Neap:

Trial Examination 2019

VCE Chemistry Units 3&4

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

1	A	B	C	**D**	11	A	**B**	C	D	21	A	**B**	C	D
2	A	B	**C**	D	12	A	B	**C**	D	22	A	B	**C**	D
3	A	B	C	**D**	13	A	B	**C**	D	23	A	B	**C**	D
4	A	B	**C**	D	14	A	**B**	C	D	24	A	**B**	C	D
5	**A**	B	C	D	15	A	B	**C**	D	25	A	**B**	C	D
6	A	**B**	C	D	16	A	B	**C**	D	26	A	**B**	C	D
7	A	B	**C**	D	17	A	**B**	C	D	27	A	B	C	**D**
8	A	**B**	C	D	18	A	B	C	**D**	28	A	B	**C**	D
9	**A**	B	C	D	19	A	B	**C**	D	29	**A**	B	C	D
10	A	B	**C**	D	20	A	**B**	C	D	30	A	B	C	**D**

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Question 1 D

Biodiesel are methyl esters that contain carbon, hydrogen and oxygen atoms. **A** is incorrect. Carbon dioxide and water are formed on complete combustion. **B** is also incorrect. Due to the partly polar nature of the molecule, forces of attraction between the biodiesel molecules increase in intensity as the temperature decreases. This prevents the fuel from flowing easily. **C** is incorrect. The polar parts of the molecules will bond with water in moisture from the air and so fuel quality is affected. **D** is the correct answer.

Question 2 C

The activation energy is always a positive value for both types of reactions and so **A** is incorrect. The enthalpy change ($H_P - H_R$) also occurs in both reactions. **B** is incorrect. In an endothermic reaction, the products contain a larger amount of energy than the reactants and so ΔH is positive. **C** is the correct answer. In an exothermic reaction, heat is lost to the surroundings and so the temperature rises. **D** is incorrect.

Question 3 D

The reactants are pentanoic acid and propanol, so the ester produced is propyl pentanoate.

Question 4 C

H_2SO_4 catalyses the reaction by lowering the activation energy.

Question 5 A

The $E°$ of the Sn^{2+}/Sn half-cell is –0.14 V and for the other half-cells as follows:

A. –1.66 V

B. +1.68 V

C. +1.36 V

D. –1.18 V

Only **A** will produce the correct voltage; that is, –0.14 – (–1.66) = 1.52 V.

Question 6 B

In the galvanic cell, tin is the cathode or positive electrode where reduction occurs.

Question 7 C

A fuel cell converts chemical energy to electrical energy and in the process some energy is lost as heat. I and III occur.

Question 8 B

$$\text{molar heat of combustion} = \frac{E}{n} = \frac{225}{0.173} = 1300 \text{ kJ mol}^{-1}$$

From the Data Booklet, the fuel is ethyne.

Question 9 A

Cellulose is a polymer of glucose units linked by glycosidic or ether bonds. Peptide/amide links occur in proteins.

Question 10 C

Fermentation converts glucose to ethanol in the absence of oxygen. **A** is correct. The vast majority of ethene is produced by cracking components of crude oil in an unsustainable process, due to the finite reserves of the fossil fuel. As the process in the flow chart uses cellulose, which is derived from plants, the process is renewable as the raw material is not in limited supply. **B** is correct and **C** is incorrect, and so **C** is the required answer. Glycogen, not cellulose, is the storage material of excess glucose in animals. Bioethanol is ethanol derived from materials produced by recently living organisms, so the ethanol in the flow chart should be classified as bioethanol. **D** is correct.

Question 11 B

Vitamin C is water-soluble due to the many hydroxyl functional groups in the molecule, whereas vitamin D is fat-soluble as there are mainly non-polar groups in the molecule. **A** and **C** are both incorrect. As vitamin D can be synthesised by the body, it is a non-essential vitamin. **D** is incorrect and **B** is the required answer.

Question 12 C

The independent variable is deliberately altered by the experimenter so that the effect on the dependent variable can be observed.

