CHEMISTRY

Units 3 & 4 – Written examination

(*TSSM's 2010 trial exam updated for the current study design*)

SOLUTIONS

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

Question 1

Answer: D

Explanation:

Coal is a fossil fuel.

Question 2

Answer: B

Explanation:

Options A, C and D all reduce kinetic energy of the particles, while Option B increases the kinetic energy of the water particles.

Question 3

Answer: D

Explanation:

All three options will improve the accuracy of the experiment.

Question 4

Answer: C

Explanation:

n (CO_2) = V/V_m = 29.5/24.5 = 1.20 mol
n ($CuCO_3$) = n (CO_2) = 1.20 mol
m ($CuCO_3$) = n x M = 1.20 x (63.5 + 12.0 + 3 x 16.0) = 149 g

Question 5

Answer: B

Explanation:

Electrochemical series:
Br_2 (l) + $2e^-$ ↔ $2Br^-$ (aq)
Ag^+ (aq) + e^- ↔ Ag (s)
I_2 (s) + $2e^-$ ↔ $2I^-$ (aq)
Cu^{2+} (aq) + $2e^-$ ↔ Cu (s)
Therefore the only correct option is that Ag will cause Br_2 to undergo reduction and itself undergo oxidation.

Question 6

Answer: D

Explanation:

Most vitamins are considered essential with the two exceptions being Vitamin D and Biotin

Question 7

Answer: D

Explanation:

The fragments must be positively charged, hence D is correct. The masses in D match each peak also.

Question 8

Answer: C

Explanation:

The fragments not passing through the spectrometer must have no charge on them, hence C is correct. CH_3 has a mass of 15. When it is subtracted from 58, the peak at 43 is obtained. CH_3CH_2 has a mass of 29. (58-29) = peak at 29.

Question 9

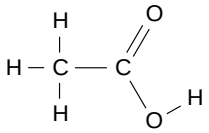
Answer: C

Explanation:

HPLC can be qualitative by comparing R_t values and quantitative by construction of a standard curve.

Question 10

Answer: C

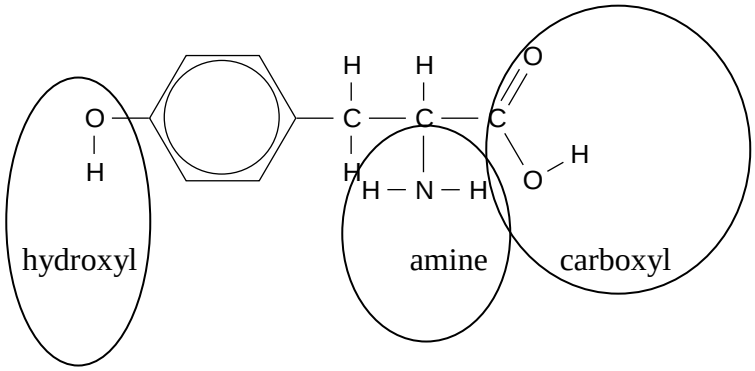


Explanation:

This molecule has 2 different hydrogen environments, hence 2 NMR peaks. There is no splitting of these peaks as there are no neighbouring hydrogen atoms.
The C=O and the O – H both give IR peaks, one at 3000 and the other 1700.
The mass spectrum has a peak at 15 due to CH_3^+ and a peak at 45 due to $COOH^+$

Question 11

Answer: A



Question 12

Answer: D

Explanation:

The benzene ring has 6 carbons not shown and 4 hydrogen atoms not shown. Add these on to the atoms visible gives D.

Question 13

Answer: C

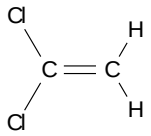
Explanation:

Start from the right hand end as it is closest to functional groups. There are 4 carbons in a row, hence butane. Therefore 1-chloro-2-methylbutane

Question 14

Answer: B

Explanation:

The monomer is usually an alkene. In this case 

The orientation of this molecule can be adjusted to match the polymer shown.
The name of this molecule is 1,1-dichloroethene.

