Sample Exam 1 – 2008 Solutions

The answers provided are suggestions only and do not represent directly or otherwise official VCAA answers.

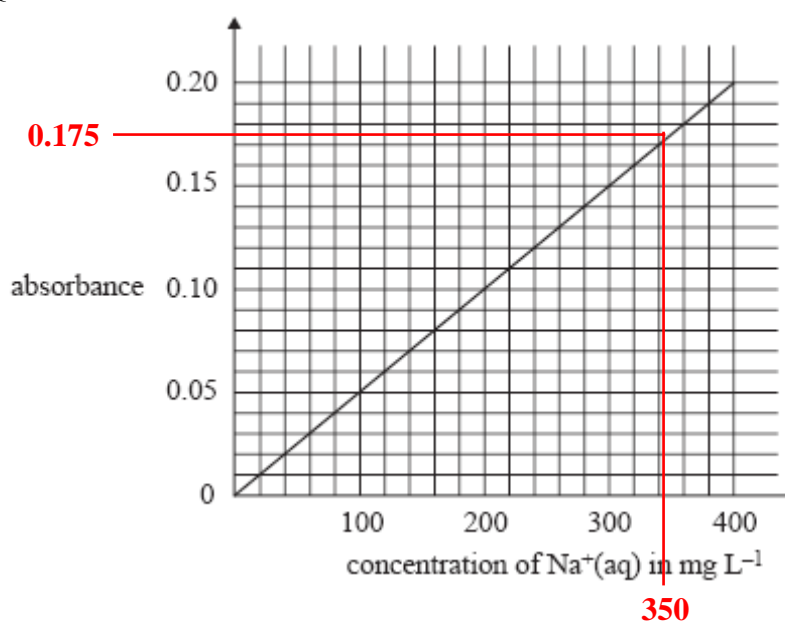## Section A

Q1 – C
$n(AgCl) = 4.85 / (107.9+35.5) = 0.00338$ mol
$n(KCl) = 0.0338$ mol
$m(KCl) = 0.0338 \times (39.1+35.5) = 2.518$ g
% KCl $= 100 \times (2.518 / 5.00) = 50.4$ %

Q2 – D

$c(Na^+)$ in dilute solution = 350 mg L^{-1}
20.00 mL of sample was diluted to 250.0 mL. Hence the dilution factor was 250 / 20
$c(Na^+)$ in sauce $= 350 \times (250 / 20)$
$= 4375$ mg L^{-1}

Q3 – C
pH 4.00 $\rightarrow c(H^+) = 10^{-4.00} = 0.00010$ M $= c(HNO_3)$
$c(HNO_3)$ has to be diluted by a factor of $0.0100 / 0.00010 = 100$
$V(HNO_3)$ needs to increase by factor of 100, from 50 mL to 5000 mL
$V(H_2O)$ required $= 5000 – 50 = 4950$ mL

Q4 – C
$M(CH_3CH_2COOH) = 74$ g mol^{-1}
N_A CH_3CH_2COOH molecules have a total mass 74 g
$m(1$ CH_3CH_2COOH molecule$) = 74 / N_A$
$= 74 / 6.02 \times 10^{23}$
$= 1.2 \times 10^{-22}$ g
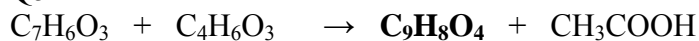
Q5 – B
$C_7H_6O_3$ + $C_4H_6O_3$ $\rightarrow$ **$C_9H_8O_4$** + CH_3COOH
30.0 g   100 g
$n(C_7H_6O_3) = 30.0/138 = 0.217$ mol
$n(C_4H_6O_3) = 100/102 = 0.980$ mol $\rightarrow$ in excess
Hence from equation: $n(C_9H_8O_4) = n(C_7H_6O_3) = 0.217$ mol

Theoretical yield: $m(C_9H_8O_4) = 0.217 \times 180 = 39.06$ g
Actual yield: 27.5 g
Percentage yield: % yield = [actual m(asprin) / theoretical m(asprirn)] x 100
                                          = (27.5 / 39.06) $\times$ 100 = 70.4 %

Q6 – D
K = +1, O = -2, sum of oxidation numbers = 0

$\overset{+1\ \ \ x\ \ \ -2}{KMnO_4} \rightarrow -1 + x + 4(-2) = 0 \rightarrow x = +7$

