CHEMISTRY

Units 3 & 4 – Written examination

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(*TSSM's 2011 trial exam updated for the current study design*)

SOLUTIONS

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

Question 1

Answer: C

Explanation:

Reduction is a gain in electrons. The oxidant undergoes reduction and may lose oxygen in this process. The substance undergoing reduction will have a decrease in oxidation number.

Question 2

Answer: D

Explanation:

A fuel cell is defined as having a constant supply of reactants. It acts as a primary galvanic cell where it converts chemical energy to electrical energy and the anode is negative.

Question 3

Answer: D

Explanation:

Chloromethane has a formula of CH_3Cl. If the chlorine atom is the ^{37}Cl isotope, then the mass of this ion will be (12 + 3 + 37) = 52

Question 4

Answer: B

Explanation:

In an electrolytic cell the anode will be positively charged, therefore negatively charged ions (anions) in the electrolyte will move toward the anode.

Question 5

Answer: C

Explanation:

An IR spectroscopy signal at 1750 cm^{-1} corresponds to a C=O bond. Option C is the only structure that contains this bond.

Question 6

Answer: D

Explanation:

High temperature, pH extremes and heavy metals (such as Lead and Mercury) can all lead to denaturation of an enzyme. Low temperatures will just lead to a decrease in activity of the enzyme.

Question 7

Answer: C

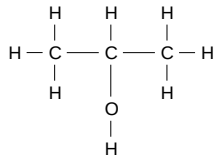
Explanation:

2 mole of ethene will produce 2 mole of ethanol.
The mass of 2 mole of ethanol is 2 x 46 = 92 g

Question 8

Answer: B

Explanation:



2-propanol will have three sets of peaks. The O – H is not split as it is attached to the oxygen atom. The other hydrogen atom on the middle carbon has 6 equal neighbouring hydrogen atoms. Under the n+1 rule, this will lead to a septet (split in 7)

Question 9

Answer: B

Explanation:

n (naphthalene) = m/M = 0.8210/128.2 = 0.006404 mol
1 mol of naphthalene → 5140 kJ
0.006404 mol of naphthalene → x kJ
x = 5140 x 0.006404 = 32.92 kJ
C.F. = 32.92/4.21 = 7.82 kJ/°C

Question 10

Answer: B

Explanation:

Both molecules are alkanols. They are both likely to be soluble in water (option B). Proton NMR will have a different number of peaks for each molecule. The first molecule is not a primary alkanol, so it will not react with $Cr_2O_7^{2}$. The fingerprint region is unique for all molecules.

Question 11

Answer: A

Explanation:

From the Data book, the amino acid is serine. It does however have an extra H atom. This will happen in acid conditions.

Question 12

Answer: A

Explanation:

- CO – O - = ester; -NH – CO - = amide, - NH_2 = amino; - COOH = carboxyl

Question 13

Answer: A

Explanation:

Adding up the atoms gives $C_{17}H_{31}COOH$. This is identified as linoleic acid from the Data book. To save adding up all the hydrogen atoms, you could count up the carbon atoms. There are 18. If saturated, the number of H atoms should be double that or 36. For each double bond, subtract 2 hydrogens. Therefore this molecule has 32 hydrogen atoms making it linoleic acid.

Question 14

Answer: C

Explanation:

R_f is inversely proportional to R_t, therefore the order on a TLC plate will be reversed on a HPLC.

Question 15

Answer: A

Explanation:
The central carbon does not have 4 different groups.

Question 16

Answer: D

Explanation:
When the reaction is reversed, the sign of ΔH is changed but the magnitude is not. Therefore ΔH is +91. The value of K becomes the reciprocal. The reciprocal of 12.5 is 0.08.

Question 17

Answer: A

Explanation:
The reaction is exothermic so an increase in temperature leads to a lower yield. A decrease in pressure also favours the reverse reaction because there are more products than reactants.

Question 18

Answer: B

Explanation:
$2SO_4^{2-} + 10H^+ + 8e^- \rightarrow S_2O_3^{2-} + 5H_2O$ (x5)
$\underline{Br_2 + 6H_2O \rightarrow 2BrO_3^- + 12H^+ + 10e^-}$ (x4)
$\mathbf{10}SO_4^{2-} + \mathbf{4}Br_2 + \mathbf{2}H^+ \rightarrow \mathbf{5}S_2O_3^{2-} + \mathbf{8}BrO_3^- + \mathbf{1}H_2O$

Question 19

Answer: D

Explanation:
Assume a volume of 1 Litre
n (NH_3) = PV/RT = ((2 x 101.3) x 1)/(8.31 x (25.0 + 273))
= 0.0818 mol
m (NH3) = n x M = 0.0818 x (14.0 + 3 x 1.0) = 1.39 g
Therefore density of ammonia at this temperature and pressure = 1.39 g/L