Question 15

Answer: D

Explanation:

Maltose is a disaccharide like sucrose. Sucrose is shown in the data book. Counting the hydroxyl groups gives 8 and there are 3 ether groups counting the two in the rings themselves.

Question 16

Answer: C

Explanation:
Gas particles have a range of speeds. The distribution curves highlight the range of velocities of the molecules. If the velocities vary, the kinetic energies will also vary.

Question 17

Answer: D

Explanation:
A higher percentage of molecules will react at 2000°C. Some molecules at each temperature have energy greater than the activation energy but there are more molecules at 2000°C that have energy above the activation energy. Note: 2000°C is not twice the temperature of 1000°C.

Question 18

Answer: A

Explanation:
Enzymes are **biological** catalysts, they **increase** the rate of reaction by providing an alternative pathway with a **lower** activation energy. Enzymes **do not change** the equilibrium of the reaction.

Question 19

Answer: A

Explanation:
The value of K of 4.6×10^{-4} is very low. This means the amount of product is much less than the amount of reactant. This means the amount of NO will be far lower than the amounts of nitrogen and oxygen. Be careful applying stoichiometry to reversible equations.

Question 20

Answer: C

Explanation:
$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$
From the equation, the reactants must decrease the same amount, while hydrogen increases at three times this rate. Alternative C matches this – the reactants both drop by 0.1 while hydrogen increases by three times this.

Question 21

Answer: A

Explanation:
Overall equation during discharge:
$Pb(IV)O_2 + 2H^+ + 2HSO_4^- + Pb \rightarrow 2Pb(II)SO_4 + 2H_2O$
There will be a decrease in H+ ions during discharge which will in turn lead to an increase in pH.

Question 22

Answer: A

Explanation:
If temperature increases, the back reaction is favoured. This means K drops and there are more reactants and less products. This matches A.

Question 23

Answer: C

Explanation:
Any metal extracted from aqueous solution must be placed above the water half equation at -0.8 on the electrochemical series. The only correct response is C.

Question 24

Answer: B

Explanation:
0.1 g of methanol is $\frac{0.1}{32} = 0.00313 mol$
Energy = 0.00313 x 725 = $2.270 J$ *(using data book)*
CF= $\frac{energy}{\Delta T} = \frac{2.270}{10} = 0.2270$

Question 25

Answer: A

Explanation:
From the electrochemical series, chlorine gas will react with magnesium metal. The magnesium is oxidised, making it the anode. The anode will be negative. The magnesium electrode loses mass as the magnesium atoms become magnesium ions. Alternative A matches the above discussion.

Question 26

Answer: A

Explanation:
Half equations are:
$Li(s) \rightarrow Li^{+}(l) + e^{-}$
$I_2(l) + 2e^{-} \rightarrow 2I^{-}(l)$
This leads to the overall equation shown in option A.

Question 27

Answer: A

Explanation:
In this cell, $Ag^{+}(aq)$ reacts with Ni(s);
$2Ag^{+}(aq) + 2e^{-} \rightarrow 2Ag(s)$
$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^{-}$
The products are Ag(s) and $Ni^{2+}(aq)$, which is green.

Question 28

Answer: B

Explanation:
$2Ag^{+}(aq) + 2e^{-} \rightarrow 2Ag(s)$
$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^{-}$
The reaction of silver ions is reduction. Reduction occurs at the cathode and the cathode is positive. This matches B.

