

Trial Examination 2010

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

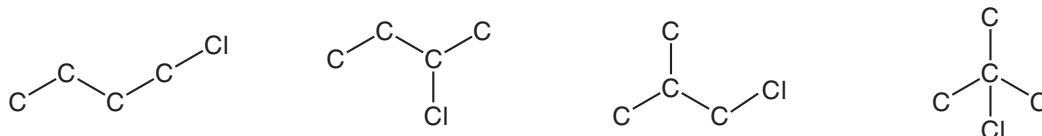
Question 1 C

$$n(\text{C}) : n(\text{H}) : n(\text{N}) : n(\text{O}) = \frac{58.5}{12.0} : \frac{4.1}{1.0} : \frac{11.4}{14.0} : \frac{26.0}{16.0} = 4.875 : 4.1 : 0.814 : 1.625 = 6 : 5 : 1 : 2$$

The empirical formula is therefore $\text{C}_6\text{H}_5\text{NO}_2$.

Question 2 B

A molar mass of 92.5 g mol^{-1} indicates that monosubstitution of butane (C_4H_{10}) has occurred to produce $\text{C}_4\text{H}_9\text{Cl}$, i.e. $M(\text{C}_4\text{H}_9\text{Cl}) = 92.5 \text{ g mol}^{-1}$. The carbon skeletons of the four isomers of $\text{C}_4\text{H}_9\text{Cl}$ are shown below.

**Question 3 C**

The three dimensional structure of the active site of a protein is investigated using X-ray crystallography rather than infrared spectroscopy. Infrared spectroscopy is used to identify the functional groups present in molecules and to verify their identity. Alternatives **A**, **B** and **D** are techniques involved in the design of medicines.

Question 4 D

Hydrogen is added across the double bond in the unsaturated fat. $7.50 \text{ g of H}_2 = 3.75 \text{ mol H}_2$.

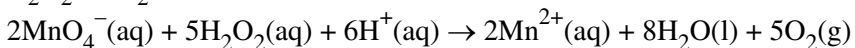
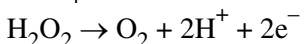
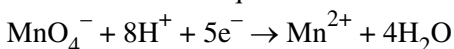
This reacts with 1.25 mol of unsaturated triglyceride.

$$\text{The number of double bonds in the triglyceride} = \frac{3.75}{1.25} = 3.$$

Thus each fatty acid molecule must contain 1 double bond. Of the fatty acids, palmitoleic acid has 1 double bond, linoleic acid has 2, linolenic acid has 3 and arachidonic acid has 4. The required answer is **D**.

Question 5 B

The relevant half-equations and overall equation are



Thus **B** is the correct answer.

Question 6 A

The higher up the fractionating column the fraction is removed, the smaller the hydrocarbon molecules. Smaller molecules have weaker dispersion forces than larger molecules. The correct answer is **A**. Fractions removed higher up the column are likely to be gases but the fractions at *S* and certainly at *T* are probably liquids. Thus **B** is incorrect. Most compounds in the column are converted to gases initially but the residue at *V* remains as a liquid at the temperatures used in the column and is distilled under reduced pressure in a separate process. **C** is not correct. Each fraction consists of various hydrocarbon molecules with similar but different molecular masses. **D** is incorrect.

Question 7 A

The reaction involves the formation of water as the amine (NH_2) group reacts with the carboxyl (COOH) group to form the amide (CONH) group. This is a condensation reaction.

Question 8 C

$$n(\text{C}_6\text{H}_7\text{NO}) = \frac{m}{M} = \frac{1.12}{109} \text{ mol}$$

$$n(\text{C}_8\text{H}_9\text{NO}_2) = n(\text{C}_6\text{H}_7\text{NO})$$

$$n(\text{C}_8\text{H}_9\text{NO}_2) = n \times M = \frac{1.12}{109} \times 151 = 1.55 \text{ g}$$

$$\% \text{ yield} = \frac{1.04}{1.55} \times 100 = 67\%$$

Question 9 D

Molecular mass increases from 109 to 151, so **A** is not the answer.

