VCE® Chemistry

Unit 3 and 4 Practice Written Examination

ADVICE FOR TEACHERS

2024-CHE-VIC-U34-NA-EX-QATS

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Solution Pathway

Below are sample answers. Please consider the merit of alternative responses.

Section A: Multiple-Choice Questions (30 marks)

Question	Correct Answer	Explanation
1	**D**	A and B are fossil fuels and C is not a fuel.
2	**D**	Three unique carbon AND four hydrogen environments.
3	**C**	Increased surface area and concentration will increase the reaction rate.
4	**B**	An endothermic reaction will be favoured at high temperature and since the product side has greater moles low pressure will favour increased product yield.
5	**A**	Lead is oxidised.
6	**C**	Hydroxy group on carbon number 2 and chlorine atom on carbon number 4.
7	**D**	The dependent variable should change as the independent variable changes.
8	**C**	Renewable fuels are replenished at a sustainable rate.
9	**A**	Octane: 8500g, Ethanol 1500g. n(octane) = 8500/114 = 74.56, n(ethanol) = 1500/46 = 32.61 Energy = 74.56 × 5470 + 32.61 × 1370 = 452525 kJ = 452.5 MJ
10	**B**	A catalyst only affects the activation energy.
11	**A**	Voltage = 0.77 – (-0.28) = 1.05V
12	**B**	Fe^{3+} is reduced.
13	**B**	Zn is a stronger reductant than Co and so it would be oxidised.

14	**A**	Validity is about whether the experimental design allows for the aim to be achieved.
15	**C**	This component will have the strongest bonding with the stationary phase and hence will leave the column last.
16	**C**	In a basic solution the amino acid will act as an acid.
17	**B**	Butanoic acid will have the strongest intermolecular forces.
18	**A**	Only temperature will affect the K value. Adding oxygen gas will cause some of the sulfur dioxide gas to react with it.
19	**B**	$K = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$, $86 = \frac{[SO_3]^2}{[0.035]^2[0.520]}$, $[SO_3]^2 = 0.054782$, $SO_3 = 0.234\ M^{-1}$
20	**D**	Q = It = 4 × 45 × 60 = 10800, n(e^-) = 10800/96500 = 0.1119 n(Fe) = 0.5 × 0.1119 = 0.05596, m(Fe) = 0.05596 × 55.8 = 3.13g
21	**B**	Na is +1, Each O is -2, therefore Mn is +7
22	**A**	n(N_2) = 15.2/28 = 0.543 mol V = n × 24.8 = 0.543 × 24.8 = 13.46 L
23	**B**	Isomers are pentane, 2-methyl butane and 2,2-dimethylpropane.
24	**C**	Secondary alcohols are oxidised into ketones.
25	**D**	Carbon 2 is the chiral carbon.
26	**B**	triglyceride + 3 water → glycerol + 3 fatty acids.
27	**C**	At the anode $CH_3OH + 6OH^- \rightarrow CO_2 + 5H_20 + 6e^-$
28	**B**	The rate will increase but yield will not change due to equal number of moles on both sides of the equation.
29	**A**	Molecular formula is $C_5H_{12}O$
30	**C**	The systematic error is caused by a consistently wrong result from the machine.

Question 1 (10 marks)

a. *The nitric acid in the electrolyte provides H+ ions required for half equations.*

- **1 mark** is awarded for a correct purpose.

b. *This is the cathode, so the polarity is +*

- **1 mark** is awarded for stating positive or +

c. $O_2(g)+4H^+(aq)+4e^- \rightarrow 2H_2O(l)$

- **1 mark** is awarded for writing the correct half equation.

d. $CH_4(g)+2H_2O(l) \rightarrow CO_2(g)+8H^+(aq)+8e^-$

- **1 mark** is awarded for writing the correct half equation.

e. $CH_4(g)+2O_2(g) \rightarrow CO_2(g)+2H_2O(l)$

- **1 mark** is awarded for writing the correct full equation.

f. *Methane could be produced by the decay of organic matter in the absence of oxygen gas. This method is considered renewable as the methane gas can be produced at a faster rate than it is used.*