Question 29

Answer: C

Explanation:
Q=It = 2.1 x 5 x 60 = 630*coulomb*
$n(e) = \frac{630}{96500} = 6.52 \times 10^{-3}$

$n(Sn) = \frac{0.388}{118.7} = 3.26 \times 10^{-3}$

ratio of n(Sn):n(e) = 1:2 therefore Sn^{2+}

Question 30

Answer: B

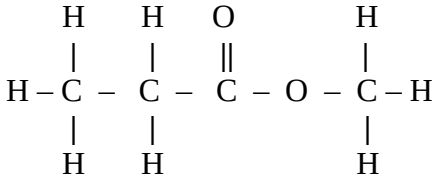
Explanation:
$n(Cl_2) = n(Sn)$ as $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$

$V = n \times 24.8 = 3.26 \times 10^{-3} \times 24.8 = 0.081\ L$

SECTION B – Short answer questions

** indicates 1 mark*

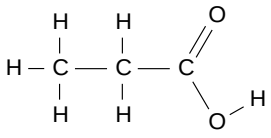
Question 1

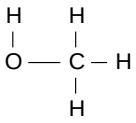


a. methylpropanoate *

1 mark

b. i. & ii. A = propanoic acid* B = methanol*

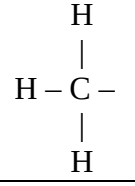
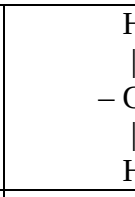
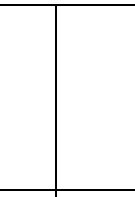




**

2 + 2 = 4 marks

c.

			
Area	3	2	3*
Number of hydrogen atoms on neighbouring atoms	2	3	0*
Number of splits	3	4	0*

1 + 1 + 1 = 3 marks

d. **i**. Pure samples of each ester could be run to determine the retention times*. The mixture could then be run. Ester could be identified if their retention times matched the pure samples.*

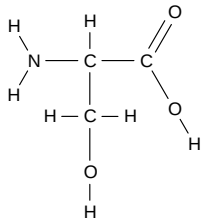
ii. A series of standards of known concentrations could be prepared. The area of the peaks could be graphed to obtain a calibration curve.* The sample to be analysed could then be run and the area plotted on the calibration curve.*

2 + 2 = 4 marks

Total 12 marks

Question 2

a. **i**. *

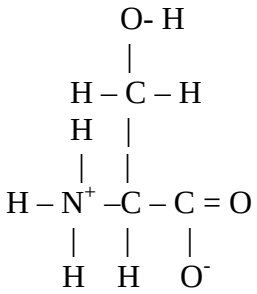


ii. serine*

iii. carboxyl, hydroxyl, amine *

1 + 1 + 1 = 3 marks

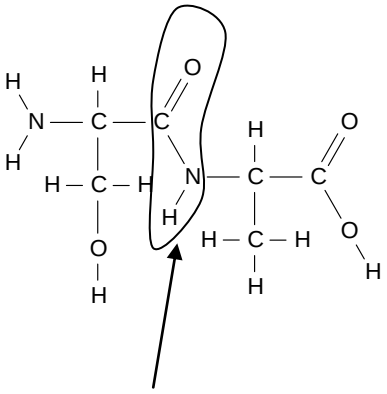
b.



*

2 marks

c. **i**.



*

ii. peptide (or amide) link

1 + 1 = 2 marks
Total 7 marks

Question 3

a. $C_6H_{12}O_6$ (aq) → $2CH_3CH_2OH$ (aq) + $2CO_2$ (g)
1 mark for correct chemicals, 1 mark for correct balancing

2 marks

b. **i**. Carbon neutral means that no nett carbon is introduced into the atmosphere.

ii. CH_3CH_2OH (l) + $3O_2$ (g) → $2CO_2$ (g) + $3H_2O$ (l)
1 mark for correct structure, 1 mark for correct balancing

1 + 2 = 3 marks

c. Oxidation: $CH_3CH_2OH + 3H_2O \rightarrow 2CO_2 + 12H^+ + 12e^-$*
Reduction: $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$*

2 marks

d. 1 mol of ethanol produces 1364 kJ of energy
x mol of ethanol produces 3000 kJ
x = 3000/1364 = 2.20 mol*
n (glucose) = n (ethanol)/2 = 2.20/2 = 1.10 mol*
m (glucose) = n x M = 1.10 x 180 = 198 g*