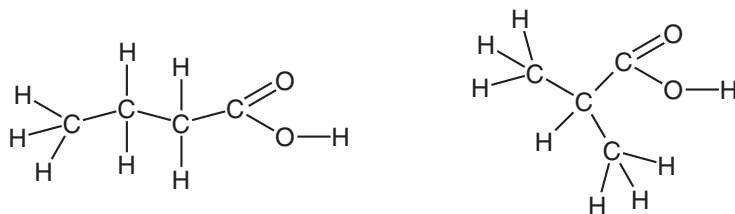
In 4-aminophenol there are 4 ^1H types, in paracetamol there are 5, so **B** is not the answer.

In 4-aminophenol there are 4 ^{13}C types, in paracetamol there are 6, so **C** is not the answer.

The amine functional group is basic, the amide functional group is not, so **D** is the answer.

Question 10 B

The carboxylic acids with the molecular formula $\text{C}_4\text{H}_8\text{O}_2$ are shown below.

**Question 11 D**

The area under the peak indicates the amount of each component and so **A** is not correct. Component *P* possibly has the smallest peak area and thus the lowest concentration but has the shortest retention time (it is eluted first). **B** is not correct. If separated using TLC, the most strongly adsorbed component (the one with the longest retention time) will have the lowest R_f value. **C** is incorrect. Component *Q* is eluted before component *S* and thus would be less attracted to the stationary phase and more attracted to the mobile phase. **D** is the required answer.

Question 12 C

Change I would make the retention times smaller for all components. Change II would slow the movement of the components through the column and thus increase the retention times. Change III would cause the more polar components to move faster through the column and the less polar ones to slow down. Some retention times would increase and some would decrease. Change IV would slow all the components in their movement through the column and hence increase their retention times. II and IV thus cause the required increase. **C** is therefore the answer.

Question 13 A

The bromine test indicates that the molecule has a double bond. The esterification test indicates that a hydroxyl functional group is present in the molecule. Oxidation to produce a carboxylic acid means that a primary hydroxyl functional group is in the molecule. The only molecule which does not match the requirements is alternative **A**.

Question 14 C

$$n(\text{MgNH}_4\text{PO}_4) = \frac{m}{M} = \frac{0.0147}{137.3} = 1.07 \times 10^{-4} \text{ mol}$$

$$n(\text{MgNH}_4\text{PO}_4) \text{ in the } 100.0 \text{ mL} = 5 \times 1.07 \times 10^{-4} = 5.35 \times 10^{-4} \text{ mol}$$

$$n(\text{P}) = n(\text{MgNH}_4\text{PO}_4) = 5.35 \times 10^{-4} \text{ mol}$$

$$m(\text{P}) = n \times M = 5.35 \times 10^{-4} \times 31.0 = 1.66 \times 10^{-2} \text{ g}$$

$$\% \text{ P in fertiliser} = \frac{1.66 \times 10^{-2}}{1.624} \times 100 = 1.02\%$$

C is the required answer.

Question 15 B

In action I, the lower mass of 1.624 g would be used as the denominator in the percentage calculation, producing a higher percentage than the actual amount. If the precipitate is not washed thoroughly (action II), some soluble material may be trapped on the precipitate and thus increase the apparent mass of the precipitate. The calculated result would be higher than the actual result. If insufficient precipitating agent is used (action III) not all the phosphorus in the fertiliser will be precipitated, leading to a lower calculated result. The presence of water in the flask would result in a total volume of greater than 100.0 mL. When a 20.00 mL aliquot was taken, slightly less than one fifth of the dissolved fertiliser will be removed, resulting in a slightly decreased calculated result for percentage phosphorus. *(It should be noted that the correct procedure is to use a standard flask, add the fertiliser, dissolve the solid then add water until the 100.0 mL calibration line is reached, i.e. it is not correct to simply add 100.0 mL of water to the solid.)* Thus only I and II produce a higher than expected percentage. Alternative **B** is the correct answer.

Question 16 A

Only situation III involves the possibility of diagnosis of a disease by determining the level of proteins in a location where they would not be found in normal functioning. In the other situations, the diseases (I. diabetes; II. heart disease; IV. digestive disease) have already been diagnosed and remedial action is being taken. **A** is the required answer.

