Neap:

Trial Examination 2011

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 **B**

$$\frac{p_1V_1}{n_1T_1} = \frac{p_2V_2}{n_2T_2} \text{ and } n = \frac{m}{M}$$

at constant temperature and pressure $\frac{V_1M_1}{m_1} = \frac{V_2M_2}{m_2}$

$$\frac{440 \times 64.1}{0.20} = \frac{469 \times M(Y)}{0.10}$$

$M(Y) = 30 \text{ g mol}^{-1}$

Only C_2H_6 has this molar mass and so **B** is the required answer.

Question 2 **B**

Alternative I would produce no reaction. Alternative II produces ethanol by adding the water molecule across the double bond of ethene. Alternative III involves the hydrolysis of an ester and will produce methanol and propanoic acid.

Question 3 **D**

For the calculated result to be too high, it requires contamination of the precipitate e.g. with water or additional other precipitate or adsorbed ions due to inadequate washing of the precipitate. Inadequate precipitation and/or loss of some precipitate will cause the calculated result to be too low. If the temperature used to dry the precipitate is very high, some decomposition of the precipitate may occur, resulting in a calculated result which is too low. The precipitating agent should be in excess, so any further addition will not alter the calculated result. Alternative **D** gives the only correct combination of errors and their effects.

Question 4 **A**

Careful inspection of the formulas shows that they all identify 2,2,3-trimethylbutan-1-ol.

Question 5 **D**

Absorption of energy by molecules as their covalent bonds vibrate and rotate is the basis of infrared spectroscopy, hence **A** is not the answer. A change in the spin alignment of certain carbon nuclei placed in a strong magnetic field is the basis of ^{13}C NMR spectroscopy, hence **B** is not the answer. Deflection of charged particles by a combination of electric and magnetic fields is the basis of mass spectroscopy, hence **C** is not the answer. During UV-visible spectroscopy, electrons in atomic and/or molecular orbitals absorb light, thus gain energy and move to an excited state. Alternative **D** is therefore the required response.

Question 6 **A**

Rinsing conical flasks and standard flasks with water will not alter the results obtained in the volumetric and gravimetric analyses in alternative **B** and **C**. The ‘blank’ in alternative **D** will contain distilled water, so rinsing with distilled water will not alter the result. Water is an infrared absorber. The presence of any water in the analysis in alternative **A** will therefore alter the reading obtained. Water should not be introduced into the sample cell and so **A** is the required response.

Question 7 C

As oxygen is the limiting reagent it is all used in the reaction. The reacting mol ratios are 4 : 5 : 4 : 6 , hence 0.48 : 0.60 : 0.48 : 0.72. NH_3 is in excess by 1.02 mol (1.5 – 0.48). 0.48 mol of NO and 0.72 mol of H_2O are formed. Thus the total amount of gas after the reaction is 1.02 + 0.48 + 0.72 = 2.22 mol.

Question 8 A

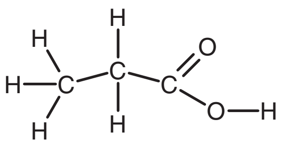
Sketch I represents the primary structure, the sugar-phosphate backbone with attached nitrogen bases held together by the covalent bonds formed during condensation reactions. Sketch II represents the secondary structure, the double helix form held together by hydrogen bonding between complementary nitrogen base pairs. Sketch III represents the tertiary structure, the attachment of the DNA double helix to the proteins of histones. Bonding here is primarily between the negatively charged DNA and positively charged protein sections by ionic bonding. Alternative **A** shows the correct combination of bond types.

Question 9 C

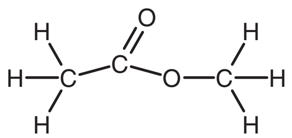
Only positively charged species will reach the detector. The parent molecular ion is the molecule with one electron removed from the structure and so it is positively charged.

Question 10 D

The structural formulas of the two molecules are shown below.



I
propanoic acid



II
methyl ethanoate

Molecule I will produce three peaks on the ^{1}H NMR spectrum, while molecule II will produce only two peaks. The region above wavenumber 1500 cm^{-1} on the infrared spectra of the two molecules will differ due to their different functional groups (carboxylic acid compared to ester). The major fragments detected on the mass spectra will differ. For example, OH^+ for the acid compared to CH_3O^+ for the ester. Both molecules will produce three peaks on their ^{13}C NMR spectrum, and so this feature will not distinguish between the two samples. Thus **D** is the required response.