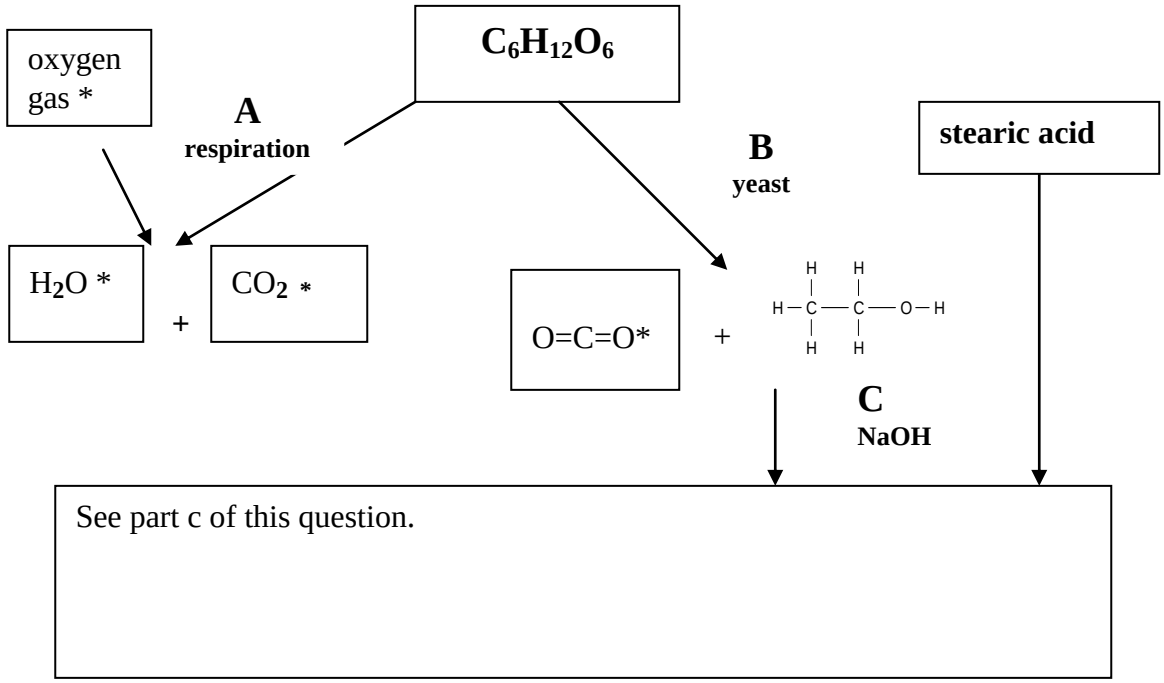
3 marks

e. Disadvantages: High production cost, water usage, food shortages, fertilisers (any one of these)

1 mark

Total 11 marks

Question 4



a. **i**. See diagram

ii. See diagram

2 + 1 = 3 marks

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

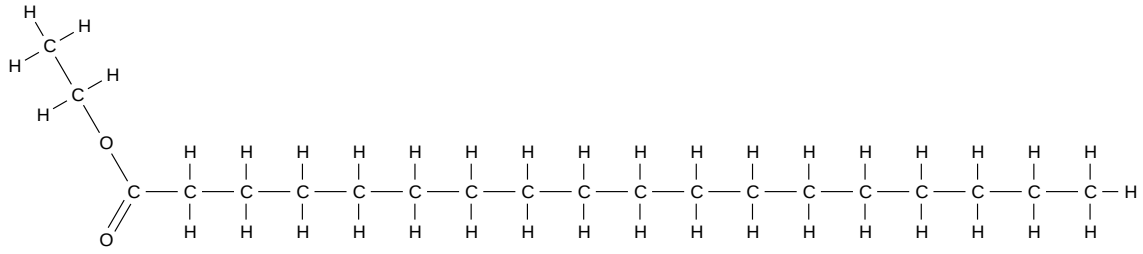
ii. See diagram

iii. Enzymes in yeast act as a catalyst*

iv. The enzymes in yeast are heat sensitive. Their ability to function is destroyed by heat. *

1 + 2 + 1 + 1 = 5 marks

c. **i**.



