

CHEMISTRY

Units 3 & 4 - Written examination



(TSSM's 2015 trial exam updated for the current study design)

SOLUTIONS

SECTION A: Multiple-choice questions (1 mark each)

Question 1

Answer: A

Explanation:

Bromine is a stronger oxidant than iodine. Thiosulfate is oxidised and bromine is reduced in this reaction.

Question 2

Answer: C

Explanation:

Option 1 cannot form a cis or trans isomer due to the fact that one of the carbons connected to the double bond has two hydrogens bonded to it.

Question 3

Answer: D

Explanation:

Options A and C will have splitting in the H-NMR

Option B will only have 2 C peaks

Option D will have 2 single H peaks and 3 C peaks

Question 4

Answer: C

Explanation:

$^1\text{H-NMR}$ uses radio waves which have the longest wavelengths.

Question 5

Answer: D

Explanation:

$$n(\text{C}_2\text{H}_5\text{OH}) = m/M = 20.0/46.0 = 0.435 \text{ mol}$$

$$E = n \times \Delta H = 0.435 \times 1372 = 597 \text{ kJ}$$

Question 6

Answer: D

Explanation:

Secondary alcohols will form ketones when oxidised.

Options A and B are primary alcohols and Option C is a tertiary alcohol.

Question 7

Answer: B

Explanation:

The number of mole of carbon has to be used for this calculation as it is the scarce reagent in this reaction.

$$n(\text{Al}) = \frac{4}{3} \times 0.72 = 0.96 \text{ mol}$$

Question 8

Answer: D

Explanation:

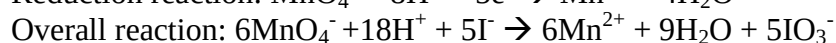
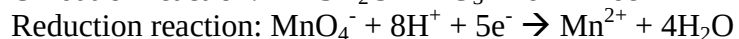
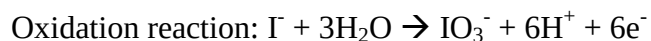
$$n(\text{C}) = \frac{36}{12} = 3 \text{ mol} = n(\text{CO}_2)$$

$$V = n \times 24.8 = 74.4 \text{ L}$$

Question 9

Answer: B

Explanation:



Question 10

Answer: A

Explanation:

Electrons flow from anode to cathode. Electrons are flowing from M $\rightarrow$ N, therefore M is undergoing oxidation.

Question 11

Answer: C

Explanation:

Catalysts decrease the activation energy.

Question 12

Answer: C

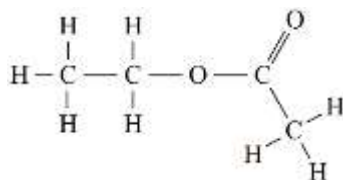
Explanation:

An equilibrium constant of 10^{-4} means that the [reactants] is much less than the [products], therefore the reaction is unfavourable and will not have very much product.

Question 13

Answer: D

Explanation:



Ethyl ethanoate is shown – it has four carbon atoms and each has a unique environment. There are three different hydrogen environments.

Question 14

Answer: C

Explanation:

Fatty acids have two oxygen atoms so the molecular formula is probably C₁₈H₃₂O₂. A saturated fatty acid will have the formula C_nH_{2n+1}COOH. In this case, the fatty acid would have 36 hydrogen atoms if it was saturated. As it has 4 less than that it must have two carbon to carbon double bonds.

Question 15

Answer: B

Explanation:

When the volume is decreased, the green intensity increases. The volume decrease favours the forward reaction, as there are less product molecules than reactants. This will reduce the green intensity but the net change in green intensity is still an increase over the original value.

Question 16

Answer: D

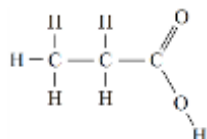
Explanation:

The temperature is increased and the amount of chlorine increases. As chlorine is a reactant then the temperature increase has led to a drop in the value of K. This is consistent with an exothermic reaction.

Question 17

Answer: C

Explanation:

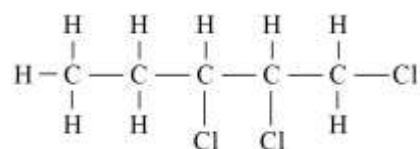


Like ethanoic acid, propanoic acid can be formed from the oxidation of the equivalent alkanol, in this case propan-1-ol. None of the other options are correct.