Question 20

Answer: A

Explanation:

The energy required will be
$E = 4.18\ x\ m\ x\ \Delta T = 4.18 \text{ x } 100 \text{ x } 40 = 16720\ J$

From Data book, 1 mole ethanol = 1364 kJ

$$n(\text{ethanol}) = \frac{16720}{1364000} = 0.0123 mol$$

$mass = n x M = 0.0123 \text{ x } 46 = 0.566\ g$

Question 21

Answer: D

Explanation:

Coal contains carbon and sulphur. Both of these burn to form carbon dioxide and sulphur dioxide. At the high temperatures, nitrogen in air also reacts to form NO. The NO reacts further to NO_2

Question 22

Answer: C

Explanation:

As the temperature increases, the yield drops. This matches an exothermic reaction. As the pressure increases the yield increases. This occurs if the forward reaction is favoured. This occurs if there are less product molecules than reactants.

Question 23

Answer: B

Explanation:

Conventional nuclear power stations use fission reactions where large uranium or plutonium nuclei are split. Radioactive waste is produced during this process. The electrons are irrelevant to the question.

Question 24

Answer: B

Explanation:

The reaction is very exothermic. As it proceeds, the temperature of the container increases. At the higher temperatures, the rate of the reaction will increase.

Question 25

Answer: B

Explanation:

$N_2(g) + O_2(g) \rightarrow 2NO(g) \quad \Delta H = +180 \text{ kJ mol}^{-1}$

$2NO(g) + O_2(g) \rightarrow 2NO_2(g) \quad \Delta H = -112 \text{ kJ mol}^{-1}$

$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$

The overall equation required is formed from the first equation provided and the second equation reversed. ΔH is therefore 180 -112 = +68

Question 26

Answer: B

Explanation:

The reaction will be $Cl_2(g) + Ni(s) \rightarrow 2Cl^-(aq) + Ni^{2+}(aq)$
This makes nickel the negative electrode. Electrons will leave here and travel to the chlorine half cell.

Question 27

Answer: D

Explanation:

The reaction will be $Cl_2(g) + Ni(s) \rightarrow 2Cl^-(aq) + Ni^{2+}(aq)$
This makes nickel the negative electrode. Electrons will leave here and travel to the chlorine half cell.

Question 28

Answer: A

Explanation:

The half equations will be
$Li \rightarrow Li^+ + e^-$ oxidation anode -ve
$Fe^{2+} + 2e^- \rightarrow Fe$ reduction cathode +ve

Question 29

Answer: C

Explanation:

The reaction occurring in the iron cell during recharge will be $Fe \rightarrow Fe^{2+} + 2e^-$
This is oxidation. Oxidation will be at the anode and the anode is positive during electrolysis

Question 30

Answer: B

Explanation:
$Q=It$ = 4 x 24125 = 96500 C
n(e)= 1mol
$Mg^{2+} + 2e^- \rightarrow Mg$
n(Mg) = 0.5

SECTION B – Short answer questions

** indicates 1 mark*

Question 1

Analytical task and technique chosen	**Reason the chosen method is unlikely to be suitable**
Gravimetric analysis to determine the mass of sodium nitrate in a 100 mL solution of sodium nitrate	$NaNO_3$ consists of Na^+ ions and NO_3^- ions. All compounds of these ions are soluble. Hence, whatever substance is added will not lead to a precipitate*
Separation of a mixture of monosaccharides using GC	Monosaccharides will decompose when heated. Since they cannot be vaporised, they cannot be carried through a GC*
Determination of the concentration of an ethanoic acid solution using a titration against sodium carbonate	Titrations between a weak acid and a weak base are not accurate. The equivalence point and the endpoint are too difficult to discern*
Determination of the concentration of ethanol solutions using infrared spectroscopy	Infrared spectroscopy might identify ethanol but it does not give an indication of the concentration. It is usually considered qualitative*

4 marks
Total 4 marks

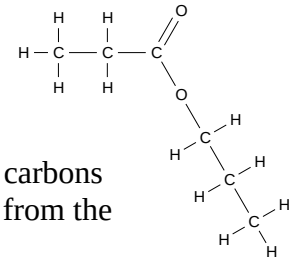
Question 2

a. i. oxidation*

ii. ester*

1 + 1 = 2 marks

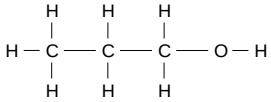
b. i. *



propylpropanoate*

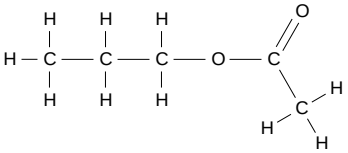
(both alkanol and acid must have 3 carbons each, since they were both formed from the same alkanol)

ii.