*

ii. The reactant is sourced from plant material, hence it is renewable. *

iii. M(stearic acid) = $M(C_{17}H_{35}COOH)$ = 12 x 17 + 35 + 12 + 32 + 1) = 284

$$n = \frac{100000}{284} = 352.1 mol\ *$$

n(stearic acid) =n(biodiesel) = $352.1 mol$

mass = $nxM = 352.1 \times 312 = 110 kg$ *

1 + 1 + 2 = 4 marks
Total 12 marks

Question 5

a. Energy lost by the hot water = c x m x ΔT
= 4.18 x 70.0 x (65.0 – 48.6)
= 4799 J*

Calibration factor of coffee cup = Energy gained/ΔT*
= 4799/(48.6 – 18.0)
= 157 J/°C*

3 marks

b. i. Na_2CO_3 (aq) + $2CH_3COOH$ (aq) → $2NaCH_3COO$ (aq) + H_2O (l) + CO_2 (g)

ii. Energy = C.F. x T = 157 x (20.4 – 15.3) = 800 J

iii. n (Na_2CO_3) = c x V = 0.0240 x 0.020 = 0.00048 mol
n (CH_3COOH) = c x V = 8.65 x 10-3 x 0.080 = 0.00069 mol
CH_3COOH is limiting*, therefore 0.00069 mol produces 800 J
2 mol produces x J
x = (2 x 800) / 0.00069 = 2.3 x 10^6 J*
ΔH = + 2.3 x 10^3 kJ/mol*

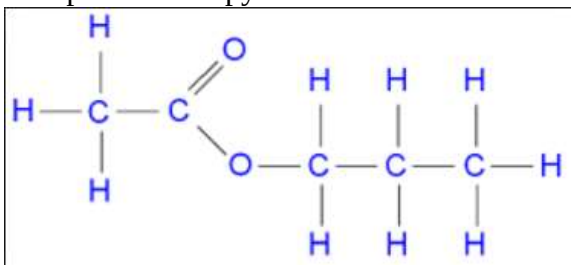
1 + 1 + 3 = 5 marks

c. This will create a larger volume, this in turn will reduce the change in temperature* leading to a reduced energy change and a lower ΔH*.

2 marks
Total 10 marks

Question 6

IR: C=O peak and no O-H peak suggests that the compound is an ester
C-NMR: 5 carbon environments
H-NMR: 4 hydrogen environments, splitting of peaks
Compound = Propyl ethanoate



4 marks

Question 7

a. **Equation** **ΔH**

Ethanol $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$* -1364 kJ mol^{-1} *

Methanol $2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g)$* -1450 kJ mol^{-1} *

4 marks

b. **i**. E = n x ΔH

$$= * \frac{0.2}{46} \times 1364 = 5930J *$$

ii. E = n x ΔH

$$= * \frac{0.4}{32} \times 725 = 9063J *$$

2 + 2 = 4 marks

c. **i**. Assume 30 mL = 30g
60% of heat transferred = 5930 x 0.60
= 3558 J

$E = 4.18 \times 30 \times \Delta T = 3558$

$\Delta T = 28.4$

Final temp = 46 °C **

ii. Assume 50 mL = 50g
60% of heat transferred = 9063 x 0.60
= 5438 J

$E = 4.18 \times 50 \times \Delta T = 5438$

$\Delta T = 26$

Final temp = 48 °C **

2 + 2 = 4 marks
Total 12 marks

Question 8

a. **i**. This will not be true* because not all of the carbon monoxide will react. The amount of hydrogen reacting will be double that of carbon monoxide but it will not be the whole 10 mol reacting*

ii. This will not be true*. The stoichiometry of the equation shows that the number of mole of hydrogen must be twice that of carbon monoxide*

iii. This is true*. The system will move to decrease the pressure by moving in the forward direction. This is exothermic*