Question 18

Answer: A

Explanation:



Numbering should start from the right hand end. This will give 1,2,3- trichloropentane making A the correct answer.

Question 19

Answer: B

Explanation:

Options 1 and 2 have uneven number of molecules on either side of the equations.

Question 20

Answer: D

Explanation:

The molecule shown contains a carboxyl group on the right hand end and an amine and amide group close to each other in the middle. It does not contain an ester or a hydroxyl group.

Question 21

Answer: A

Explanation:

When a reaction is reversed, the sign of the value of ΔH changes (it becomes positive) and the numerical value of K becomes the reciprocal of the original value ($1/5.6 = 0.18$).

Question 22

Answer: A

Explanation:

Commercial production of electricity from nuclear sources involves nuclear fission. In nuclear fission, large nuclei are split, releasing neutrons that can further split more nuclei. Large amounts of energy are released as thermal energy in this process.

Question 23

Answer: D

Explanation:

$$n(\text{ethanol}) = \frac{0.46}{46} = 0.01 \text{ mol}$$

$$\text{energy released (from Data Book)} = 0.01 \times 1364 = 13.64 \text{ kJ} = 1.36 \times 10^4 \text{ Joule}$$

Question 24

Answer: B

Explanation:

$$E = shc \times \text{mass} \times \Delta T \quad \text{where shc} = \text{specific heat capacity}$$

$$750 = x \times 80 \times 3.9$$

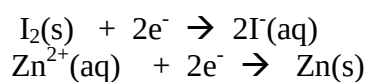
$$x = 750/312 = 2.40$$

Question 25

Answer: B

Explanation:

The relevant half-equations are



Iodine will react with zinc metal. The zinc will be oxidised to zinc ions at the anode which is the negative electrode.

Question 26

Answer: A

Explanation:

The question states that the cell is using an alkaline electrolyte, so OH^- ions will be present and not H^+ ions. The carbon in methane will form carbon dioxide, meaning the balanced half equation will be :



This is oxidation, which will occur at the anode.

Question 27

Answer: D

Explanation:

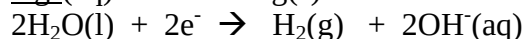
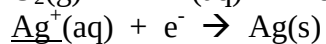
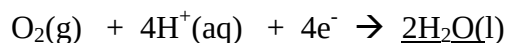
Methane is produced from biomass from the action of anaerobic bacteria. Biomass can be obtained from sewerage, food scraps and other organic waste. Fermentation is not a correct answer as it produces ethanol. Coal as a fuel is not a sustainable resource.

Question 28

Answer: D

Explanation:

This is electrolysis of an aqueous solution so the relevant half equations are;



The strongest oxidant, Ag^+ , will react with the strongest reductant, $\text{H}_2\text{O}(\text{l})$
The silver ions are reduced and water is oxidised to oxygen gas at the anode.
Therefore oxygen gas is produced at the positive electrode.

Question 29*Answer:* C*Explanation:*

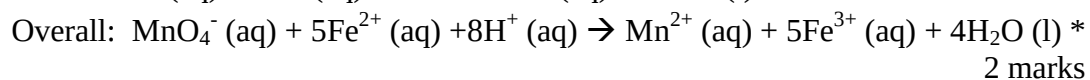
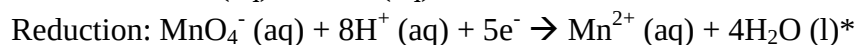
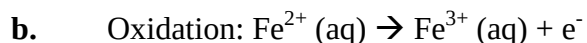
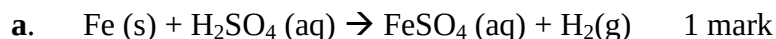
Using the working from question 28, silver metal is produced in a reduction reaction, which will occur at the negative cathode.

