Neap:

Trial Examination 2012

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 D

The order of R_f values for the TLC is $P < R < Q$. These values indicate that *P* has the strongest adsorption to the stationary phase, and *Q* the weakest. The time spent in the column will therefore be longest for *P*, the most strongly adsorbed. The order for the retention times will be the reverse of the order for R_f values, i.e. $Q < R < P$. The required answer is **D**.

Question 2 C

When a strong acid and a weak base react, the conjugate of the weak base, a weak acid, will be present at the equivalence point. This will cause the solution, at equivalence, to have a pH less than 7. Phenolphthalein will change colour at a pH well above 7. This is before equivalence is reached, and so phenolphthalein is unsuitable. Bromothymol blue changes at a pH very close to 7, again, before equivalence is reached. Thymol blue changes at a pH of around 2, well after equivalence is reached (and so leading to an incorrectly large titre). **A**, **B** and **D** are therefore incorrect. Methyl red changes colour in the pH range 3.0–4.6, just after equivalence has been reached. The correct response is therefore **C**.

Question 3 B

Being carbohydrates, cellulose and starch are composed of carbon, hydrogen and oxygen only. Therefore **A** is not correct. Both of the polysaccharides are polymers of glucose formed by condensation reactions, not addition polymerisation. In these condensation reactions, water is formed, and so the mass of the polymer is less than the sum of the masses of the monomers used. **C** and **D** are incorrect. Glycosidic or ether linkages are formed in the condensation reactions and so **B** is the required answer.

Question 4 D

The DNA fragments are negatively charged due to the phosphate groupings, and so will be attracted to the positive terminal in electrophoresis. As the gel is a molecular sieve and allows smaller fragments to move faster through it, the band labelled *P* must have components with lower molecular mass.

Question 5 B

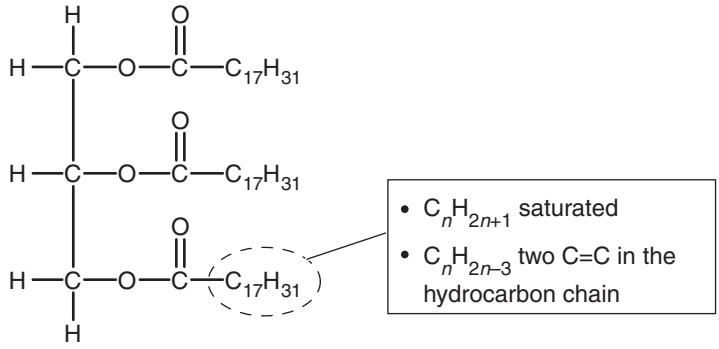
Triglycerides are formed by condensation reactions from fatty acids and glycerol. Thus **A** and **C** are incorrect.

$$n(\text{glycerol, } C_3H_8O_3) = \frac{m}{M} = \frac{4.60}{92} = 0.050 \text{ mol}$$

As each molecule of glycerol has three hydroxyl groups, during the condensation reactions 3×0.050 mol of water will be produced, i.e. $0.050 \times 3 \times 18 = 2.70$ g.

Question 6 D

Triglycerides formed using linoleic acid will have the structure shown below.



Iodine number refers to the mass of iodine reacting with 100 g of the fat/oil.

For 100 g of the fat/oil composed of these triglycerides of linoleic acid,

$$n(\text{triglyceride}) = \frac{m}{M} = \frac{100}{878} \text{ mol}$$

$$n(I_2) = 6 \times n(\text{triglyceride}) = 6 \times \frac{100}{878} \text{ mol (each linoleic acid molecule has two C=C bonds)}$$

$$m(I_2) = n \times M = 6 \times \frac{100}{878} \times 253.8 = 173 \text{ g}$$

The iodine number is therefore in the range 151–200, so answer **D**.

Question 7 D

Bonding between the base and the sugar is via the nitrogen atom at position 9. Thus **A** and **B** are incorrect. Hydrogen bonding between guanine and cytosine occurs through positions 1, 2 and 6. Thus **A** and **C** are incorrect. **D** is the required response.

Question 8 A

A blue-coloured solution absorbs radiation in the red section of the spectrum, and thus this wavelength is utilised in UV-visible spectroscopy. **B** and **D** are incorrect. When copper sulfate solution is sprayed into a flame, the electrons in the copper atoms gain energy and move to an excited state. When the electrons return to their ground state, a quantum of energy is emitted and this is often seen as light of a particular wavelength (in this case a green colour). Thus **C** is incorrect, and **A** is correct.