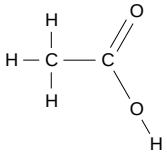
2 + 1 = 3 marks *

c.



* 1 mark

d. * 1 mark



e. **i**. $CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$*

ii. $n(NaOH) = c \times V = 0.1 \times 0.0086 = 0.00086\ mol$

$n(CH_3COOH) = n(NaOH) = 0.00086\ mol$*

$$c(CH_3COOH) = \frac{0.00086}{0.02} = 0.043\ M^*$$

1 + 2 = 3 marks

Total 10 marks

Question 3

A	B	C
CH_2O	$C_3H_7NO_3$	$C_8H_{16}O$

a. **i**. $CH_2O = 30$ $\frac{180}{30} = 6$ => molecular formula = $C_6H_{12}O_6$ *

ii. glucose (or fructose or aldose etc)*

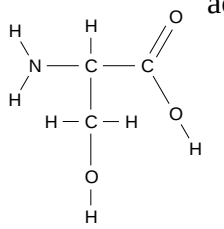
iii. there are several monosaccharides with the same molecular formula as this, but each have different structural formulae.*

1 + 1 + 1 = 3 marks

b.

i. Yes, as most amino acids have one nitrogen atom*

ii.



iii. Serine*

1 + 1 + 1 = 3 marks

c. Molecule C is a saturated fatty acid.

i. No, as a carboxyl group has two oxygen atoms*

ii. To get 2 oxygen atoms, double the formula $C_{16}H_{32}O_2$ * palmitic acid

1 + 1 = 2 marks

Total 8 marks

Question 4

a. **i**. 3 *

ii. 3:2:1 *

iii. CH_3 split into a triplet*, - CH_2 - split into 4*, O – H not split at all *

1 + 1 + 3 = 5 marks

b. **i**. 3300 cm^{-1} alcohol*; 3000 cm^{-1} C – H *

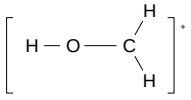
ii. Similarity: both have a broad peak around 3300 cm^{-1} for alcohol.(also C—C, C—H)*

Difference: the fingerprint region for each molecule will not overlap*

2 + 2 = 4 marks

c. **i**. The ethanol molecule might have a ^{13}C atom in it, making its mass 61 *

ii. The other fragment will be CH_2OH^+ *



1 + 1 = 2 marks

Total 11 marks

Question 5

a. $CH_3COOC_6H_4COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COOC_6H_4COO^-(aq)$*

1 mark

b. **i.** $CH_3COOC_6H_4COOH(aq) + NaOH(aq) \rightarrow CH_3COOC_6H_4COONa(aq) + H_2O(l)$*

ii. Being an ionic compound, its solubility is greater*

1 + 1 = 2 marks

c. n (NaOH) = c x V = 0.0250 x 0.01232 = 3.08 x 10^{-4} mol*
n (aspirin) = n (NaOH) = 3.08 x 10^{-4} mol*
m (aspirin) = n x M = 3.08 x 10^{-4} x (9 x 12.0 + 8 x 1.0 + 4 x 16.0)
= 0.0554 g*
M (aspirin) in 1 tablet = 0.0554/5 = 0.0111 g*

4 marks

Total 7 marks

Question 6

a. i. $Fe \rightarrow Fe^{2+} + 2e^-$

1 mark

ii. $H_2O + ½\ O_2 + 2e^- \rightarrow 2OH^-$

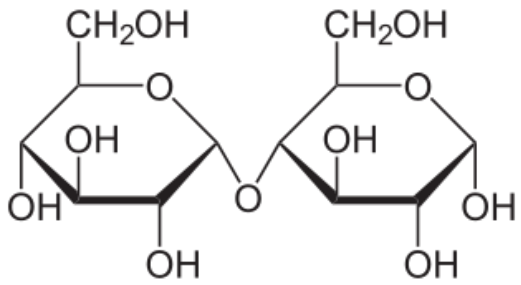
1 mark

b. n (Fe) = m/M = 5.00/ 55.8 = 0.0896 mol*
n (e-) = n (Fe) x 2 = 0.0896 x 2 = 0.179 mol*
Q = n (e-) x F = 0.179 x 96500 = 17293 C*
Q = I x t
T = Q/I = 17293/20 = 865 sec*