- **1 mark** is awarded for stating a method.
- **1 mark** is awarded for stating why it is renewable.

g. $Q = It = 4.0 \times 5.5 \times 60 \times 60 = 79200\ C$
$n(e^-) = \frac{Q}{F} = \frac{79200}{96500} = 0.8207\ mol$
$n(O_2) = \frac{1}{4} \times 0.8207 = 0.205 mol$
$m(O_2) = 0.205 \times 32 = 6.6g$

- **1 mark** is awarded for calculating the number of moles of electrons.
- **1 mark** is awarded for calculating the number of moles of oxygen gas.
- **1 mark** is awarded for calculating the mass of oxygen gas correct to 2 decimal places.

Question 2 (12 marks)

a. *This reaction is exothermic. It is important to know whether a reaction is exothermic or endothermic as a change in temperature will affect the product yield differently depending on the type of reaction.*

- **1 mark** is awarded for stating that this reaction is exothermic.
- **1 mark** is awarded for explaining that exothermic and endothermic reactions product yield is affected differently by temperature.

b. Below is a I.C.E. table to assist with answering this question.

	N_2	$3H_2$	$2NH_3$
Initial	*2*	*4*	*0*
Change	*-1*	*-3*	*+2*
Equilibrium	*1 mol*	*1 mol*	*2 mol*
Equilibrium Concentration	*0.25 M*	*0.25 M*	*0.5M*

$$K = \frac{[NH_3]^2}{[H_2]^3[N_2]} = \frac{[0.5]^2}{[0.25]^3[0.25]} = 64\ M^{-2}$$

- **1 mark** is awarded for calculating the number of moles of nitrogen gas at equilibrium.
- **1 mark** is awarded for calculating the number of moles of hydrogen gas at equilibrium.
- **1 mark** is awarded for using the correct equilibrium expression using concentration values.
- **1 mark** is awarded for the correct answer with units.

c. *This reaction is exothermic. The temperature should be lowered to increase product yield. The pressure should be increased. A higher pressure will favour the side with the least number of moles as the reaction will compensate for this lower pressure by trying to reduce the overall concentration.*

- **1 mark** is awarded for stating that temperature should be lowered.
- **1 mark** is awarded for stating that a lower temperature will favour a higher product yield for an exothermic reaction.
- **1 mark** is awarded for stating that the pressure should be lowered.
- **1 mark** is awarded for explaining that the product side is favoured since it has a least number of moles.

d. *A catalyst will increase the reaction rate. It will not affect the yield.*

- **1 mark** is awarded for stating that the reaction rate will increase.
- **1 mark** is awarded for stating that it will have no effect on the product yield.

Question 3 (9 marks)

a. *C_3H_8O. The parent peak in the mass spectrum has an m/z value of 60.*

- **1 mark** is awarded for the correct molecular formula.
- **1 mark** is awarded for a correct justification using the mass spectrum.

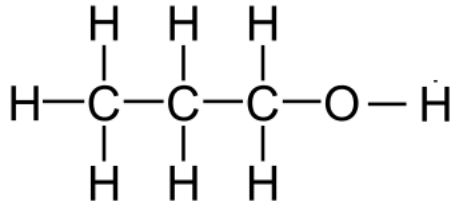
b. *This peak at an m/z value of 61 is likely to be caused by an isotope such as C-13.*

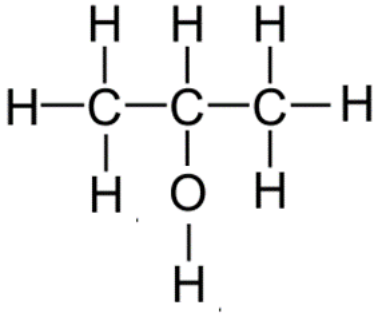
- **1 mark** is awarded for a correct explanation.

c. *O-H (alcohol)*

- **1 mark** is awarded for identifying the correct functional group.

d. See below:





- **1 mark** is awarded for each correct structural formula.

e. *propan-2-ol. This compound has two distinct carbon environments: CH(OH) and the two identical CH_3 groups. It also has three distinct hydrogen environments: O-H, CH and the two identical CH_3 groups.*

- **1 mark** is awarded for the correct name.
- **1 mark** is awarded for an explanation relating to the carbon environments.
- **1 mark** is awarded for an explanation relating to the hydrogen environments.