Q7 – D
$H_2S(g) + 2OH^-(aq) \rightarrow S^{2-}(aq) + 2H_2O(l)$
Acid-base reaction; H_2S acting as a dipotic acid
$SO_4^{2-}(aq) + H_3O^+(aq) \rightarrow HSO_4^-(aq) + H_2O(l)$
Acid-base reaction
$NH_4^+(aq) + CO_3^{2-}(aq) \rightarrow NH_3(g) + HCO_3^-(aq)$
Acid-base reaction
There is no change in oxidation number in these three equations hence they are not redox reactions.
$I_2(aq) + 2OH^-(aq) \rightarrow I^-(aq) + IO^-(aq) + H_2O(l)$
Oxidation number increases from 0 (I_2) to +1 (IO^-) and also decreases from 0 (I_2) to -1 (I^-).
Hence this is a **redox reaction.**
Chemical reactions in which a pure element is a reactant or a product are redox reactions.

Q8 – B
The name 1-propyl butanoate indicates that the ester was formed from the alcohol, propanol,
$CH_3CH_2CH_2OH$, and the carboxylic acid butanoic acid, $CH_3CH_2CH_2COOH$.
$CH_3CH_2CH_2COOH + CH_3CH_2CH_2OH \rightarrow$ **$CH_3CH_2CH_2COOCH_2CH_2CH_3$** $+ H_2O$
butanoic acid   1-propanol   1-propyl butanoate

Q9 – B
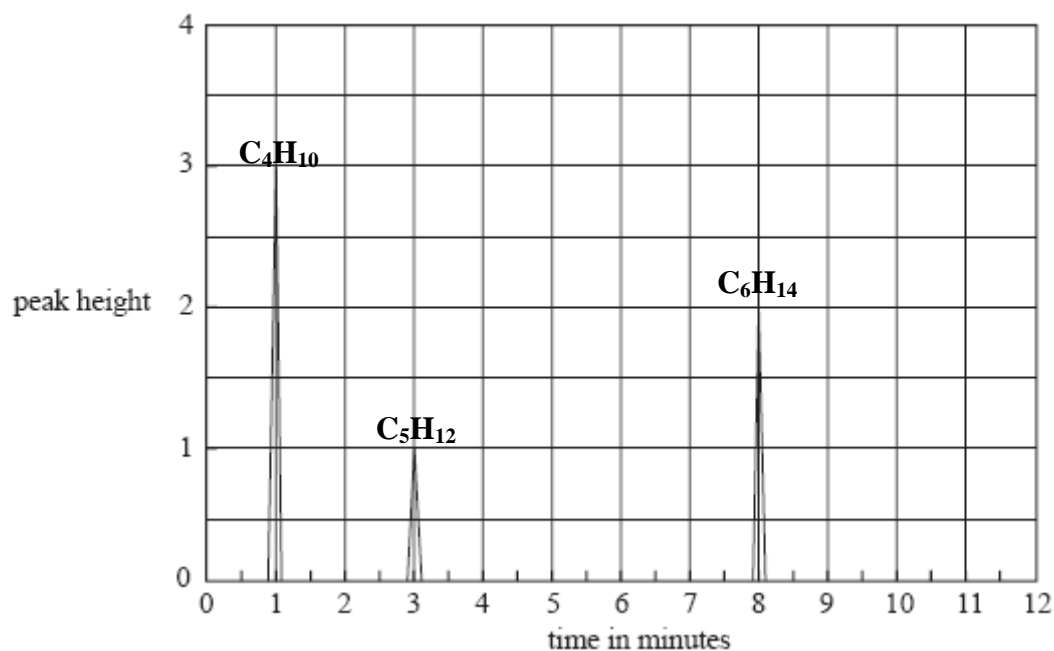A – UV-Visible radiation
B – IR radiation
C – NMR
D – mass spectrometry

Q10 – A
Unburnt hydrocarbon pollutants in the atmosphere suggest they must be gases.

Q11 – C

Peak heights (peak areas) are in the ratio 3 : 1 : 2 for C_4H_{10} : C_5H_{12} : C_6H_{14}
Hence % C_6H_{14} = (2 / 6) x 100 = **33 %**

Q12 – A
HPLC does not utilise a carrier gas; the mobile phase is a liquid. The retention times will be lower at a higher temperature and higher for a longer column.