4 marks
Total 6 marks

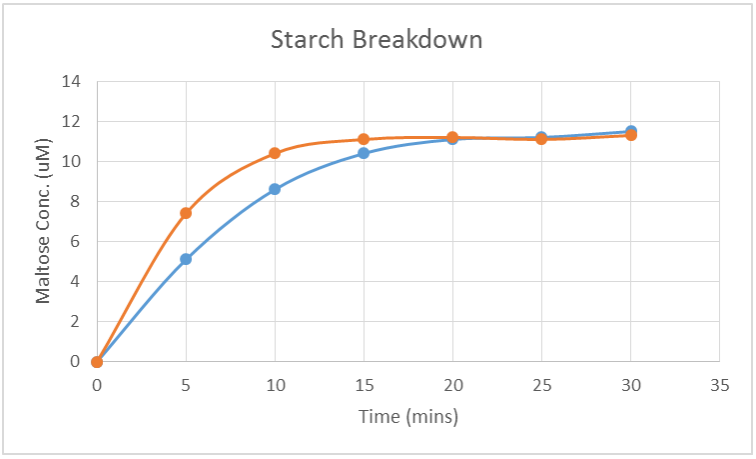
Question 7

a.



2 marks

b.



1 mark each for axis labels, scaling, correct plotting and title

4 marks

c. All of the starch had been converted to maltose.

1 mark

d. See graph

1 mark

e. Factors that affect the rate of a reaction:

- Concentration – an increase in the concentration of the starch solution will lead to an increase in the rate of a reaction due to an increased number of particles.

- Temperature – an increase in the temperature, increases the kinetic energy of particles and leads to a greater proportion of fruitful collisions.
- Surface Area – If we increase the surface area of the reactants then the rate will increase due to a greater number of collisions.
- If we take away or reduce the catalyst then the reaction will decrease its rate.

(Any 2 of the above for 2 marks each)

4 marks
Total 12 marks

Question 8

a. i. From the 1 minute mark to the 5 minute mark = 4 minutes*
The temperature is increasing consistently during calibration.

ii. $CF = \frac{VIt}{\Delta T} = \frac{3.6 \times 5.8 \times 4 \times 60}{3.2} = 1570 J°C^{-1}$ **

(answers will vary with reading of graph)

1 + 2 = 3 marks

b. **i**. The temperature change should be double*

ii. It should be unchanged*. The temperature change is greater but the energy input is also greater *

1 + 2 = 3 marks

c. i. 6.5 ºC (depending upon reading of graph)*

ii. $E = CF \times \Delta T$ = 1570 x 6.5 = 10205 J*

$n(CuSO_4) = \frac{5}{159.5} = 0.0313 mol$ *

$\Delta H = \frac{10205}{0.0313} = -326 kJmol^{-1}$ *

1 + 3 = 4 marks
Total 10 marks

Question 9

a. **i**. Steam, carbon dioxide, sulphur dioxide, nitrogen oxides, carbon monoxide**

ii. $S(s) + O_2(g) \rightarrow SO_2(g)$*
$C(s) + O_2(g) \rightarrow CO_2(g)$

1 + 1 = 2 marks

b. **i**. in the generator? mechanical → electrical *

ii. in the boiler chemical potential → thermal *

1 + 1 = 2 marks

c. Increase the surface area to make the reaction rate higher.* Helps dry the coal

1 mark

d. Coal takes millions of years to form hence it is not considered renewable*

1 mark
Total 6 marks

Question 10

a.

	cell A	**cell B**
anode: half equation	$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$	$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$
cathode: half equation	$Mg^{2+}(l) + 2e^- \rightarrow Mg(l)$	$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
products	$Mg(l)$, $Cl_2(g)$	H_2, O_2, $H^+(aq)$, $OH^-(aq)$

1 mark each cell 6 marks

b.

Species	**number of mole produced**
magnesium	2.2 mole from cell A as Mg^{2+}
chlorine gas	2.2 mole from cell A as Cl_2
oxygen gas	1.1 mole from cell B as O_2
hydrogen gas	2.2 mole from cell B as H_2

1 mark each cell 4 marks

c. Total gas = oxygen + hydrogen + chlorine = 1.1 + 2.2 + 2.2 = 5.5 mole *

$V=nx22.4$ at STP = 5.5 x 22.4 = 123 *L* *

2 marks
Total 12 marks

Question 11

a. **i**. No. A lower figure will be reached as this reaction is reversible hence all of the reactants are not used*

ii. 3.2 mole of CO must have reacted therefore 10 – 3.2 remains = 6.8 mole*

1 + 1 = 2 marks

b. **i**. No. The K value for the reverse reaction is very low. The level of CO will be very low*.

ii. The sealed room makes a big difference. The engine running will use up significant oxygen so the concentration will be very low. There is so little oxygen left the forward reaction is limited leaving CO levels still dangerously high. *

1 + 1 = 2 marks

c. Add air to the room*
Decrease the temperature*
Increase the pressure*

3 marks
Total 7 marks