= **2.586×10^{-3} mol** ❶

f. The $NaHCO_3$ reacting in (d) included the $NaHCO_3$ in the original 50.00 aliquot of bath salts solution as well as the $NaHCO_3$ produced between the first reaction between Na_2CO_3 and HCl.
n($NaHCO_3$) in original bath salts solution
= *n*($NaHCO_3$) reacting in (d) – *n*($NaHCO_3$) produced in (b)
= $2.586 \times 10^{-3} - 1.046 \times 10^{-3}$
= 1.540×10^{-3} mol ❶
c($NaHCO_3$) in original bath salts solution
= 1.540×10^{-3} mol / 50.0×10^{-3} L
= **0.03080 M** ❶

g. The **calculated amount of $NaHCO_3$** would be **higher** than the true value. ❶
Traces of bath salts solution would remain in the burette and **some** of the **HCl** added **would react** with the Na_2CO_3 and $NaHCO_3$ in those traces. This would effectively **decrease the concentration of the HCl(aq)** in the burette leading to **larger titres** and a **higher calculated amount of $NaHCO_3$.**❶

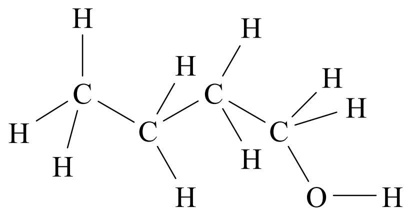
Question 3

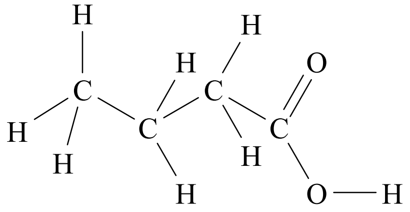
a. i. $C_6H_{12}O_6(aq) \rightarrow 2C_2H_6O(aq) + 2CO_2(g)$ ***or***
$C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(aq) + 2CO_2(g)$ ❶❶
One mark for correctly balanced equation; one mark for correct states.

ii. Biofuels are fuels produced from **renewable organic sources such as plant materials**, e.g. sugar cane or various grains as a source of sugars for fermentation. ❶

iii. $C_2H_4(g) + H_2O(g) \rightarrow C_2H_6O(g)$ ***or*** $CH_2{=}CH_2(g) + H_2O(g) \rightarrow CH_3CH_2OH(g)$ ❶

b. i.