1 + 1 + 2 = 4 marks

b. Graph B shows K dropping as temperature increases. (exothermic reaction)*

1 mark

c. $K = \frac{[CH_3OH]}{[CO][H_2]^2}$ *

As methanol is the only reactant at the start, twice as much hydrogen is formed as carbon monoxide.
Let [CO] = X, then $[H_2] = 2X$ *

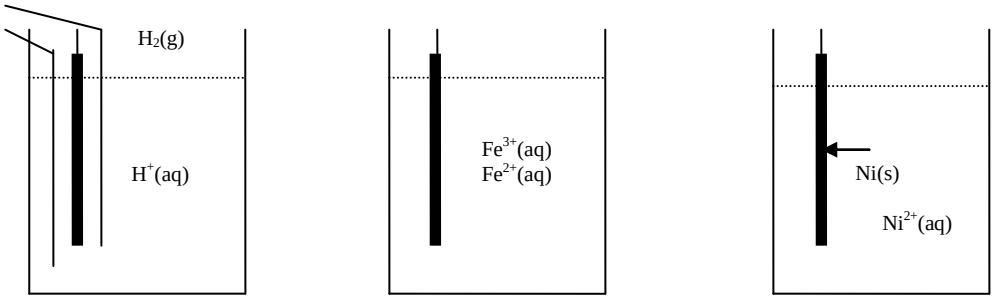
$$1 = \frac{0.1}{X \times (2X)^2}$$

$$4X^3 = \frac{0.1}{1} = 0.1 \quad *$$

$$X = \sqrt[3]{0.025} = 0.29M$$

3 marks
Total 8 marks

Question 9



A **B** **C**

a. **i**. Beaker A: $2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$

ii. Beaker B: $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ See diagram above***

iii. Beaker C: $Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$

iv. $Fe^{3+}(aq)$ * (See Data Booklet)

v. Beakers B and C* (See Data Booklet)

1 + 1 + 1 + 1 + 1 = 5 marks

b.

In this cell, the

i. positive electrode will be $Fe^{3+}(aq)$ half cell electrode*

ii. $Fe^{3+}(aq)$ *

iii. electrons will flow from beaker C to beaker B*

1 + 1 + 1 = 3 marks

Total 8 marks

Question 10

Polarity

$CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$ (+) cathode*

$LiC_6 \rightarrow C_6 + Li^+ + e^-$ (-) anode *

(phases are not shown as organic solvents are used)

a. **i**. & **ii**. see above

iii. $CoO_2 + LiC_6 \rightarrow LiCoO_2 + C_6$ *

iv. Before = +4 After = +3 *

1 + 1 + 1 + 1 = 4 marks

b.

$E = VIt = 4.6 \times 1.1 \times 5 \times 60 = 1518 Joules$ *

1 mark

c. **i**. $LiCoO_2 + C_6 \rightarrow CoO_2 + LiC_6$ *

ii. $LiCoO_2 \rightarrow CoO_2 + Li^+ + e^-$ Anode * (same as during discharge)

1 + 1 = 2 marks

Total 7 marks

Question 11

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

1 mark

b. **i**. pH will increase toward 7. *

ii. It will only get close to 7 if the $CaCO_3$ is in excess*. Given that CO_2 is slightly soluble to form a weak acid, the pH will not reach 7.*

1 + 2 = 3 marks

c. The acid in Beaker B might be about twice the concentration of the acid in flask A. This is assuming the $CaCO_3$ is in excess in both beakers.*

1 mark

d. The $CaCO_3$ in flask A might have been ground into very fine particles, hence the reaction rate is faster. The concentration of the acid might however have been weaker, hence the mass loss is less. Alternatively, the temperature in Beaker A might have been higher and the concentration of the acid weaker. A catalyst is added to the solution.

2 marks

Total 7 marks