Question 13 C

The usual way to identify the compounds that produce the various peaks is to use samples of known compounds in the analysis under identical conditions. **C** is the best answer. A standard database is only useful if the conditions of the HPLC analysis are identical to the conditions under which the data was collected. **A** is incorrect. The heights, or more correctly the area under the peaks, relate to the concentration of the components in the mixture. **B** is also incorrect. The distance between the peaks has no bearing on the identity of the compounds. **D** is incorrect.

Question 14 B

The weakest attraction to the stationary phase is exhibited by the compound with the lowest retention time; that is, ethanoic acid.

Question 15 C

The features of FAD – which include being derived from a vitamin, carrying electrons and binding to an active site during catalysis – strongly suggest that it is a coenzyme.

Question 16 C

It can be seen from the graphs that any change in the concentration of Y is mirrored by changes in X, which is approximately twice the value of the change in Y. The change in Z has the same value as the change in X, but in the opposite direction. Alternative **C** is consistent with this observation.

Question 17 B

In the first 10 minutes the concentrations changed little but, when the change was made at 10 minutes, equilibrium was reached within about 6 minutes. This indicates that a catalyst was introduced. At 20 minutes the concentrations of all gases increased instantaneously. This is caused by a decrease in the volume of the vessel. At 30 minutes the concentration of Y increased instantaneously but the other gases were not changed. More gas Y was introduced.

Question 18 D

There is no evidence in the graphs that the temperature was changed and so the values of the equilibrium constants would be identical.

Question 19 C

A and **B** are correct factual statements. Aspartame is many times sweeter than sucrose and so less mass must be used to achieve the same level of sweetness. **D** is also factually correct. Sucrose has the C : O ratio 12 : 11. Aspartame has the C : O ratio 14 : 5. **C** is incorrect and so is the required answer.

Question 20 B

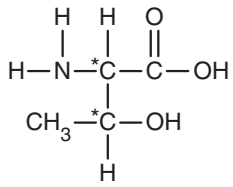
$C_{19}H_{29}COOH$ has the general formula $C_nH_{2n-9}COOH$. There are five C=C bonds in this molecule and one C=O grouping in the carboxyl functional group. **A** and **D** are incorrect.

$\%\ \text{carbon} = \dfrac{(20 \times 12)}{(20 \times 12 + 30 + 2 \times 16)} \times 100 = 79.4\%$ and so **C** is incorrect.

Omega-3 fatty acids have a double bond between the third carbon atom and the fourth carbon atom from the end opposite the –COOH end. Thus there is a double bond on carbon number 17 and so **B** is the required answer.

Question 21 B

The carbon atoms marked with an asterisk in the diagram below are chiral, as each of these carbon atoms has four different groups attached to it, arranged tetrahedrally.



Question 22 C

Optical isomers have identical molecular formulas and functional groups. **A** and **B** are incorrect. As it is an optical isomer, the groups that bind to the surface of the enzyme will not be in the same locations to match the binding sites. Therefore at least one or perhaps two groups on the optically isomeric substrate molecule will still bind, but three sites will not be matched. **C** is the correct answer. As the enzyme will not catalyse the optical isomer, it is unlikely that more than three sites will match. **D** is incorrect.

Question 23 C

carbohydrates: $0.65 \times 150 \times 16 = 1560$ kJ

fats and oils: $0.20 \times 150 \times 37 = 1110$ kJ

protein: $0.12 \times 150 \times 17 = 306$ kJ

total energy = 2976 kJ = 3.0 MJ

Question 24 B

Compounds in food are digested by hydrolysis reactions and so statement I is incorrect. It is likely that the food contains cellulose, which cannot be digested by the human body as it lacks the appropriate enzyme. The energy from cellulose would be released when burnt in a calorimeter. Statement II is correct. The solid waste produced by humans would contain compounds that have not been broken down fully and so had some stored energy unreleased. This would not be the case in a calorimeter. Statement III is also correct.

Question 25 B

At C_2–C_3 the alkyl groups are opposite each other and hence trans. At C_4–C_5 the alkyl groups are on the same side of the C=C bond and hence cis.

Question 26 B

As the temperature increases, the percentage of compound X formed decreases and so this is an exothermic reaction, as the reverse reaction is favoured by heating the process. As the pressure increases at a particular temperature, more compound X is produced and so the forward reaction is favoured. This indicates that there are fewer mole of gas in the products than in the reactants, as the system will oppose an increase in pressure by moving to the side of the reaction that lowers the pressure ($n \propto p$).