Question 30*Answer:* D*Explanation:*

$$Q = It = 8.4 \times 12 \times 60 = 6048 \text{ C}$$

$$n(e) = \frac{6048}{96500} = 0.0627 \text{ mol} = n(\text{Ag})$$

$$\text{mass}(\text{Ag}) = n \times M = 0.0627 \times 107.9 = 6.77 \text{ g}$$

SECTION B : Short-answer questions**Question 1** (9 marks)

c. $n(\text{MnO}_4^-) = c \times v = 0.0196 \times 0.0220 = 4.31 \times 10^{-4} \text{ mol}^*$

$$n(\text{Fe}^{2+}) \text{ in } 25 \text{ mL} = 4.31 \times 10^{-4} \times 5 = 0.00216 \text{ mol}^*$$

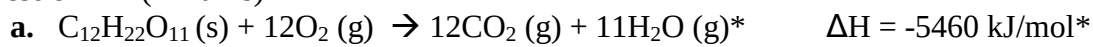
$$n(\text{Fe}^{2+}) \text{ in } 250 \text{ mL} = 0.00216 \times 250/25 = 0.0216 \text{ mol}^*$$

$$m(\text{Fe}) = 0.0216 \times 55.8 = 1.20 \text{ g}^*$$

$$m(\text{C}) = 1.27 - 1.20 = 0.07 \text{ g}$$

$$\%(\text{C}) = 0.07/1.27 \times 100 = 5.51\%^*$$

Question 2 (4 marks)



2 mark

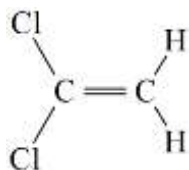
b. $n(\text{sucrose}) = m/M = 1.00/(12 \times 12.0 + 22.0 + 11 \times 16.0) = 1.00/342.0 = 0.00292 \text{ mol}^*$
 $E = n \times \Delta H = 0.00292 \times 5460^* = 16.0 \text{ kJ}^*$

3 marks

Question 3 (11 marks)

a.

i.



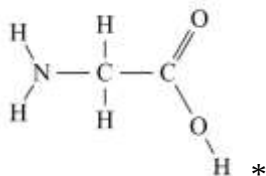
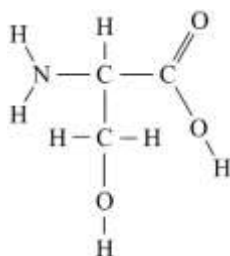
1 mark

ii. 1,1-dichloroethene

1 mark

b.

i.



*

ii.

glycine *

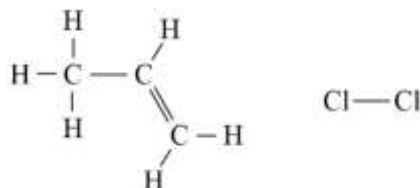
2 marks

Molecule A: serine *

Molecule B:

c. i.

2 marks

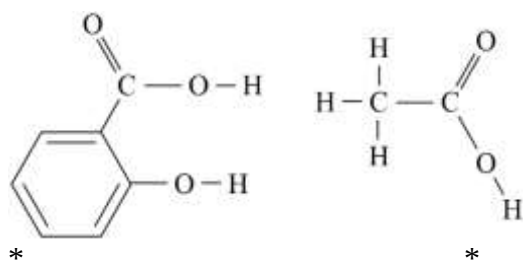


ii. Addition.

1 mark

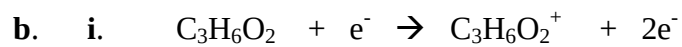
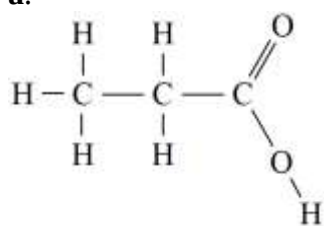
d.

2 marks

**Question 4** (11 marks)

a.

1 mark



1 mark



1 mark

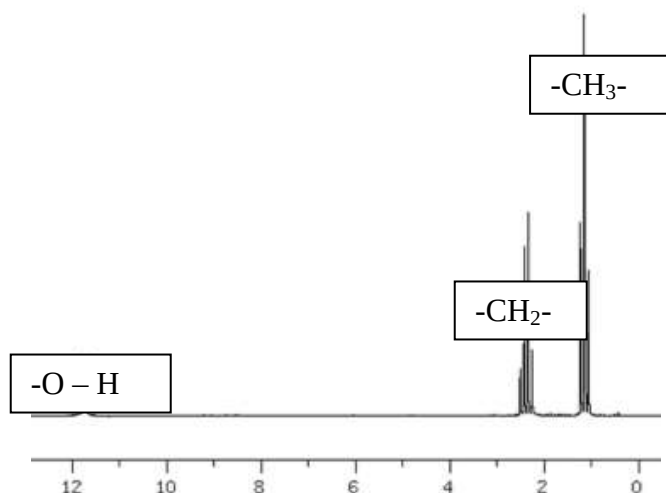
c.