Q13 – B
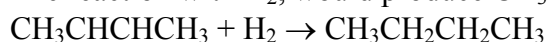Refer to amino acid structures in the data booklet – Table 8
For an aqueous solution of the amino acid to have a pH greater than 7 it must react with water to produce OH^-(aq) ions when placed in water.
Both glutamine and glutamic acid have 5 C atoms in their molecules.
Glutamine with a basic amino functional group in its Z-(R-) group will produce the more basic solution when placed in water.

Q14 – C
The reaction with H_2, would produce $CH_3CH_2CH_2CH_3$
$CH_3CHCHCH_3 + H_2 \rightarrow CH_3CH_2CH_2CH_3$
$M(CH_3CH_2CH_2CH_3) = 58$

Q15 – A
According to Table 7 in the data booklet, the hydroxyl group –OH in alcohols has an infrared absorption band in the range 3200-3550 cm^{-1}

Q16 – A
Because both methyl (CH_3-) groups have hydrogen atoms in identical environments in $(CH_3)_2CHBr$, it will produce two peaks on a ^1H NMR spectrum whereas there are three different hydrogen environments in a $CH_3CH_2CH_2Br$ sample will three peaks.
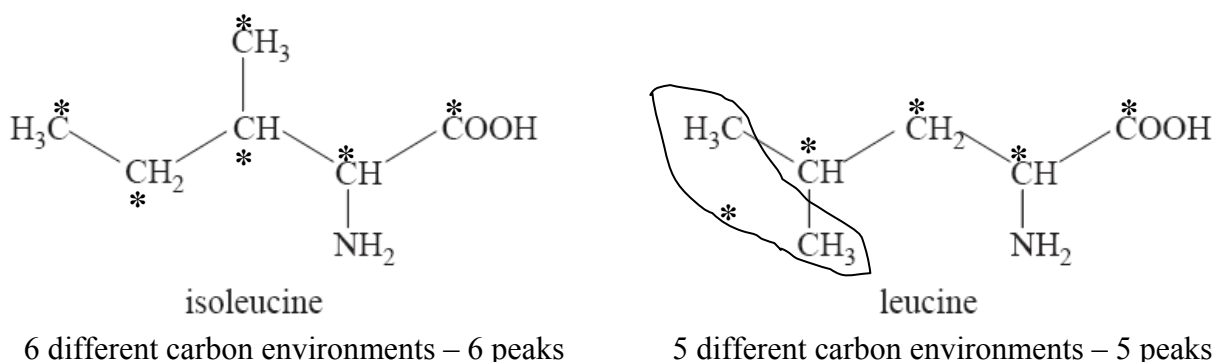All other alternatives would be identical for both compounds

Q17 – B
Hydrolysis of paracetamol occurs at the peptide or amide CO-NH functional group. This reacts with water to form an amino $-NH_2$, functional group and a carboxyl $-COOH$ functional group. So the products will not include CH_3OH.
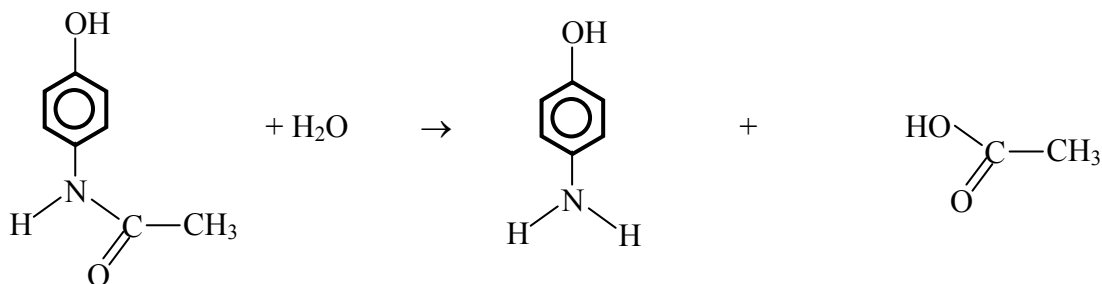
On the ^{1}H NMR spectrum the 3 H atoms (protons) on the CH_3 group would be expected to produce a singlet at around 2.0 (consistent with $RCOCH_3$). See Table 5 in Data Booklet
The C=O group will be expected to show an IR absorption band at 1670-1750 cm^{-1}. See Table in Data Booklet.