Question 27 D

$n(\text{e}) = \dfrac{I \times t}{F}$ and $n(\text{Cl}_2) = \dfrac{1}{2} \times n(\text{e})$.

The amount of chlorine depends directly on the current and time, so neither **A** nor **B** is the correct response. Temperature may have some effect on the current flow and so may alter the amount of chlorine produced. **C** is incorrect. The volume and concentration of the sodium chloride solution are fixed, so the size of the vessel is unlikely to alter the amount of chlorine produced. **D** is the required response.

Question 28 C

C_6H_6 is benzene, a non-polar hydrocarbon that is insoluble in water. **A** and **B** are incorrect. Benzene undergoes substitution reactions, not addition reactions. The structure of benzene does not include carbon–carbon double bonds. The six carbon–carbon bonds are intermediate in length and strength between double and single bonds. **C** is correct, not **D**.

Question 29 A

At time t_1 the reverse reaction rate increases, but the forward reaction remains unchanged. A change in temperature or volume would affect both rates. The addition of a catalyst would also affect both rates. The changes in **B**, **C** and **D** would not produce the graph shown.

Question 30 D

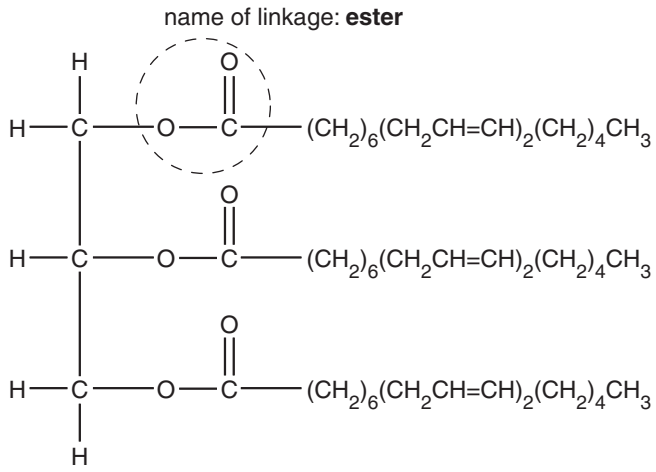
Sucrose forms by the condensation reaction between glucose and fructose to form a glycosidic (ether) link. I and II are incorrect statements. Sucrose has the empirical formula $C_{12}H_{22}O_{11}$, while glucose and fructose have the empirical formula CH_2O. Statement III is also incorrect.

SECTION B

Question 1 (11 marks)

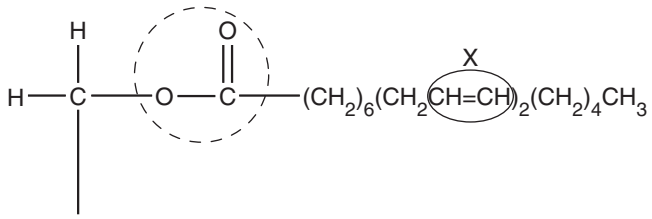
a. **i.** The molecule has two C=C bonds in the hydrocarbon tail, and a compound that has bonds other than single carbon-to-carbon bonds is unsaturated. 1 mark

ii.



3 marks
1 mark for correct structure of glycerol component.
1 mark for correct arrangement of atoms in ester linkages and ester label.
1 mark for correct formula of linoleic acid components.

iii.



1 mark

iv. Even though trilinolein has polar sections in the molecule, most of the molecule consists of non-polar hydrocarbon regions, which do not bond with water molecules, and so trilinolein is insoluble in water. 1 mark

The double bonds in the hydrocarbon tails prevent the tails from packing closely together. Thus the weak dispersion forces between the tails are further reduced in strength. 1 mark

Weak intermolecular bonding leads to low melting temperature; that is, the compound is a liquid at room temperature. 1 mark

b. $n(\text{KOH}) = c \times V = 0.0125 \times 0.01635 = 2.043 \times 10^{-4}$ mol 1 mark