Question 11 D

Calculation of the acid concentration requires the following steps:

$n(\text{NaOH}) = c \times V = 0.100 \times (\text{volume of NaOH aliquot used})$

$n(\text{CH}_3\text{COOH}) = n(\text{NaOH})$

$c(\text{CH}_3\text{COOH}) = \dfrac{n}{V} = \dfrac{n}{(\text{titre recorded})}$

The equivalence point of this titration occurs at a pH above 7 (due to the presence at the equivalence point of the weak base CH_3COO^-). The methyl red indicator changes colour at a pH of 4.2–6.3. This will occur well after the equivalence point of approximately pH 8.5. Thus the recorded titre will be higher than it should be, leading to a calculated concentration lower than the true value.

Question 12 C

A weak base hydrolyses in water to a small extent. Thus the product ions, OH^- and $CH_3NH_3^+$ will be present in low concentrations. The solution is basic, so the concentration of H_3O^+ is also low. The most concentrated species is therefore the molecule, CH_3NH_2.

Question 13 B

The maximum concentration of creatinine in the normal range is 0.13 mM.

m(creatinine) in 5.6 L is $5.6 \times 0.13 \times M(\text{creatinine}) = 5.6 \times 0.13 \times 113 = 82.26 \text{ mg} = 0.082 \text{ g}$.

Question 14 C

As the blood concentration is kept constant by excretion by the kidneys, more creatinine put into the blood will mean a higher mass is excreted. Thus **A** is accurate and so is not the required response. If muscle damage occurs there will be leakage of substances normally within the muscles, so **B** is also accurate. A greater level of kidney damage would be expected to produce a higher concentration of creatinine in the blood as it cannot be excreted efficiently. Alternative **D** is therefore also a reasonable conclusion. Kidney disease would cause an elevated level of creatinine in the blood which would remain high as normal metabolism is producing creatinine but it is only being excreted at a lower level. Alternative **C** is not correct and so is the required response.

Question 15 D

Relevant oxidation numbers are:

S in H_2SO_3 is +4, S in SO_4^{2-} is +6, Mn in MnO_4^- is +7, Mn in MnO_2 is +4.

Therefore alternatives **B** and **D** are possible. The decrease in oxidation number shows that manganese has been reduced, and so the oxidant is MnO_4^-.

Question 16 C

Statement I is incorrect as crude oil consists mostly of alkanes. Statement II is accurate as the lower boiling point hydrocarbons will be distilled first and some are gases even at cold water temperature. Statement III is not correct as fractions are always mixtures of hydrocarbons of similar boiling points, not molecules of a single compound. Statement IV is correct as the larger molecules will have higher boiling points and will be distilled later in the process. These molecules have stronger dispersion forces because of the number of atoms that they contain. The required answer is thus **C** as only statements II and IV are correct.

Question 17 A

The introduction of another polar group (OH) into the molecule which can hydrogen bond with water would be expected to increase the solubility of the compound. Thus **A** is a correct statement. The hydroxyl group is not strongly acidic, and so malic acid will be diprotic, as is fumaric acid. Thus statement **B** is incorrect. The double bond of fumaric acid would be expected to react readily with bromine in an addition reaction. Reaction of malic acid with bromine will be less likely. Thus statement **C** is incorrect. A wavelength of 5900 nm corresponds to a wavenumber of close to 1700 cm^{-1}. This is the region of absorption by the carbonyl group (C=O). Absorption in this region will be similar for both fumaric and malic acids. Thus statement **D** is incorrect.

Question 18 A

Change I shows a hydroxyl group (O–H) becoming an ether (–O–) group. Change II shows an amino group (NH_2) becoming an amide (N–C=O) group.

Question 19 B

The reaction involving reagent *X* is a condensation reaction between an acid and an amine. The acid must contain two carbon atoms and so is ethanoic, not methanoic. Alternatives **C** and **D** are incorrect. Reaction *Y* converts an ether functional group to a hydroxyl group. This can be achieved by a hydrolysis reaction to yield acetaminophen and ethanol. Option **B** is the required response.