Question 17 D

If a weak, monobasic base (B) is mixed with an equimolar amount of a strong, monoprotic acid (HA), the resulting solution will contain the weak acid HB^+ . The presence of this ion will make the solution slightly acidic, thus the pH will be less than 7. The phenol red indicator would therefore be yellow, or possibly orange if the HB^+ ion is an extremely weak acid. Therefore **C** is not the answer. The colour of the thymol blue indicator will depend on the acidity of the solution. If the pH is greater than 2.8, the indicator will be yellow.

To check the pH, consider the following calculation.

$$n(\text{HB}^+) = n(\text{B}) = n(\text{HA}) = c \times V = \frac{0.0030 \times 20.0}{1000} \text{ mol}$$

$$c(\text{HB}^+) = \frac{n}{V} = \frac{0.0030 \times 20.0}{40.0} = 0.0015 \text{ M}$$

$c(\text{H}^+)$ must therefore be less than 0.0015 M, as the acid is weak.

The minimum pH must therefore be $-\log[\text{H}^+] = -\log(0.0015) = 2.8$.

Thus the thymol blue indicator will be yellow, and so **C** or **D** is correct. Thus **D** is the required response.

Question 18 D

The characteristic peak at 1700 cm^{-1} suggests the presence of the carbonyl ($\text{C}=\text{O}$) group. Thus structure **C** is unlikely. A peak in the $2500\text{--}3000 \text{ cm}^{-1}$ region could be the OH group of an acid, or simply a CH.

Structure **A** would have only two peaks on the ^1H NMR spectrum, so **A** is not correct. Structure **B** would have 3 peaks on the ^1H NMR spectrum, but the splitting pattern would be a singlet, a doublet and a septet, so **B** is not correct. Structure **D** fits the data provided.

Question 19 B

2-butyl propanoate is formed by the reaction of 2-butanol and propanoic acid in the presence of an acid catalyst (*M*). 2-butanol can be produced by the reaction of 2-chlorobutane with $\text{KOH}(\text{aq})$ (*K*). Thus *X* could be 2-butanol, and *Y* propanoic acid. Propanoic acid is produced by the oxidation of 1-propanol (*W*) using acidified KMnO_4 or $\text{K}_2\text{Cr}_2\text{O}_7$ solutions (*L*). 1-propanol could be produced by an addition reaction of propene using acidified water.

Question 20 A

See explanation for Question 19.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. i. $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) \rightarrow 2\text{C}_2\text{H}_5\text{OH}(\text{aq}) + 2\text{CO}_2(\text{g})$ 1 mark

ii. Carbon dioxide is used in photosynthesis to make glucose which is used to make ethanol which releases the carbon dioxide on combustion. Therefore there is no net addition of carbon dioxide to the atmosphere. 1 mark

iii. For example:

- It is renewable in that the source of the ethanol (glucose) is produced by growing crops.
 - Waste plant materials can be used to produce ethanol by fermentation, effectively using the stored energy in the waste.
- 1 mark

b. i. $\text{CH}_3(\text{CH}_2)_{14}\text{COOCH}_3$ 1 mark

	Soluble	Not soluble
solubility of biodiesel in water		✓
solubility of biodiesel in organic solvents	✓	

1 mark

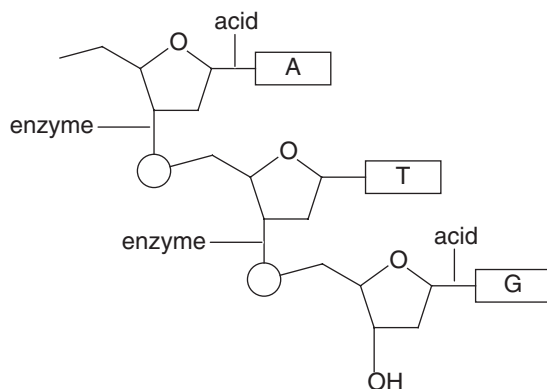
iii. The ester functional group is polar and enables small esters to dissolve in water. However, the very long non-polar hydrocarbon chain would dissolve in organic solvents and prevent the biodiesel ester from being water soluble.

1 mark

Total 6 marks

Question 2

a.