As there is one –COOH group per linoleic acid molecule, $n(H^+) = n(\text{KOH})$. 1 mark

$$c(\text{acid}) = \frac{n}{V} = \frac{2.043 \times 10^{-4}}{0.020} = 1.02 \times 10^{-2} \text{ M}$$ 1 mark

Question 2 (9 marks)

a. **i.** aluminium casing *(sodium is oxidised)* 1 mark

ii. $S(l) + 2e^- \rightarrow S^{2-}(l)$ 1 mark

iii. $Na(l) \rightarrow Na^+(l) + e^-$ 1 mark

b. Even though the main energy transformation is chemical to electrical, this is not 100% efficient and there is some heat produced internally. This heat is sufficient to keep the reactants molten. 1 mark

c. **i.** It provides electrical connection between the electrolyte solutions/half-cells. 1 mark

It allows movement of ions so that charge does not build up in either half-cell. 1 mark

ii. solid ceramic casing 1 mark

d.

	Positive	**Negative**
Oxidation	✓	
Reduction		

1 mark

e. The products of the cell reaction remain in contact with the electrodes. 1 mark

Question 3 (11 marks)

a. **i.** C_3H_6O *(The parent molecular ion has a molar mass of 58 g mol^{-1}.)* 1 mark

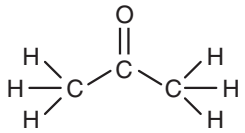
ii. 43 1 mark

iii. CH_3^+ 1 mark

b. **i.** Due to the presence of the O–H bond, an alcohol would have a large signal at 3200–3600 cm^{-1}. As no such signal appears in the spectrum, the compound is not an alcohol. 1 mark

ii. C=O (ketone) 1 mark

iii.



1 mark

c. **i.** *Any two of the following:*

- There are three carbon environments in the molecule.
- There is a $-CH_3$ grouping (chemical shift 8 ppm).
- There is a $-CH_2$ grouping (chemical shift 38 ppm).
- There is a C=O grouping (chemical shift 205 ppm).
- There is no OH grouping since there is no peak in the 50–90 chemical shift range.

2 marks

ii.

Feature in proton NMR of isomer	Information revealed by this feature about the structure of the isomer
relative areas in the ratio of 1 : 2 : 3	The hydrogen atoms are in the ratio of 1 : 2 : 3.
signal at 1.3 ppm	There is a $-CH_2-$ grouping in the molecule.
signal at 9.8 ppm is a triplet	The adjacent carbon atom has two equivalent proton atoms attached.

3 marks

Question 4 (11 marks)

a. **i.** negative cathode 1 mark

ii. $M^{3+}(aq) + 3e^- \rightarrow M(s)$ 1 mark

b. **i.** *For example*:

Graphite is inert and so will not take any part in the cell reaction. 1 mark

ii. *For example*:

The only source of metal ions is in the electrolyte and so when these are reduced the electroplating will stop, whereas if the metal M had been used for the positive electrode, there would be an almost unending supply of metal ions. 1 mark

c. **i.** $Q = I \times t = 0.734 \times 46.5 \times 60 = 2047 = 2.05 \times 10^3$ C 1 mark

ii. $n(e^-) = \dfrac{2047}{96\,500} = 0.0212$ mol 1 mark

iii. $n(\text{metal}) = \dfrac{1}{3} \times n(e) = \dfrac{0.02122}{3}$ mol 1 mark

$n(\text{metal deposited}) = \dfrac{m}{M} = \dfrac{0.368}{\text{molar mass}}$ 1 mark

$\text{molar mass} = 0.368 \times \dfrac{3}{0.02122} = 52.0 \text{ g mol}^{-1}$

The metal is chromium. 1 mark

d. For example, Mn, Al, Mg, Na, Ca, K, Li, or any other metal with ions that are weaker oxidants than water. 1 mark

If water was present it would be reduced in preference to the metal ion. 1 mark

Question 5 (6 marks)

a.