Question 20 B

$$n(\text{aminophenol}) = \frac{m}{M} = \frac{4.32}{109} \text{ mol}$$

$$n(\text{phenacetin}) = n(\text{aminophenol})$$

$$m(\text{phenacetin}) = n \times M = \frac{4.32}{109} \times 179 = 7.09 \text{ g}$$

$$\%\text{ yield of phenacetin} = \frac{m(\text{obtained})}{m(\text{theoretical})} \times 100 = \frac{3.51}{7.09} \times 100 = 49.5\%$$

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. **i.** $m(\text{H}) = m(\text{H})$ in 8.19 g of water $= \frac{2.0}{18.0} \times 8.19 = 0.91$ g — 1 mark

ii. $m(\text{C}) = m(\text{C})$ in 20.2 g of carbon dioxide $= \frac{12.0}{44.0} \times 20.2 = 5.51$ g — 1 mark

iii. $m(\text{O}) = m(\text{sample}) - m(\text{H}) - m(\text{C}) = 8.20 - 0.91 - 5.51 = 1.78$ g — 1 mark

iv. $n(\text{C}) : n(\text{H}) : n(\text{O}) = \frac{5.51}{12} : \frac{0.91}{1.0} : \frac{1.78}{16} = 0.459 : 0.91 : 0.111 = 4 : 8 : 1$

The empirical formula is therefore C_4H_8O. — 1 mark

b. **i.** C=O bond — 1 mark

ii. Either carboxylic acid (COOH) or ester (COOR)

(Note: aldehyde or ketone is also a possible answer but these functional groups are not required in the VCE Unit 3 course.) — 1 mark

iii. Neither carboxylic acid nor ester can be present in the molecule. The molecular formula C_4H_8O shows that there is only one oxygen atom per molecule, and these functional groups each have two oxygen atoms.

(Note: aldehydes and ketones each have only one oxygen atom per group and so could be present in the molecule, but these functional groups are not required in the VCE Unit 3 course.)

1 mark

c. The molecule contains three ^{1}H environments. — 1 mark

These environments contain 3, 3 and 2 hydrogen atoms respectively. — 1 mark

Total 9 marks

Question 2

a. **i.** The non-polar WVO will dissolve in the 2-propanol which will then allow the NaOH solution to mix and react with the free fatty acids. 1 mark

ii. $n(\text{NaOH}) = c \times V = 0.0100 \times 0.01230 = 1.23 \times 10^{-4}$ mol 1 mark

iii. NaOH solutions react with carbon dioxide in the air, thus altering the concentration of the solution.

OR

Solid NaOH absorbs water from the atmosphere. It is therefore difficult to accurately weigh a known mass of pure NaOH. 1 mark

b. **i.** $m(\text{KOH})$ needed is 0.35 g.

$n(\text{KOH}) = \frac{m}{M} = \frac{0.35}{56.1} = 6.24 \times 10^{-3}$ mol 1 mark

$V(\text{KOH}) = \frac{n}{c} = \frac{6.24 \times 10^{-3}}{10.0} = 6.24 \times 10^{-4}$ L = 0.62 mL 1 mark

(In practice, the volume of KOH added to the oil would be greater than this value to allow for reaction of any free fatty acids present in the oil sample.)

ii. $RCOOH + CH_3CH_2OH \rightarrow RCOOCH_2CH_3 + H_2O$ 1 mark

c. **i.** The biodiesel must be of a high enough concentration to burn in the combustion process. 1 mark

ii. The glycerol molecule has a polar hydroxyl functional group attached to each of the three carbon atoms present. This enables it to form hydrogen bonds with water molecules in the dissolving process. 1 mark

d. **i.** $n(S_2O_3^{2-}) = c \times V = 0.500 \times 0.01604 = 8.02 \times 10^{-3}$ mol 1 mark

$n(I_2) = \frac{1}{2} \times n(S_2O_3^{2-}) = 4.01 \times 10^{-3}$ mol 1 mark

ii. $m(I_2)$ unreacted in the 20.0 mL aliquot = $n \times M = 4.01 \times 10^{-3} \times (2 \times 126.9)$ g 1 mark

$m(I_2)$ unreacted in the 100.0 mL solution $= 4.01 \times 10^{-3} \times (2 \times 126.9) \times \frac{100.0}{20.0}$