2 marks

- Peak at $2500\text{--}3300\text{ cm}^{-1}$ O – H (acid)
- Peak at $1680\text{--}1750\text{ cm}^{-1}$ C = O

d. i.

3 marks



ii. 2.4 ppm quartet as group is beside $-\text{CH}_3$ $n + 1$ rule gives quartet 2 marks

1.1 ppm triplet as group is beside $-\text{CH}_2$ $n+1$ rule gives triplet

iii. 1:2:3 (from left to right) 1 mark

Question 5 (9 marks)

a. i. Glucose will be soluble due to the presence of so many $\text{O}-\text{H}$ bonds. These bonds are highly polar and will lead to hydrogen bonds forming between water and glucose. 1 mark

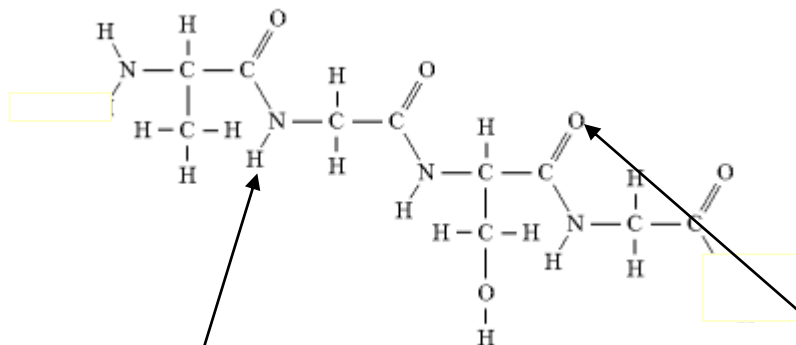
ii. Ether or glycosidic. 1 mark

iii. One of starch, cellulose or glycogen. 1 mark

iv. $\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$ 1 mark

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

b.



- i. The secondary structure is the result of hydrogen bonding between one part of the chain and another part.* The hydrogen bonds form as a result of dipoles between positive charges on hydrogen atoms attached to nitrogen atoms and negative charges on oxygen atoms attached to carbon atoms.*

2 marks

- ii. The difference in the amino acids is the -R group. In glycine and alanine, the R group is an alkyl group that is non-polar and low in solubility*. In serine, a significant dipole exists, so the solubility in water will be higher*.

2 marks

Question 6 (10 marks)

a. i.

1 mark

$$K = \frac{[\text{CO}_2][\text{H}_2]^4}{[\text{CH}_4][\text{H}_2\text{O}]^2}$$

ii.

	$\text{CH}_4(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + 4\text{H}_2(\text{g})$			
Initial	1	1.4	0	0
Equilibrium	1-0.22 0.78 *	1.4 - 0.44 0.96*	0.22	0.88* (as 4 times CO_2)

3 marks

iii. $K = \frac{(0.22)(0.88^4)}{(0.78)(0.96^2)} \quad * \quad = \frac{0.132}{0.719} = 0.18 \text{ M}^2 \quad *$

2 marks

b. Answer True or False to each of the following.

4 marks

Statement	True or False
If 4 mol of methane is added to steam in a reactor and the amount of methane changes to 3 mol over time, the amount of carbon dioxide formed will be 1 mol.	True (1 mol of methane will form 1 mol CO ₂)
1 mol of carbon dioxide and 1 mol of hydrogen gas are added to an empty reactor. No reaction will occur as they are both products.	False (It is a reversible reaction)
1 mol of methane is added to 10 mol of steam in an empty reactor. When equilibrium is reached the methane will be all gone as it is very much the scarce reagent.	False (In a reversible reaction, some reactant will remain)
If 4 mol of methane and 8 mol of steam are added to an empty reactor, 4 mol of carbon dioxide will form.	False (not all the methane will react)

Question 7 (11 marks)

a. $E = c \times m \times \Delta T^* = 4.18 \times 450 \times (35-15) = 3.8 \times 10^4 \text{ J}^*$

2 marks

b. i. $E \text{ lost by copper} = E \text{ gained by water} = 3.8 \times 10^4 \text{ J}$ 1 mark

ii. $\Delta T (\text{copper}) = E/(c \times m)^* = 3.8 \times 10^4 \text{ J}/(390 \times 0.12) = 804 \text{ }^\circ\text{C}^*$ 2 marks

iii. Initial temperature of the copper = $35 + 804 = 839 \text{ }^\circ\text{C}$ 1 mark