Q18 - D

isoleucine
6 different carbon environments – 6 peaks

leucine
5 different carbon environments – 5 peaks

Q19 – C
Each DNA nucleotide consists of a **phosphate group**, a **deoxyribose** sugar group, and one of the four bases **adenine** (A), **cytosine** (C), **guanine** (G) and **thymine** (T). The structures of each of these units are provided in the Data Booklet – Table 10 .
Alternative A does not include a phosphate group
Alternative B does not include A a correct nitrogen base structure
Alternative C does not include the correct deoxyribose structure.
Alternative D includes the correct structures for phosphate, deoxyribose and guanine.

Q20 – D
If the DNA contains 100 base pairs, and 30 guanine bases, then there must be 30 G-C pairs and hence, there will be 70 A-T pairs.

Section B
Question 1

(a) n(NaOH) used to neutralise $= 0.142 \times 11.88 \times 10^{-3}$ *
$$= 1.69 \times 10^{-3} \text{ mol}$$

$n(C_6H_8O_7)$ in 20.00 mL aliquot diluted lemon juice $= \frac{1}{3} \times n$(NaOH)
$$= \frac{1}{3} \times 1.68 \times 10^{-3} \text{ *}$$
$$= 5.62 \times 10^{-4} \text{ mol}$$

$n(C_6H_8O_7)$ in 25.00 mL undiluted lemon juice $= (5.62 \times 10^{-4} / 20) \times 100$ *
$$= 2.817 \times 10^{-3} \text{ mol}$$

$c(C_6H_8O_7) = 2.817 \times 10^{-3} / 25.00 \times 10^{-3}$ *
$$= 0.113 \text{ mol L}^{-1}$$

(b) The indicator should change colour in a pH range that includes the equivalence point (pH approx 9). Phenolphthalein is the indicator (Table 11 – Data Booklet) that changes in the range of pH 8.3 - 10.0. At the start of the titration the solution will be acidic (pH < 7) due to the citric acid and hence the phenolphthalein will be colourless (pH < 8.3). The end point of the indicator is very close to the equivalence point – where exactly 3 mol NaOH has been added for each 1 mol $C_6H_8O_6$ present – and the pH is 9 due to the weakly basic citrate ion, $C_6H_5O_7^{3-}$(aq). Phenolphthalein will cause the solution to change colour from colourless to red.

(c) (i) A primary standard is a **pure substance** which does not decompose or react with the atmosphere and **for which the number of mole present can be accurately calculated from the mass**. *
Alternatively – a substance, for which a known mass can be used to produce a solution of accurately known concentration'

(ii) Solid NaOH exposed to the atmosphere is of uncertain composition because it
- absorbs water from the atmosphere
- reacts with atmospheric CO_2 *

(iii) Possible answers
- sprinkle solid $NaHCO_3$ over the spill and then clean it up
- add sodium carbonate solution to the spill then wipe up
- further dilute the spill with a small volume of water then wipe.

(d)

	Glassware	Solution(s) used for final rinsing	Result too low	Result too high	Correct result
i.	burette	water		✓	
ii.	20.00 mL pipette	diluted lemon juice			✓
iii.	100 mL conical flask	0.142 M NaOH(aq)	✓		
iv.	250.0 mL volumetric flask	water			✓

4 marks

(i) Burettes should be rinsed with distilled water to remove any impurities and then the solution being used in the titration to ensure the concentration of that solution remains constant and accurately known. Rinsing only with water dilutes the NaOH(aq) and leads to a higher V(NaOH) used and subsequently a higher calculated % citric acid.

(ii) Pipettes should be rinsed with distilled water to remove any impurities and then with the solution they are being used to transfer to ensure the concentration of that solution remains constant and accurately known

(iii) Conical flasks should be rinsed with distilled water, since traces of water remaining do not change the number of mole of substance then added. Traces of NaOH(aq) remaining in the flask will react

with added citric acid and so reduce the V(NaOH) needed in the titration. A lower added V(NaOH) will lead to a lower calculated % citric acid.

(iv) Volumetric flasks are rinsed with distilled water, since traces of water remaining do not change the number of mole of substance then added.