Question 9 C

Separation of the products of pyrolysis occurs in a separate tower on the basis of their boiling points. Air admitted into the furnace would have no impact on this and so **A** is incorrect. The strength of the bonds to be broken in the polymers is a feature of the polymers. This is unaffected by the presence or absence of air. **B** and **D** are incorrect. Any air would allow combustion of the products of pyrolysis, and this would yield the unwanted compounds of CO and CO_2, together with particulate matter. **C** is the required answer.

Question 10 A

The separation of the products is completed by fractional distillation. Compounds removed at *X* have lower boiling points due to the weaker dispersion forces between these smaller molecules. Conversely, larger molecules with stronger dispersion forces between them are removed at *Y*. These would have higher boiling points. Thus **D** is accurate. **A** is incorrect, and therefore is the required answer. As with other fractionating towers, each fraction is a mixture of compounds of similar size and the temperature decreases moving up the tower. Both **B** and **C** are correct statements.

Question 11 A

The high molar mass compounds are difficult to vaporise without decomposition occurring. Therefore HPLC, rather than GLC, would be used. **C** and **D** are incorrect. The preferred choice for wavelength is that with the maximum absorption, provided no other components of the mixture also absorb at this wavelength. Since the components have been separated before the UV-visible analysis is conducted, no interference from other absorbing components is possible. Therefore 480 nm, rather than 630 nm, would be chosen (answer **A**).

Question 12 C

Statement I is incorrect, as the absorbance would be expected to decrease with decreasing concentration of CH_3CHO as the reaction proceeds. As the concentration of CH_3CHO would plateau, due to the incomplete nature of the reaction, the absorbance of the solution could remain constant. Statement II is correct. The original solution was made by dissolving CH_3CHO in water, and this solution would absorb strongly. Statement III is also correct. The required statements are therefore II and III, so response **C**.

Question 13 C

In DNA, adenine bonds to thymine (A–T) and cytosine bonds to guanine (G–C). The complementary fragment to GTAACGA must be CATTGCT.

Question 14 B

As the number of base pairs is the same for each fragment, it is the base components of the fragments which will determine the temperature required for separation. So **D** is not correct. The C–G combination is held by three hydrogen bonds, whereas the A–T has two hydrogen bonds. The fragment with the lowest numbers of G or C will be more weakly held to its complementary DNA sequence, and thus will require a lower temperature to disrupt these forces, allowing separation to occur. Fragment 1 has three of G or C, fragment II has two, and fragment III has four. Alternative **B** is thus the required answer.

Question 15 B

Tallying the numbers of each atom on both sides of the equation shows that Compound *Y* must be water.

Question 16 D

$$n(\text{aspirin}) = \frac{m}{M} = \frac{88.3}{180} = 0.491 \text{ mol}$$

$$n(C_4H_6O_3) \text{ reacting} = \frac{1}{2} \times n(\text{aspirin})$$

$$m(C_4H_6O_3) \text{ reacting} = n \times M = \frac{1}{2} \times 0.491 \times 102 = 25.0 \text{ g}$$

It is not clear from the information whether 25.0 g of ethanoic anhydride was all that was provided in the reaction. Similarly, without knowing how much salicylic acid was present initially, it is not possible to say definitively whether one or the other reactant was in excess. The fact that the amount of aspirin formed is stoichiometrically correct for the amount of ethanoic anhydride which reacted in the synthesis does not provide any clarifying information.

Question 17 B

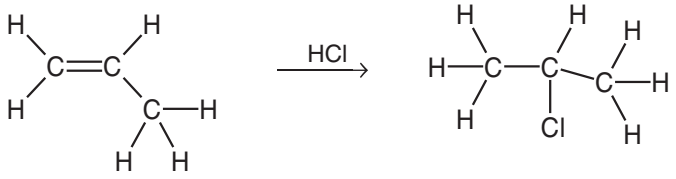
The sharp band on the IR spectrum at 1720 cm^{-1} indicates a carbonyl group (C=O). **A** is incorrect. Three sets of peaks on the ^1H NMR indicates three ^1H environments. **D** is incorrect as it has four ^1H environments. The integration ratio for **C** will be 6:1:1, not the required 3:2:2. **C** is incorrect. **B** fits all the data provided.