Compound A	Compound C
$CH_3CH_2CH_2CH_3$	$CH_3CH_2CHClCH_3$

2 marks

b. C_4H_8 1 mark

c. chlorine gas (in the presence of UV light) 1 mark

d. butan-2-amine 1 mark

e. ketones 1 mark

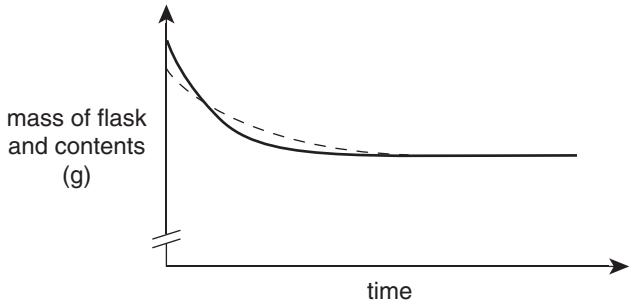
Question 6 (16 marks)

a. **i.** Oxygen gas escaped from the flask and so mass was lost. 1 mark

ii. The rate is fastest immediately after the reaction started. At this time the concentrations of the reactants are the highest and so the frequency of collisions is high. 1 mark

Reaction rate decreases as the concentration of reactants decreases, and consequently the frequency of collisions decreases. 1 mark

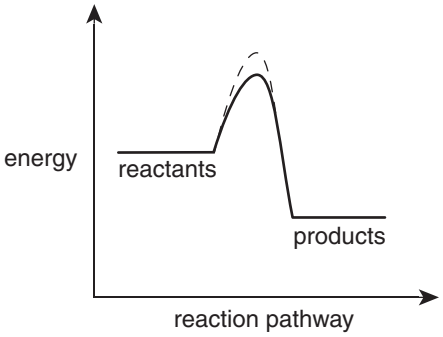
iii.



2 marks

1 mark for the graph showing the starting point a little lower.
1 mark for the graph showing a more gentle fall and the same plateau reached a little later.

iv.



1 mark

b. **i.**

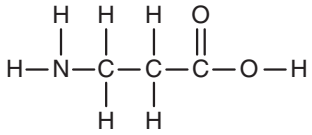
Treatment of freshly sliced apple	Result	Level of enzyme structure affected by each treatment			
		Primary structure	Secondary structure	Tertiary structure	No effect on enzyme structure
1. sliced apple put in refrigerator	very slow browning				✓
2. lemon juice spread on sliced apple	no browning occurs			✓	
3. sliced apple boiled in water	no browning occurs		✓	✓	

3 marks
1 mark for each correct row of table.

ii. Boiling will disrupt the hydrogen bonding in the secondary structure and any similar or weaker bonding in the tertiary structure. 1 mark

Thus the active site will be destroyed and the browning reaction will not occur, as the enzyme will not catalyse the formation of products. 1 mark

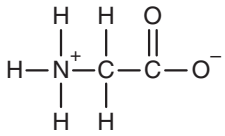
c. **i.** *For example:*



2 marks
1 mark for correct functional groups.
1 mark for any arrangement where the amino group and carboxyl group are not attached to the same carbon atom.

ii. The peptide bonds linking the constituent amino acid are strong covalent bonds. To break these strong bonds, boiling in acid for several hours is required. 1 mark

iii.



2 marks
1 mark for correct amino acid with all bonds.
1 mark for correct charges on relevant atoms.

Question 7 (7 marks)

a. **i.** The K_c is a quotient of the concentration of the products divided by the concentration of the reactants, and this is a reasonably low number. Thus the position of equilibrium lies strongly with the reactants. 1 mark

ii. $K_c = \dfrac{[CH_3OH]}{[CO][H_2]^2} = 0.417$ 1 mark

$$[H_2]^2 = \frac{[CH_3OH]}{[CO] \times 0.417} = \frac{\left(\dfrac{1.25 \times 10^{-2}}{5.0}\right)}{\left(\dfrac{0.51}{5.0}\right) \times 0.417} = 0.0587 \text{ M}$$ 1 mark

$[H_2] = \sqrt{0.0587} = 0.242$ M

Therefore $n(H_2) = 0.242 \times 5.0 = 1.2$ mol 1 mark

b. The methane gas would need to be produced from a renewable source such as biogas. 1 mark

c. $n(CO_2) = \dfrac{m}{M} = \dfrac{10^6}{44}$ mol

$n(CH_3OH) = n(CO_2)$ 1 mark

molar heat of combustion of methanol = 726 kJ mol^{-1}

energy generated for each tonne of $CO_2 = 10^6 \times \dfrac{726}{44} = 1.65 \times 10^7$ kJ 1 mark