Question 2

(a) fractional distillation *

(b) (i) Assume 100 g sample → 35.0 g C, 6.6 g H, 58.4 g Br

n(C) = 35.0 / 12 = 2.92 mol; n(H) = 6.6 / 1.0 = 6.6; n(Br) = 58.4 / 79.9 = 0.73 mol

Ratio n(C)   : n(H)   : n(Br)

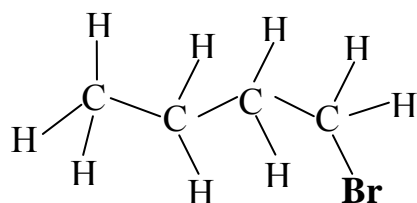2.92   :   6.6   :   0.73

2.92/0.73 : 6.6/0.73 : 0.73/0/73

4   :   9   :   1

Empirical formula **C_4H_9Br** *

(ii) Molar mass → molecular mass = 137

Empirical formula mass = 4x12.0 + 9x1.0 + 1x79.9

= 136.9

Hence molecular formula is the same as the empirical formula - **C_4H_9Br** *

(iii)

1-bromobutane   **2-bromobutane**

1-bromo-2-methylpropane   **2-bromo-2-methylpropane**
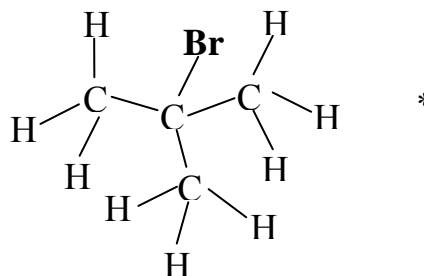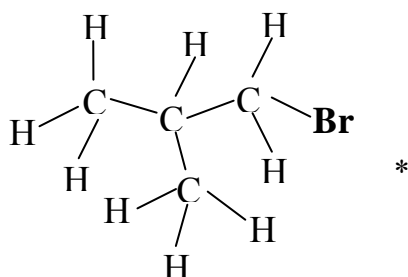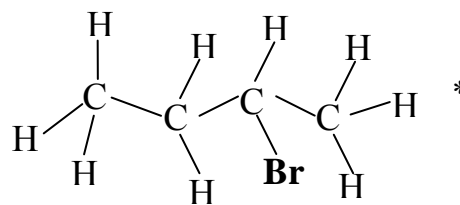
(c) (i)
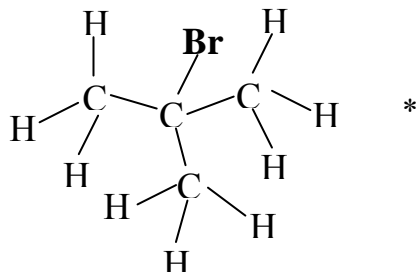
(ii) 2 lines in the ^{13}C spectrum implies two different carbon environments – CH$_3$ (x3) and C-Br *
1 line in the ^{1}H spectrum implies that all the hydrogen atoms in the molecules are in equivalent environments. * 2-bromo-2-methylpropane (CH$_3$)$_3$Br has 3 methyl groups that are all equivalent) hence the 9 hydrogen atoms will resonate at the same value (have the same chemical shift).* The lack of peak splitting in the ^{1}H spectrum indicates than the C atom adjacent to the methyl groups does not have any H atoms attached to it. * (Student must have the first point and any one of the other three points.)