Question 4 (10 marks)

a. *This is a redox equation because both reduction and oxidation are occurring. This is highlighted by the oxidation number of iodine which decreases from 0 to -1.*

- **1 mark** is awarded for an explanation of why this is a redox equation.
- **1 mark** is awarded for stating the change in oxidation number of iodine.

b. $I_2 + 2e^- \rightarrow 2I^-$

- **1 mark** is awarded for writing the correct reduction half equation.

c. $n = c \times V = 0.0150 \times 0.04340 = 0.000651\ mol$

- **1 mark** is awarded for a correct line of working out.
- **1 mark** is awarded for the correct answer.

d. $n = 0.000651\ mol$

- **1 mark** is awarded for the correct answer.

e. $m = n \times M = 0.000651\ \times 176 = 0.114576 = 0.115\ g$

- **1 mark** is awarded for a correct line of working out.
- **1 mark** is awarded for the correct answer.

f. $\%\left(\frac{m}{v}\right) = \frac{0.115}{250} \times 100 = 0.046\%$

- **1 mark** is awarded for a correct line of working out.
- **1 mark** is awarded for the correct answer.

Question 5 (10 marks)

a. *(-) or negative*

- **1 mark** is awarded for the correct polarity.

b. $Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$

- **1 mark** is awarded for writing the correct half equation at the cathode.

c. $2H_20(l) \rightarrow O_2(g)+4H^+(aq) +4e^-$

- **1 mark** is awarded for writing the correct half equation at the cathode.

d. $Q=It = 2.5\times10\times60 = 1500C$

- **1 mark** is awarded for the correct answer.

e. $n(e^-)= Q/F = 1500/96500 = 0.0155\ mol$

- **1 mark** is awarded for the correct answer.

f. $n(Ni) = ½ \times 0.0155 = 0.0078\ mol$
$m(Ni) = 0.0078\times58.7 =0.46g$

- **1 mark** is awarded for a correct line of working out.
- **1 mark** is awarded for the correct answer.

g. *If the carbon anode was replaced with iron, the iron would be a stronger reductant than water. This would mean that* $Fe^{2+}(aq)$ *would be produced instead of oxygen gas. The new equation at the anode would be* $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

- **1 mark** is awarded for stating the iron is a stronger reductant than water.
- **1 mark** is awarded for stating what the new products are.
- **1 mark** is awarded for writing the new anode half equation OR stating that the products at the cathode are unchanged.

Question 6 (10 marks)

a. $CH_3CH_2CH_2OH(l) + CH_3COOH(l) \rightarrow CH_3COOCH_2CH_2CH_3(l)+ H_2O(l)$

- **2 marks** are awarded for the correct equation with states. (Molecular formulas could be used)
- **1 mark** if one error.

b. *Propyl ethanoate*

- **1 mark** is awarded for the correct name.

c. H^+/MnO_4^- *or* $H^+/Cr_2O_7^{2-}$

- **1 mark** is awarded for the reagents.

d. $CH_3CH_2OH(l) + H_2O(l) \rightarrow CH_3COOH(l) + 4H^+(aq) + 4e^-$

- **1 mark** is awarded for the correct equation.

e. *Propane*

- **1 mark** is awarded for the correct name.

f. *Step 1: $CH_3CH_2CH_3 + Cl_2 \rightarrow CH_3CH_2CH_2Cl + HCl$*

Step 2: $CH_3CH_2CH_2Cl + NaOH \rightarrow CH_3CH_2CH_2OH + NaCl$

- **1 mark** is awarded for the correct equation for Step 1.
- **1 mark** is awarded for the correct equation for Step 2. KOH also acceptable.

g. $\%atom\ economy = \frac{M(Butan-1-amine)}{M(all\ reactants)} \times 100 = \frac{73}{109.5} \times 100 = 66.7\%$

- **1 mark** is awarded for a correct line of working out.
- **1 mark** is awarded for the correct answer.