Question 8 (8 marks)

a. i. The value of ΔT will be lower than that of a well insulated calorimeter. 1 mark

ii. The calibration factor will be higher than that of a well-insulated calorimeter. 1 mark

b. i. $\text{HCl(aq)} + \text{NaOH(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$ 1 mark

ii. The number of mole of HCl must be used as it is the limiting reagent in this experiment. 1 mark

c. i. The value of ΔT will be lower than it should be as more water is being heated. 1 mark

ii. the value of ΔH will be lower than it should be as a result of the low ΔT 1 mark

d. $n(\text{ethanol}) = \frac{0.552}{46} = 0.012 \text{ mol}$

$$E = n \times 1364 = 0.012 \times 1364 = 16.368 \text{ kJ} = 16368 \text{ J} *$$

$$\Delta T = E/CF = 16368/684 = 23.9 ^\circ\text{C} *$$
 2 marks

Question 9 (8 marks)

a. V^{3+} , V^{2+} , V^{5+} (in VO_2^+), V^{4+} (in VO^{2+}) $\frac{1}{2}$ mark each 2 marks

b. i. $\text{VO}_2^+(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{V}^{2+}(\text{aq}) \rightarrow \text{VO}^{2+}(\text{aq}) + \text{V}^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$ 1 mark

ii. 1.26 V 1 mark

iii. The left hand side is the negative electrode and the right hand side the positive 1 mark

c. i. $\text{VO}^{2+}(\text{aq}) + \text{V}^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{VO}_2^+(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{V}^{2+}(\text{aq})$ 1 mark

ii. Voltage must be greater than 1.26 V for recharging to occur. 1 mark

iii. A secondary cell is a cell that can be recharged. A power supply can be applied that reverses the discharge equation, reforming the reactants. 1 mark

Question 10 (9 marks)

a. Cell A: Molten KCl 2 marks

- the cathode: $\text{K}^+(\text{l}) + \text{e}^- \rightarrow \text{K}(\text{l})$
- the anode: $2\text{Cl}^-(\text{l}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$

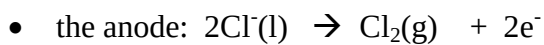
b. Cell B: Dilute KCl solution 2 marks

- the cathode: $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$
- the anode: $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^-$

c. Cell C: 4.0 M KCl solution 2 marks

i.

- the cathode: $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$



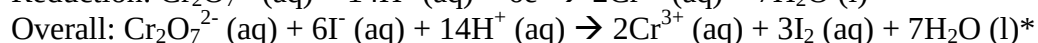
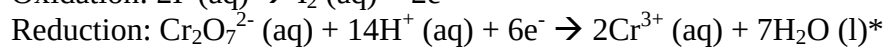
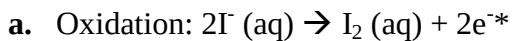
ii. $Q = It = 3.4 \times 25 \times 60 = 5100 \text{ C}^*$

3 marks

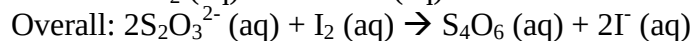
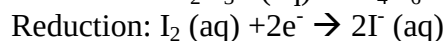
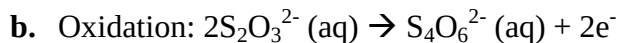
$$n(\text{e}) = \frac{5100}{96500} = 0.0528 \text{ mol}$$

$$n(\text{H}_2) = \frac{1}{2} n(\text{e}^-) = 0.0528 \times 0.5 = 0.0264 \text{ mol}^*$$

$$\text{volume}(\text{H}_2) = \frac{nRT}{P} = \frac{0.0264 \times 8.31 \times 297}{105} = 0.62 \text{ L}$$

Question 11 (8 marks)

3 marks



3 marks

c. $n(\text{S}_2\text{O}_3^{2-}) = c \times v = 0.0244 \times 0.102 = 0.00249 \text{ mol}^*$

$$n(\text{I}_2) = 0.00249/2 = 0.00124 \text{ mol}^*$$

$$n(\text{Cr}_2\text{O}_7^{2-}) = 0.00124/6 = 2.07 \times 10^{-4} \text{ mol}^*$$

$$c(\text{K}_2\text{Cr}_2\text{O}_7) = n/v = 2.07 \times 10^{-4} / 0.025 = 0.00830 \text{ mol}^*$$

4 marks