Question 3

(a) (i) $M_r(CH_3Cl) = 50.5$; $M_r(CH_2Cl_2) = 85$

Lines at 50 and 52 are produced by chloromethane

Line at 50 is caused by $CH_3{}^{35}Cl^+$
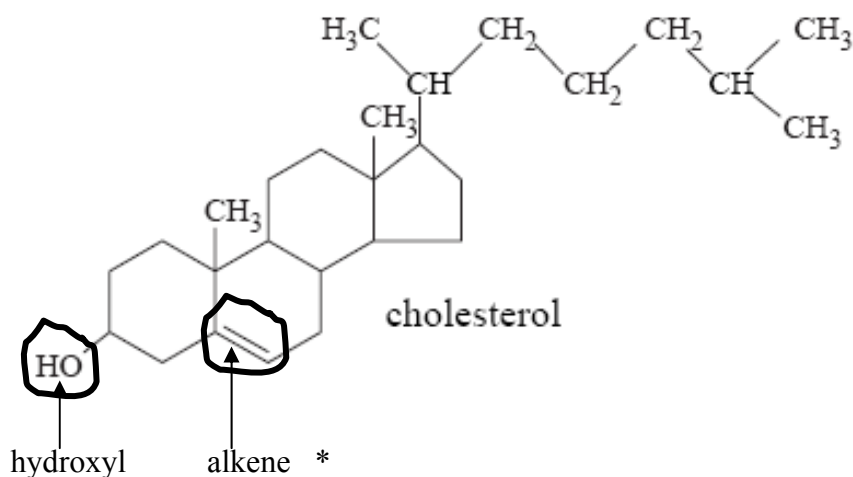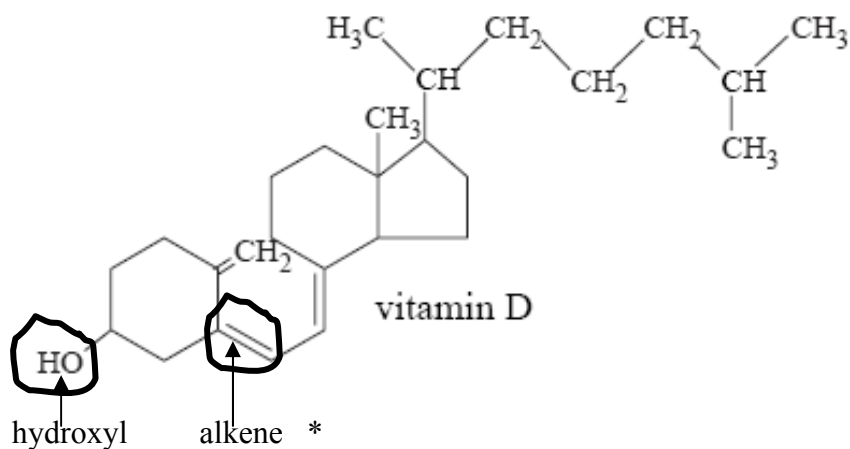
Line at 52 is caused by $CH_3{}^{37}Cl^+$ *

(ii) Line at 15 is caused by $CH_3{}^+$ * - produced by fragmentation of chloromethane molecules.

(b) The identity of the substance is confirmed by the highest m/e ratio which will be close to the relative molecular mass. The highest m/e ratio for dichloromethane – CH_2Cl_2 ($M_r = 85$) – would be 88 ($CH_2{}^{37}Cl_2$). The highest m/e ratio for chloromethane – CH_3Cl (($M_r = 50.5$) – would be 52 ($CH_3{}^{37}Cl$).Hence **X** is **chloromethane**. *
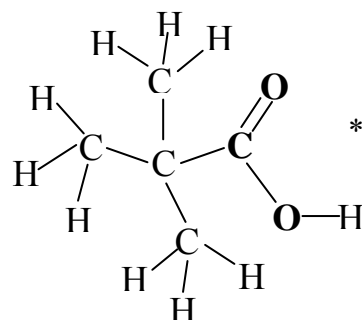
The mass spectrum indicates that $CH_3{}^{35}Cl^+$ is more abundant than $CH_3{}^{37}Cl^+$, hence the relative molecular mass is closer to 50 than 52. Also the presence of the $CH_3{}^+$ fragment indicates CH_3Cl
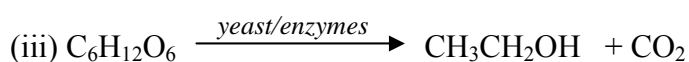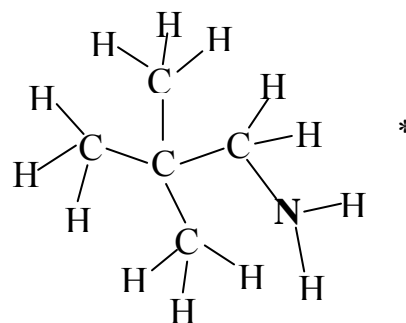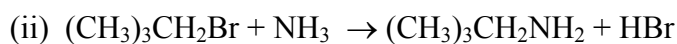
Question 4

(a)

vitamin D

hydroxyl   alkene *

cholesterol

hydroxyl   alkene *

(b) (i) $(CH_3)_3CCH_2OH \xrightarrow{Cr_2O_7{}^{2-} / H^+} (CH_3)_3CCOOH$

(ii) $(CH_3)_3CH_2Br + NH_3 \rightarrow (CH_3)_3CH_2NH_2 + HBr$

*

(iii) $C_6H_{12}O_6 \xrightarrow{\textit{yeast/enzymes}} CH_3CH_2OH + CO_2$

$O{=}C{=}O$ *

To receive the mark assigned to structural formulae all bonds should be shown.