Question 18 C

Statement I is incorrect as proteins do not contain phosphorus. Statement II is correct as damage caused by a heart attack will produce leakage of CPK into the blood. As CPK is in other tissues, elevated levels cannot be relied upon alone for diagnosis. Other tests would be needed to confirm diagnosis and so statement III is incorrect. Minor injury to the tissues containing CPK would produce leakage and normal minor levels of CPK in the blood, so statement IV is correct.

Question 19 A

Reaction *U* converts propene to 2-chloropropane (which in turn is converted to 2-propanol). The required reaction is shown below.



Thus **C** and **D** are incorrect (as addition of Cl_2 would produce 1,2-dichloropropane). Reaction *X* converts an alcohol to a carboxylic acid. The reagent required is a strong oxidant, such as acidified dichromate solution. Thus **A**, and not **B,** is the required response.

Question 20 A

Reaction *V* is a substitution to produce 1-chloropropane from propane. It is also a chlorination reaction. Reaction *X* is an oxidation. Reaction *Y* is a condensation/esterification reaction. **A** is the correct answer.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. Ethanol is produced by the action of enzymes in yeast in the process of fermentation in the absence of oxygen. 1 mark

$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$ 1 mark

b. $C_2H_4 + H_2O \rightarrow C_2H_5OH$ 1 mark

Conditions: H_3PO_4 catalyst with temperature of 300°C 1 mark

c. **i.** Measure a volume of the ethanol solution → add an excess of potassium iodide solution with some drops of sodium hypochlorite solution, and heat → filter precipitate using filter paper of known mass → rinse precipitate with a small amount of potassium iodide solution → dry precipitate to constant mass → determine mass of precipitate → calculate the concentration of ethanol solution.

2 marks

Any correct step scores 0.5 marks to a maximum of 2 marks

ii.

Analytical technique	Tick if appropriate for ethanol concentration determination
mass spectroscopy	
UV-visible spectroscopy	✓
NMR spectroscopy	
thin layer chromatography	
gas chromatography	✓

1 mark

d. **i.** CH_2OH^+ 1 mark

ii. Both compounds would have a peak at m/z of 46. 1 mark

iii. *One of:*

- Common fragments may have different abundances
- Different fragments may be produced

1 mark

e. **i.** C–O 1 mark

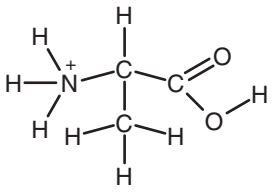
ii. At 1610 to 1680 cm^{-1} there would be an absorbance band for the carbon to carbon double bond for ethene. 1 mark

Total 12 marks

Question 2

a. **i.** hydrolysis 1 mark

ii.



2 marks
1 mark for correct structure showing all bonds
1 mark for protonated amine group

b. **i.** four 1 mark

ii. The enzyme has an active site which temporarily bonds to molecules of a certain conformation. 1 mark

As the conformation of atoms on the carboxyl side of lysine would differ from those on the amine side, the enzyme active site will not be able to form bonds and catalyse the cleavage of the linkage. 1 mark

iii. Changing the pH can alter the charge on various atoms or groups of atoms in the protein structure of the enzyme. 1 mark

This will affect their interactions with other parts of the protein chain causing disruption to the structure of the enzyme's active site and loss of catalytic activity. 1 mark

iv. Trypsin is itself a protein, and unless the conditions which prevent enzyme activity are observed, trypsin may cleave trypsin molecules. 1 mark

c. **i.** Isoleucine 1 mark

ii. The amino acid which is mostly non-polar will be more strongly adsorbed to the non-polar stationary phase and be the least soluble in the polar mobile phase. 1 mark

Isoleucine is mostly non-polar. The other amino acids have polar side groups. Thus they would be more soluble in the mobile phase, and so move more quickly through the column. 1 mark

Total 12 marks

Question 3

a. **i.** $CrO_4^{2-}(aq) + 8H^+(aq) + 3e^- \rightarrow Cr^{3+}(aq) + 4H_2O(l)$ 1 mark

ii. $n(H_2O_2) = c \times V = 0.0341 \times 18.95 \times 10^{-3} = 6.462 \times 10^{-4}$ mol 1 mark

$n(CrO_4^{-2}) = \frac{2}{3} \times n(H_2O_2) = \frac{2}{3} \times 6.462 \times 10^{-4} = 4.308 \times 10^{-4}$ mol 1 mark