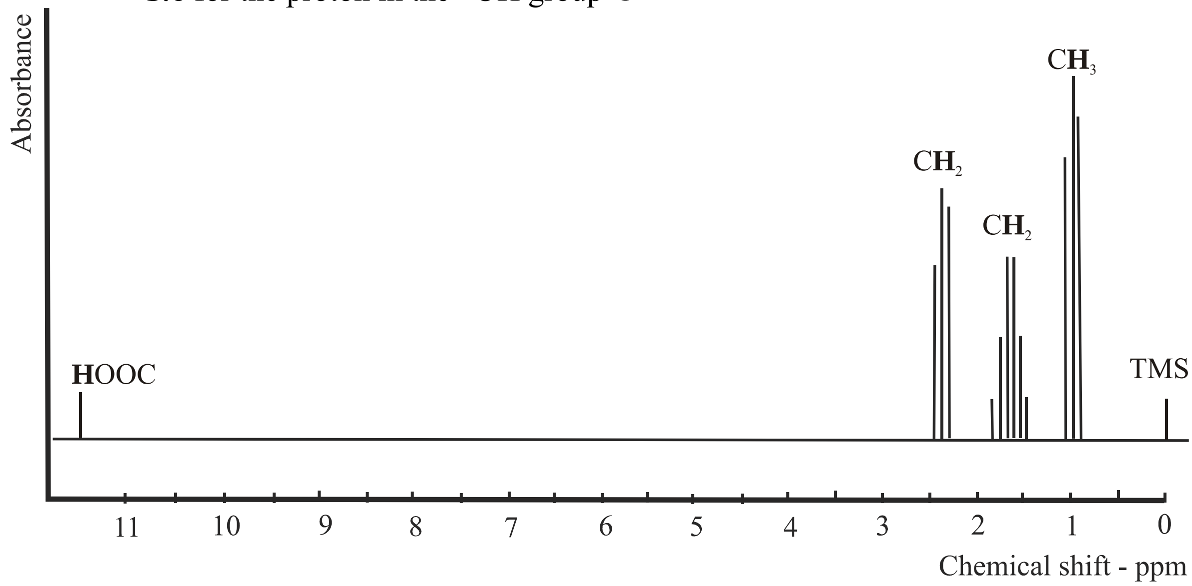




❶ ❶

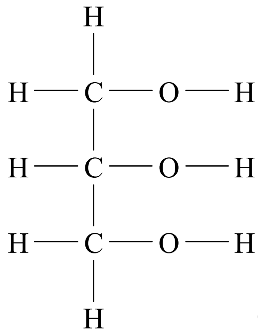
1-butanol butanoic acid

ii. **butanoic acid** ❶
Both compounds would be expected to show four distinct peaks or sets of peaks because there are four different hydrogen environments on each molecule.
According to the information in Table 5 of the VCE Data Book, the single peak at chemical shift 11.5 would be produced by the proton in a carboxyl –COO**H** group. ❶
If the compound was **1-butanol** a **peak would be expected** around chemical shift **3.6** for the proton in the –OH group ❶



iii. 1-butanol, $CH_3CH_2CH_2OH$, and ethanol, CH_3CH_2OH, molecules both have the **polar hydroxyl group which allows for hydrogen bonding with water molecules**. Their **solubility in petrol** is due to attraction between their **non-polar hydrocarbon sections** and non-polar octane molecules. ❶ Because **1-butanol molecules have a longer hydrocarbon section** they dissolve more easily in petrol and less readily in water than ethanol molecules. ❶

c. i. **Glycerol** ❶



❶

ii. The monounsaturated fatty acid produced during hydrolysis of the oil has the chemical formula

$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$

To produce the methyl ester it must be reacted with methanol, CH_3OH, according to the equation

$\mathbf{CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH(l) + CH_3OH(l)}$

$\mathbf{\rightarrow CH_3(CH_2)_7CH{=}CH(CH_2)_7COOCH_3(l) + H_2O(l)}$ ❶❶

One mark for the correct fatty acid formula

One mark for the balanced equation

d. Whilst combustion of biofuels does produce CO_2, the carbon being released into atmosphere is the same **carbon that was taken in by the plant,** which was the source of the biofuel, **during photosynthesis**. ❶ Fossil fuel combustion releases carbon that has been trapped for millions of years.

Question 4

a. i. **hydroxy group –OH** (in an alcohol) ❶ Table 7 VCE Data Book

ii. **fingerprint region** ❶

b. i. The largest significant *m* / *e* ratio is at 60, so the relative molecular mass is **60** ❶

ii **3 carbon** atoms ❶

The compound is an alcohol and had has a relative molecular mass of 60.

Relative mass of C and H atoms = 60 – relative mass of OH

= 60 – 17

= 43

Since each carbon atom has an atomic mass of 12, there will be 3 C atoms present. ❶

Alternatively check the known alcohols

$M_r(CH_3OH) = 32$, $M_r(CH_3CH_2OH) = 46$, $M_r(CH_3CH_2CH_2OH$ or $(CH_3)_2CHOH) = 60$.

c. i. **Four (4)** ❶

Four different sets of peaks imply four different hydrogen environments.

ii. $\mathbf{CH_3CH_2CH_2OH}$ ❶

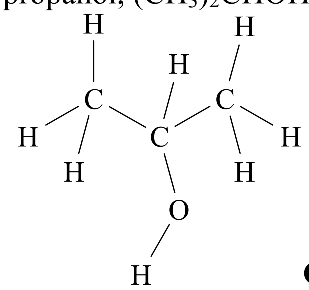
Knowing from the IR and mass spectra data that the compound is an alcohol with 3 C atoms, four sets of peaks on the ^1H NMR spectra are consistent with 1-propanol, $CH_3CH_2CH_2OH$

iii. For a peak to be split into a triplet the **hydrogen atoms in that environment must have a neighbouring CH_2 group,** i.e. must have 2 neighbouring hydrogens. ❶ A CH_2 splits the ^1H NMR signal for hydrogens attached to adjacent carbon atoms into 2+1 = 3 peaks – the (n+1) rule.