2 marks

1 mark for either of the enzyme cleavage sites

1 mark for either of the acid cleavage sites

b. i. The higher the percentage of guanine and cytosine in the DNA molecule of the sample, the higher the melting temperature. 1 mark

The G–C base pairs are bonded by three hydrogen bonds per pair (compared with only two for an A–T pair), and so more energy is required to disrupt DNA molecules with a higher percentage of these base pairs. 1 mark

ii. *E. coli* has 50% G and C and so will have 50% A and T, i.e. 1500 A + T base pairs. 1 mark

In a single strand of DNA, there will be 1500 A + T molecules. 1 mark

- c. ionic bonding 1 mark
- The DNA molecule is negatively charged due to the phosphate groups. The side chain groups of the histone amino acids are positively charged in an acidic environment, enabling ionic bonding to occur. 1 mark
- d. Using different solutions of DNA with known levels of unwinding, establish a calibration curve by reading each solution's absorbance at 260 nm. 1 mark
- Read the absorbance at 260 nm of the sample of DNA under consideration. 1 mark
- Use this absorbance reading to determine from the calibration curve the level of unwinding of the sample of DNA. 1 mark
- Total 11 marks

Question 3

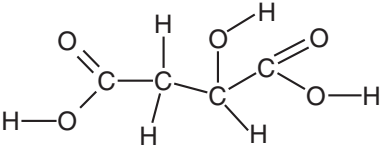
- a. $n(\text{C}_2\text{H}_2\text{O}_4) = c \times V = 0.0200 \times \frac{500.0}{1000} \text{ mol}$
- $m(\text{C}_2\text{H}_2\text{O}_4) = n \times M = 0.0200 \times \frac{500.0}{1000} \times 90.0 = 0.900 \text{ g}$ 1 mark
1. Accurately weigh 0.900 g of pure oxalic acid crystals
 2. Transfer all the crystals to a volumetric flask
 3. Add distilled water and dissolve the crystals
 4. Add distilled water so that the bottom of the meniscus is level with the mark
 5. Shake to ensure a homogeneous solution
- 2 marks
- b. i. $n(\text{MnO}_4^-) = c \times V = 0.0184 \times 0.01791 = 3.295 \times 10^{-4} \text{ mol}$ 1 mark
- $n(\text{Fe}^{2+}) = 5 \times n(\text{MnO}_4^-) = 5 \times 3.295 \times 10^{-4} \text{ mol in } 10.00 \text{ mL of solution A}$ 1 mark
- Total $n(\text{Fe}^{2+})$ in solution A = $10 \times 5 \times 3.295 \times 10^{-4} = 0.0165 \text{ mol}$ 1 mark
- ii. $m(\text{Fe}) = n \times M = 10 \times 5 \times 3.295 \times 10^{-4} \times 55.8 = 0.919 \text{ g}$ 1 mark
- % Fe in steel = $0.919 \times \frac{100}{0.981} = 93.7\%$ 1 mark
- c. $T = 293 \text{ K}$
- $p = 770 \times \frac{101.3}{760} = 102.6 \text{ kPa}$
- $n(\text{H}_2) = n(\text{Fe}^{2+}) = 0.0165 \text{ mol}$ 1 mark
- $V = \frac{nRT}{P} = \frac{0.0165 \times 8.31 \times 293}{102.6} = 0.392 \text{ L} = 392 \text{ mL}$ 1 mark
- d. i. The lamp emits wavelengths of radiation which can be absorbed by the metallic element being analysed, e.g. in the analysis of iron in steel, an iron emission lamp is used. 1 mark
- ii. $m(\text{Fe})$ in 10.0 mL of solution A is 0.0919 g.
- The concentration of solution A is therefore $\frac{0.0919}{0.0100} = 9.19 \text{ g L}^{-1}$ 1 mark
- To use the calibration curve the concentration must be below 0.6 g L^{-1} . A dilution factor of 20 will produce a satisfactory concentration of 0.46 g L^{-1} . 1 mark

- e. i. If the Cr^{2+} ion reacts with the MnO_4^- ion the calculated percentage iron would increase above its true value. 1 mark
- ii. The wavelength chosen for use in the AAS would be one that is absorbed by Fe and not Cr. Thus the presence of Cr would not affect the calculated percentage iron. 1 mark
- Total 15 marks