Question 8 (5 marks)

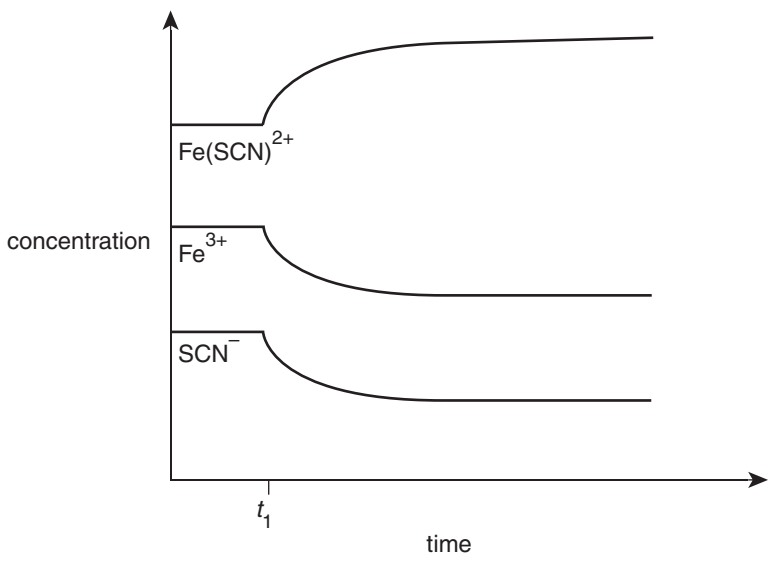
a.

The contents of the beaker will be coloured red.	✓
The concentration of Fe^{3+} ions in the beaker is 1.0 M.	
The formation of the complex ion ceases at equilibrium.	
The [SCN^-] remains constant at equilibrium.	✓

1 mark

Note: Both ticks are required for the mark.

b. **i.**



2 marks
1 mark for each correct graph.

ii. exothermic 1 mark

The mixture was cooled at t_1, which caused more product to be generated and reactants to be used up. When an equilibrium mixture is cooled, the change will be opposed and so more heat will be generated; that is, the forward reaction is exothermic. 1 mark

Question 9 (14 marks)

a. to allow an average to be taken for the heat of combustion values from each experiment so random error is minimised, 1 mark
and to allow the experimenter to check that the procedure produces reliable/reproducible results 1 mark

b. The metal will conduct heat much better than glass and so there will be more heat transfer into the water, resulting in more accurate results. 1 mark

c. energy = $m \times c \times \Delta T$

$= 75.4 \times 4.18 \times (36.1 - 18.0)$ 1 mark

$= 5705 \text{ J} = 5.705 \text{ kJ}$ 1 mark

$n(\text{ethanol}) = \frac{m}{M} = \frac{127.34 - 126.86}{46.0} = 0.01043 \text{ mol}$ 1 mark

molar heat of combustion $= \frac{E}{n} = \frac{5.705}{0.01043} = 547 \text{ kJ mol}^{-1} = 5.5 \times 10^2 \text{ kJ mol}^{-1}$ 1 mark

d. Provided that the experiments replicated other conditions, the different masses of water and different masses of ethanol do not affect the validity of the experiments. 1 mark

As the molar heat of combustion of ethanol has one accepted value, burning more ethanol leads to a larger temperature increase for the same mass of water heated or, when a constant mass of ethanol is burnt, a smaller mass of water heated results in a higher temperature. 1 mark

e. *For example, any two of:*

- Place a lid on the metal can.
- Move the flame closer to the metal can.
- Place an aluminium foil sleeve around the equipment.

2 marks

Note: Any other suggestions that reduce heat loss would be acceptable.

f. **i.** Calibration relates the heat change to a temperature change so that when a temperature change occurs in a subsequent reaction, the enthalpy change for the reaction can be determined. 1 mark

ii. Burn a set mass of propan-1-ol in the spirit burner and measure the change in temperature of the mass of water in the metal can. 1 mark

Using the accepted value for the heat of combustion of propan-1-ol, calculate the percentage heat loss and use this percentage value in subsequent experiments to adjust calculated values to allow for the heat loss. 1 mark