iv. The sextet peak set is the peak for the two hydrogens on the CH_2 between CH_3 and the other CH_2. i.e. CH_3**CH_2**CH_2OH. These **two H atoms have 5** (3 on the adjacent CH_3 and 2 on the adjacent CH_2) **neighbouring H atoms a**nd so their **peak is split into 5 + 1 = 6 finer peaks.** ❶

d. **Three (3)** ❶
There are three different carbon environments, hence 3 peaks on the ^{13}C NMR spectrum.

e. i. The other isomer is 2-propanol, $(CH_3)_2CHOH$



❶

ii. 3 Peaks – ^{1}H NMR spectrum. ❶
The ^{1}H NMR spectrum will show 3 peaks because there are *three different hydrogen environments* – the *CH_3 groups, the CH group*, and the *OH group*. The *6 H atoms on the two CH_3 groups are all in the same environment.*
2 Peaks – *^{13}C* NMR spectrum. ❶
The *^{13}C spectrum* will show 2 peaks because there are two different carbon environments; the *CH_3 groups* and the *CH group*.

Question 5

a. Cells in cancerous **tumours and damaged or diseased organs can leak proteins** into blood, urine and other body fluids. These proteins may be ones that are **not normally found in these body fluids or abnormal levels of expected proteins**. These proteins are **called marker proteins**, can be extracted and identified (using electrophoresis and mass spectroscopy) and used to **detect the presence and/or progress of a disease**. ❶

b. **Condensation** reaction ❶
Carboxyl (-COOH) and amino (-NH_2) ❶ functional groups react to **produce a peptide** (amide) **(-CONH-)** functional group (and water). ❶

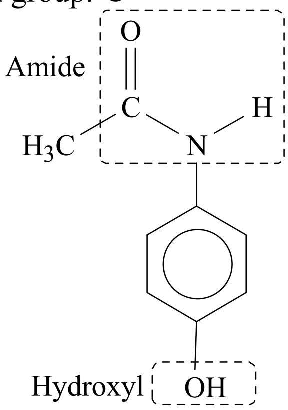
c. i. The gel pH will determine whether an amino acid assumes a (+) charge, a (-) charge, or is a zwitterion.
At **low pH**, an **amino acid will act as a base**, accept a proton, **assume a (+) charge and migrate towards the (-) electrode**. ❶
At **high pH**, an **amino acid will act as an acid**, donate a proton, **assume a (-) charge and migrate towards the (+) electrode**. ❶
At a pH at which an amino acid is a zwitterion it will not migrate to either electrode.

ii. At pH 2, cysteine $NH_2CH(CH_2SH)COOH$ will accept a proton and become $^{+}NH_3CH(CH_2SH)COOH$. It will migrate towards the **negative electrode.** ❶
(Structure of cysteine obtained from Table 8 in the VCE Data Book.

d. **Mass spectrometer.** ❶

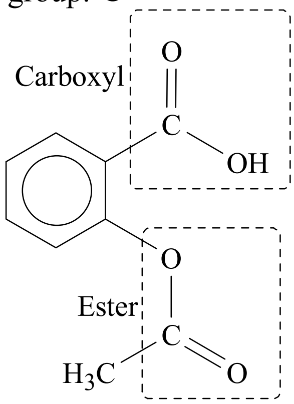
Question 6

a. **amide** group and **hydroxyl** group. ❶



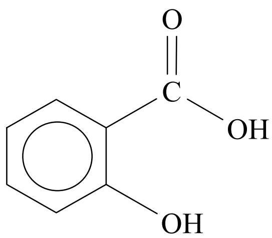
❶

b. **carboxyl** group and **ester** group. ❶



❶

c.



❶

d. i. It contains **caffeine**, **aspirin** and at least one other substance which appears **not to be paracetamol** ❶ because its R_F value is different. ❶

ii. **HPLC** (High Performance Liquid Chromatography) ❶

End of Suggested Answers