(c) $\mathbf{C_3H_8 + Cl_2} \xrightarrow{\text{UV light}} \mathbf{CH_3CH_2Cl + HCl}$ *or* $\mathbf{CH_3CH_2CH_3} \xrightarrow[\text{UV light}]{\text{Cl}_2} \mathbf{CH_3CH_2CH_2Cl}$ *

$\mathbf{CH_3CH_2CH_2Cl + OH^- \rightarrow C_3H_8O + Cl^-}$ *or* $CH_3CH_2CH_2Cl \xrightarrow{OH^-} \mathbf{CH_3CH_2CH_2OH}$ *
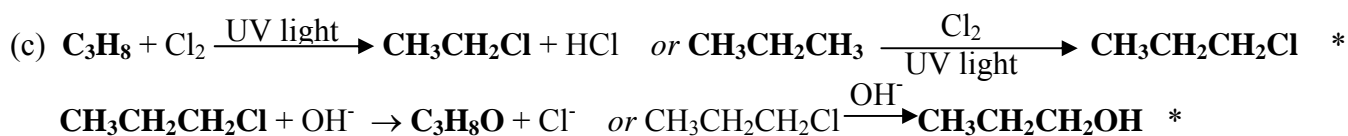
Question 5
(a)

*
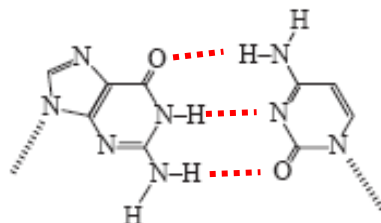
(b) (i) Fragment A
   Guanine and cytosine have three sites for hydrogen bonds between the base pairs, whereas adenine
   and thymine have only two sites for hydrogen bonding. Hence G-C bonds are stronger that A-T bonds
   and the strands in fragment A with the lower proportion of G-C pairs will separate more readily as the
   temperature is raised.   *
   (ii) 16 molecules. *
   There are 9 nucleotides in each strand in fragment. Hence 8 water molecules are needed to react at
   the phosphate groups and hydrolyse each strand into its nucleotides. Therefore 16 H_2O molecules are
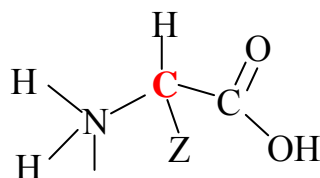   required for the two strands.

(c)