$c(CrO_4^{2-}) = \frac{n}{V} = \frac{4.308 \times 10^{-4}}{0.0250} = 1.72 \times 10^{-2}$ M 1 mark

b. During conversion $n(Cr^{3+}) = n(CrO_4^{2-}) = c \times V = 1.72 \times 10^{-2} \times 5.0 \times 10^{3}$ mol 1 mark

$n(Cr^{3+}) = c \times V = 1.5 \times 10^{-3} \times 5.0 \times 10^{3}$ mol

$n(Cr^{3+})\text{total} = (1.72 \times 10^{-2} \times 5.0 \times 10^{3}) + (1.5 \times 10^{-3} \times 5.0 \times 10^{3}) = 93.5$ mol 1 mark

$n(Cr(OH)_3) = n(Cr^{3+})\text{total}$

$m(Cr(OH)_3) = n \times M = 93.5 \times 103 = 9631\text{g} = 9.63\text{kg}$ 1 mark

c. **i.** The laboratory methods are time consuming and not as accurate as AAS. 1 mark

ii. The other metals are unable to absorb at the chosen wavelength and thus will not interfere with the analysis of Cr. 1 mark

iii. The flame removes water and reduces the ions to chromium atoms. 1 mark

iv. $0.060 \text{ mg L}^{-1} = 6.0 \times 10^{-5} \text{ g L}^{-1} = \dfrac{6.0 \times 10^{-5}}{52.0} = 1.15 \times 10^{-6}$ M chromium ions. 1 mark

$$\text{Absorbance} = \frac{\text{molarity of chromium ions}}{1.52 \times 10^{-5}} = \frac{1.15 \times 10^{-6}}{1.52 \times 10^{-5}} = 0.076$$ 1 mark

Total 12 marks

Question 4

a. **i.** $m(C) : m(H) : m(O) = 48.6 \text{ g} : 8.1 \text{ g} : 43.3 \text{ g}$

$n(C) : n(H) : n(O) = 4.05 : 8.1 : 2.71 = 1.49 : 2.99 : 1 = 3 : 6 : 2$ 1 mark

$\text{EF} = C_3H_6O_2$ 1 mark

ii. $pV = nRT$ and $n = \dfrac{m}{M}$

$$M = \frac{mRT}{pV} = \frac{5.33 \times 8.31 \times 373}{1.00 \times 10^{2} \times 2.22}$$ 1 mark

$= 74 \text{ gmol}^{-1}$ 1 mark

$M(C_3H_6O_2) = 74 \text{ gmol}^{-1}$. MF is the same as EF.

Molecular formula is $C_3H_6O_2$ 1 mark

b. **i.** A singlet means that there are no H atoms attached to adjacent carbon atoms. 1 mark

ii. The 1:1 ratio of peak areas shows the relative numbers of hydrogen atoms in each environment are the same. 1 mark

c. **i.** Compound *A* is an ester which is mostly a non-polar molecule, apart from bonds in the ester linkage. Being non-polar means that little interaction with polar water molecules will occur. 1 mark

Compound *B* is small chain alcohol with a highly polar hydroxyl group. This group is capable of forming hydrogen bonds with water molecules, resulting in the compound's high solubility. 1 mark

ii. CH_3COONa is an ionic compound. When CH_3COONa dissolves in water the ions are free to move in water and conduct electricity. 1 mark

Compound *B* is a molecular species which has no charge, does not ionise in water and thus will not conduct electricity. 1 mark

Total 11 marks

Question 5

a. $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

2 marks
1 mark for reactants and products
1 mark for symbols of state and balancing

b. **i.** $n(HCl) = n(NaOH) = c \times V = 0.5011 \times 14.2 \times 10^{-3} = 7.12 \times 10^{-3}$ mol 1 mark

ii. $n(HCl)\text{reacting} = n(HCl)\text{initially} - n(HCl)\text{unreacted}$

$= (1.003 \times 40.00 \times 10^{-3}) - (7.12 \times 10^{-3})$ 1 mark

$= 3.30 \times 10^{-2}$ mol 1 mark

iii. The molar mass of $CaCO_3$ 1 mark

c. Any CO_2 present would react with the NaOH in the titration step, causing an increased titre. 1 mark

d. $CaCO_3$ is an insoluble solid and so is unsuitable for direct titration.

or

The carbonate ion is a weak base and does not give a sharp endpoint during a titration. 1 mark

Total 8 marks