$= 5.09$ g

1 mark

iii. $m(I_2)$ reacted with 10 g of plant oil = 15.0 – 5.09 = 9.91 g 1 mark

iv. $m(I_2)$ reacting with 100 g of oil is $10 \times 9.91 = 99.1$ g

From the table the pure plant oil is canola oil. 1 mark

Total 14 marks

Question 3

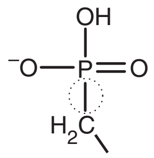
a. **i.** The hydrogen bonding between the two strands must be disrupted so that each strand can act as a template for the making of the new complementary strands. 1 mark

ii. The sugar-phosphate bonds in the DNA strands are covalent bonds. These require a much higher temperature to disrupt. 1 mark

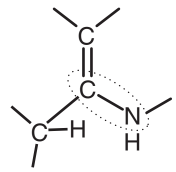
b. The polymerase from *E.Coli* would denature at the temperatures used in PCR as the optimum temperature for *E.Coli* is likely to be about human body temperature. Thus the PCR process would be less efficient and would need to be stopped to replenish the enzyme. 1 mark

As *Taq* polymerase is extracted from bacteria living in hot springs, it will remain active at elevated temperatures, allowing PCR to continue efficiently through many cycles. 1 mark

c.



An oxygen atom has been omitted here.



The C of the sugar should join to the N of the thymine, not to the C.

2 marks

1 mark for correct circling of one error

1 mark for correct explanation of the error

d. **i.** negative 1 mark

The phosphate groups in DNA have a negative charge and so will be attracted to the positive electrode. The well would therefore be at the negative end of the gel. 1 mark

ii. ^{37}Cl and ^{35}S could not be used. 1 mark

These elements are not part of a DNA molecule. 1 mark

Total 10 marks

Question 4

a. $2Cr^{3+}(aq) + 7H_2O(l) \rightarrow Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^-$ 1 mark

b. **i.** 0.082 M 1 mark

ii. $n(Cr_2O_7^{2-}) = c \times V = 0.082 \times \frac{150.0}{1000}$ mol 1 mark

$n(Cr) = 2 \times n(Cr_2O_7^{2-}) = 2 \times 0.082 \times \frac{150.0}{1000}$ mol 1 mark

$m(Cr) = n \times M = 2 \times 0.082 \times \frac{150.0}{1000} \times 52.0 = 1.279$ g 1 mark

$\%\text{ Cr in steel} = \frac{m(Cr)}{m(\text{steel})} \times 100 = \frac{1.279}{21} \times 100 = 6.1\%$ 1 mark

c. A wavelength is selected so that the dichromate would absorb the light strongly, but that any other substances present would not absorb at that wavelength. 1 mark

Total 7 marks

Question 5

a. **i.** Very lightly: so the stationary phase is not damaged. 1 mark

Pencil: using ink may cause the ink colours to separate and obscure the components of the sample. 1 mark

ii. The mixtures in the spots are soluble in the solvent and will dissolve if placed below its surface.

1 mark

b. Distance travelled by glucose = 4.0 units; solvent front = 9.0 units

$R_f = \frac{4.0}{9.0} = 0.44$ 1 mark

c. Enzyme hydrolysis produces maltose, glucose and another product. 1 mark

Acid hydrolysis of starch produces only glucose. 1 mark

d.

Conditions which must be the same for the two experiments	Tick your choices
distance travelled by solvent front	
stationary phase composition	✓
length of time running TLC	
composition of solvent mixture	✓

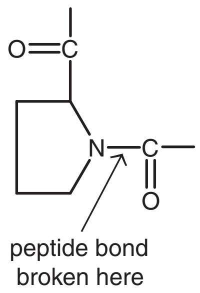
2 marks

Total 8 marks

Question 6

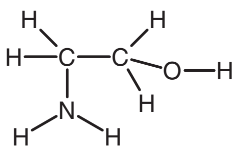
a. **i.** proline and tyrosine 1 mark

ii.

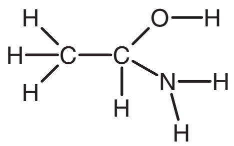


1 mark

b.



OR



1 mark

c. The drug must be absorbed into the bloodstream and be transported around the body in an essentially aqueous medium. Increased solubility allows for more efficient transport of the drug. 1 mark

d. **i.** 2-amino-3-methylpentanoic acid 1 mark

ii. The group of atoms marked *D* on the drug would be largely non-polar. 1 mark

The side chain on isoleucine is non-polar. Only a non-polar or low-polarity group of atoms will interact appreciably with this non-polar side chain. 1 mark

Total 7 marks