*

*
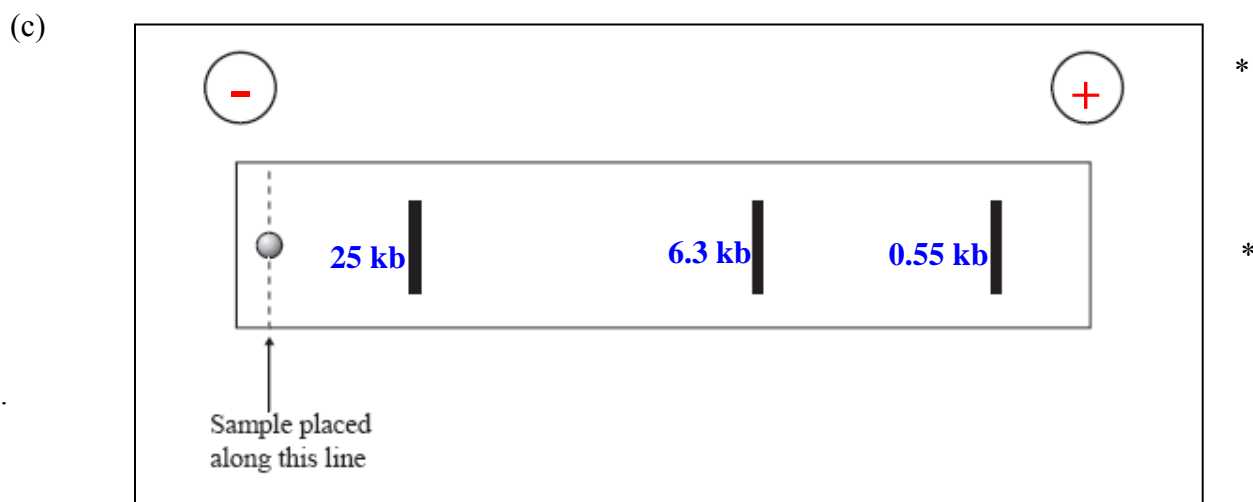
DNA fragments have a negative charge due to the phosphate groups, so they are placed near the negative terminal of the gel. Speed of movement through the gel depends on molecular size which depends on the number of base pairs in the fragment.
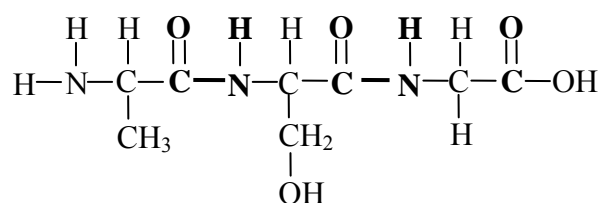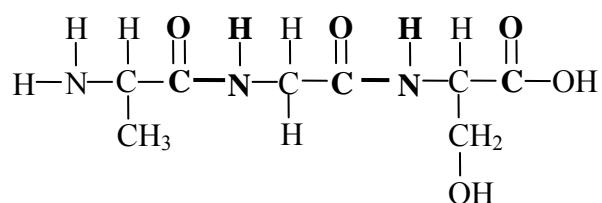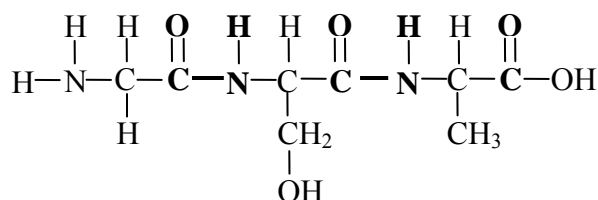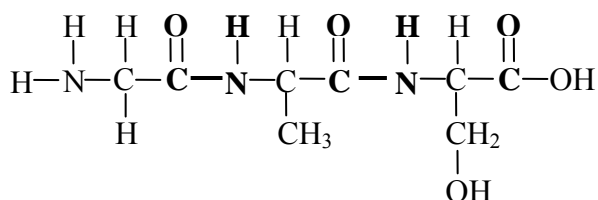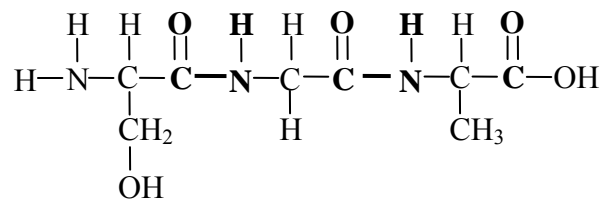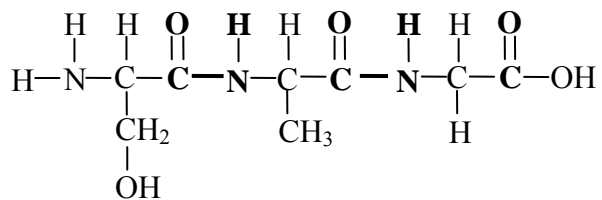
Question 6

(a) (i) Cells in damaged or diseased body organs may release proteins unique to that organ into the blood. Such proteins are called marker proteins and can be use to detect the presence of a disease and monitor its progress. *

   (ii) The primary structure is the sequence of amino acids in a protein chain. *
   The secondary structure is the coiling or folding of a protein chain due to hydrogen bonding between peptide groups. * (between the H on one peptide group and the O on a different peptide group)

(b) In 2-amino acids both the amino –NH_2 and carboxyl –COOH functional group are bonded to the same carbon atom (carbon atom number 2)   *

   (Lone pairs do not need to be shown)

(c) (i) 6 tripeptides *
   (ii) one of *

H H O H H O H H O
H—N—C—C—N—C—C—N—C—C—OH
     | | |
     CH₂   CH₃   H
     |
     OH

H H O H H O H H O
H—N—C—C—N—C—C—N—C—C—OH
     | | |
     CH₂   H   CH₃
     |
     OH

(d) The chromatogram for the second amino acid mixture would contain more bands because of contamination with the first amino acid mixture. *