Question 7 (9 marks)

a. *$CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$*

- **2 marks** are awarded for the correct equation with states.
- **1 mark** if one error.

b. *$q = mC_p\Delta T = 200 \times 4.18 \times 4 = 3344\ J$*

- **1 mark** is awarded for a correct line of working out.
- **1 mark** is awarded for the correct answer.

c. *n(ethanol) = 0.450/46 = 0.00978 mol*
$\Delta H = 3.344/0.00978 = 341.8\ kJ\ mol^{-1}$

$$\%energy\ lost = \frac{1370 - 341.8}{1370} \times 100 = 75\%$$

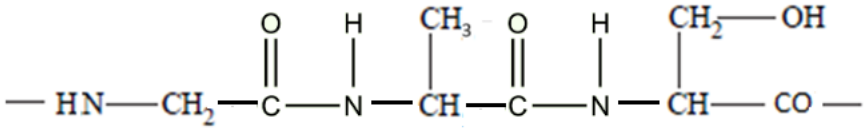
- **1 mark** is awarded for calculating number of moles of ethanol.
- **1 mark** is awarded for the correct experimental enthalpy value.
- **1 mark** is awarded for the correct answer.

d. $C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(aq) + 2CO_2(g)$

- **2 marks** are awarded for the correct equation with states.
- **1 mark** if one error.

Question 8 (8 marks)

a. See below:



- **1 mark** is awarded for having two correct peptide links.
- **1 mark** is awarded for having the correct Z groups.
- **1 mark** is awarded for leaving the terminals open.

b. *The structure of the active site of the enzyme will exactly match the structure of the substrate. The enzyme will then attach to the substrate. The enzyme is a biological catalyst that will lower the activation energy by providing an alternative energy pathway and hence the reaction rate will increase.*

- **1 mark** is awarded for stating that the active site will match the substrate.
- **1 mark** is awarded for stating that the enzyme and substrate will come together.
- **1 mark** is awarded for explaining how the reaction rate is increased.

c. *If the environment becomes basic, then the tertiary and secondary structure of the enzyme can be affected. This will alter the active site and hence the enzyme will not be able to catalyse the reaction.*

- **1 mark** is awarded for stating that the tertiary and/or secondary structure will be altered.
- **1 mark** is awarded stating that this will alter the active site and hence the enzyme will no longer be effective.

Question 9 (7 marks)

a. *The time*

- **1 mark** is awarded for stating the correct answer.

b. *The volume of solution in each half cell or the original size of the electrode.*

- **1 mark** is awarded for stating the correct answer.

c. *It is lower than expected. Perhaps some of the mass did not stay attached to the electrode.*

- **1 mark** is awarded for stating that it is lower.
- **1 mark** for describing a possible reason for this value.

d. *Cu^{2+} is a stronger oxidant than Co^{2+}. This would mean that the Cu^{2+} ions would be reduced first. Since copper has a larger molar mass than cobalt the mass increase on the cathode would be larger than expected.*

- **1 mark** is awarded for stating that the copper ion is a stronger oxidant than the cobalt ion.
- **1 mark** is awarded for stating that this would be the copper ion is reduced first.
- **1 mark** is awarded for stating that the increase in mass of the electrode would therefore be greater than expected.

Question 10 (5 marks)

a. *The electrolysis of water could be used to produce green hydrogen. One method would be to use an alkaline electrolysis circuit to do this process that uses electricity from a renewable source such as solar. There is no net release of carbon dioxide during this process.*

- **1 mark** is awarded for stating a general principle to produce hydrogen.
- **1 mark** is awarded for a specific cell or design that can make hydrogen.
- **1 mark** is awarded for stating that no net greenhouse gas emissions will occur.

b. *Hydrogen should be stored under pressure to ensure that the amount of energy available for a given volume of hydrogen is suitable.*

- **1 mark** is awarded for stating a correct storage method.
- **1 mark** is awarded for explaining why this method is useful.