Question 4

- a. i. At low temperatures, the substrate molecule collisions with the enzyme are infrequent, producing a slow rate of reaction and so a low percentage conversion to glucose. 1 mark
- ii.
- | Test tube | Predicted percentage yield of glucose |
|-----------|---------------------------------------|
| <i>A</i> | 90%
(85–95% is acceptable) |
| <i>F</i> | 30% |
- 2 marks
- iii. In tube *F* at high temperatures, denaturation of the enzyme has occurred which prevents it from catalysing the conversion of starch to glucose. 1 mark
- Once denatured, the enzyme will not catalyse the conversion beyond the percentage achieved at the original denaturation temperature. 1 mark
- b. i. hydroxyl (or hydroxy) 1 mark
- ii. ether (or glycosidic) 1 mark
- c. To form the starch molecule from 2000 glucose molecules, 1999 molecules of water are produced in forming ether links. 1 mark
- Molar mass (starch) = $2000 \times 180 - 1999 \times 18 = 324\,018 \text{ g mol}^{-1}$ 1 mark
- Total 9 marks

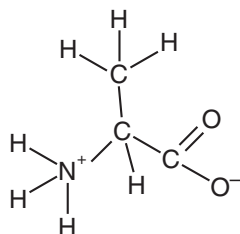
Question 5

- a.
- 
- 1 mark
- b. i. 2-hydroxypropanoic acid 1 mark
- ii. $3\text{C}_4\text{H}_6\text{O}_5(\text{aq}) + 12\text{H}^+(\text{aq}) + 12\text{e}^- \rightarrow 4\text{C}_3\text{H}_6\text{O}_3(\text{aq}) + 3\text{H}_2\text{O}(\text{l})$ 1 mark
- c. $n(\text{C}_3\text{H}_6\text{O}_3) = \frac{m}{M} = \frac{45 \times 10^{-3}}{90.0} \text{ mol}$ 1 mark
- $N(\text{C}_3\text{H}_6\text{O}_3) = n \times N_A = \frac{45 \times 10^{-3}}{90.0} \times 6.02 \times 10^{23} = 3.0 \times 10^{20} \text{ molecules}$ 1 mark
- Total 5 marks

Question 6

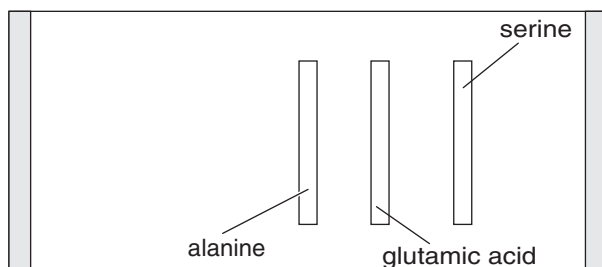
- a. i. The paper is sprayed with a chemical that binds to the amino acids to produce coloured spots, or spots that can be seen under a UV lamp. 1 mark
- ii. $R_f = \frac{7.2}{13} = 0.55$ 1 mark
- The amino acid at spot X could be lysine or alanine. 1 mark
- iii. Run the chromatogram using a different solvent. Compare the R_f value with known R_f values for lysine and alanine. 1 mark

b. i.



1 mark

ii.



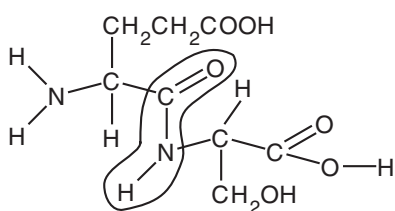
Note: At a pH below their isoelectric point, amino acids will be in their base form (positively charged). At a pH above their isoelectric point, amino acids will be in their acid form (negatively charged). At pH = 6.0, glutamic acid and serine are above their isoelectric points and so will move towards the positive electrode. Serine is lighter and so will move farther through the gel.

2 marks

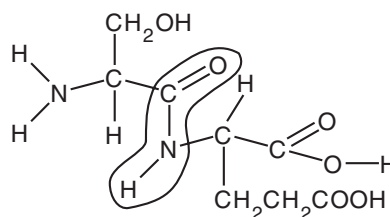
1 mark for the correct direction of movement of the serine and glutamic acid

1 mark for the correct relative positions of serine and glutamic acid

c.



or



2 marks

Total 9 marks