

CHEMISTRY

Units 3 & 4 – Written examination



(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

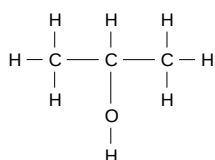
Explanation:

2 mole of ethene will produce 2 mole of ethanol.
The mass of 2 mole of ethanol is $2 \times 46 = 92\text{ g}$

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:

$$n(\text{naphthalene}) = m/M = 0.8210/128.2 = 0.006404 \text{ mol}$$

$$1 \text{ mol of naphthalene} \rightarrow 5140 \text{ kJ}$$

$$0.006404 \text{ mol of naphthalene} \rightarrow x \text{ kJ}$$

$$x = 5140 \times 0.006404 = 32.92 \text{ kJ}$$

$$\text{C.F.} = 32.92/4.21 = 7.82 \text{ kJ/}^\circ\text{C}$$

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 $\text{Cr}_2\text{O}_7^{2-}$. 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, - NH₂ = 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

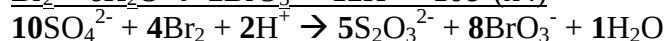
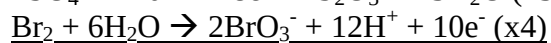
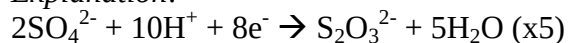
Explanation:

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:



Question 19

Answer: D

Explanation:

Assume a volume of 1 Litre

$$n(\text{NH}_3) = PV/RT = ((2 \times 101.3) \times 1)/(8.31 \times (25.0 + 273)) \\ = 0.0818 \text{ mol}$$

$$m(\text{NH}_3) = n \times M = 0.0818 \times (14.0 + 3 \times 1.0) = 1.39 \text{ g}$$

Therefore density of ammonia at this temperature and pressure = 1.39 g/L

Question 20

Answer: A

Explanation:

The energy required will be

$$E = 4.18 \times m \times \Delta T = 4.18 \times 100 \times 40 = 16720 \text{ J}$$

From Data book, 1 mole ethanol = 1364 kJ

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

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

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 NO₂

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

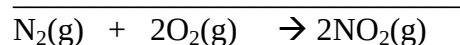
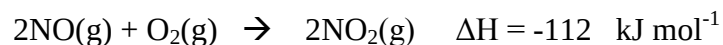
Explanation:

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:



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 $\text{Cl}_2(\text{g}) + \text{Ni}(\text{s}) \rightarrow 2\text{Cl}^-(\text{aq}) + \text{Ni}^{2+}(\text{aq})$

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 $\text{Cl}_2(\text{g}) + \text{Ni}(\text{s}) \rightarrow 2\text{Cl}^-(\text{aq}) + \text{Ni}^{2+}(\text{aq})$

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

$\text{Li} \rightarrow \text{Li}^+ + \text{e}^-$ oxidation anode -ve
 $\text{Fe}^{2+} + 2\text{e}^- \rightarrow \text{Fe}$ reduction cathode +ve

Question 29

Answer: C

Explanation:

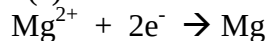
The reaction occurring in the iron cell during recharge will be $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$

This is oxidation. Oxidation will be at the anode and the anode is positive during electrolysis

Question 30*Answer: B**Explanation:*

$$Q = It = 4 \times 24125 = 96500 \text{ C}$$

$$n(e) = 1 \text{ mol}$$



$$n(\text{Mg}) = 0.5$$

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	Titration 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*

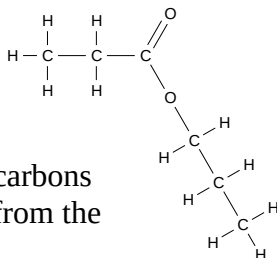
ii. ester*

1 + 1 = 2 marks

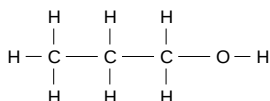
b. i. *

propylpropanoate*

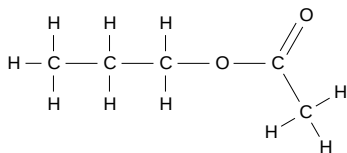
(both alkanol and acid must have 3 carbons each, since they were both formed from the same alkanol)



ii.



c.

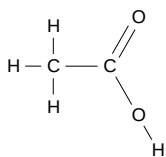


* 1 mark

2 + 1 = 3 marks

*

d. * 1 mark

e. i. $\text{CH}_3\text{COOH}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{CH}_3\text{COONa}(\text{aq}) + \text{H}_2\text{O}(\text{l})^*$

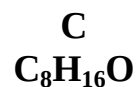
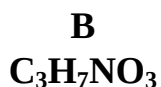
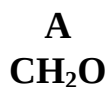
ii. $n(\text{NaOH}) = c \times V = 0.1 \times 0.0086 = 0.00086 \text{ mol}$
 $n(\text{CH}_3\text{COOH}) = n(\text{NaOH}) = 0.00086 \text{ mol}^*$

$$c(\text{CH}_3\text{COOH}) = \frac{0.00086}{0.02} = 0.043 \text{ M}^*$$

1 + 2 = 3 marks

Total 10 marks

Question 3



a. i. $\text{CH}_2\text{O} = 30 \quad \frac{180}{30} = 6 \Rightarrow \text{molecular formula} = \text{C}_6\text{H}_{12}\text{O}_6 *$

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.*

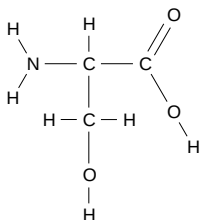
1 + 1 + 1 = 3 marks

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 $\text{C}_{16}\text{H}_{32}\text{O}_2 *$ palmitic acid

1 + 1 = 2 marks

Total 8 marks

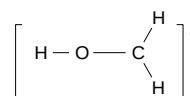
Question 4**a. i.** 3 ***ii.** 3:2:1 *

iii. CH₃ split into a triplet*, -CH₂- 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 ¹³C atom in it, making its mass 61 ***ii.** The other fragment will be CH₂OH⁺ *

1 + 1 = 2 marks

Total 11 marks

Question 5**a.** CH₃COOC₆H₄COOH(aq) + H₂O(l) ⇌ H₃O⁺(aq) + CH₃COOC₆H₄COO⁻(aq)*

1 mark

b. i. CH₃COOC₆H₄COOH(aq) + NaOH(aq) → CH₃COOC₆H₄COONa(aq) + H₂O(l)***ii.** Being an ionic compound, its solubility is greater*

1 + 1 = 2 marks

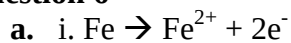
c. n(NaOH) = c x V = 0.0250 x 0.01232 = 3.08 x 10⁻⁴ mol*n(aspirin) = n(NaOH) = 3.08 x 10⁻⁴ mol*
$$m(\text{aspirin}) = n \times M = 3.08 \times 10^{-4} \times (9 \times 12.0 + 8 \times 1.0 + 4 \times 16.0)$$

$$= 0.0554 \text{ g}^*$$

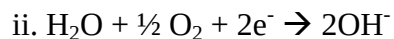
M(aspirin) in 1 tablet = 0.0554/5 = 0.0111 g*

4 marks

Total 7 marks

Question 6

1 mark



1 mark

b. $n(\text{Fe}) = m/M = 5.00/55.8 = 0.0896 \text{ mol}^*$

$n(\text{e}^-) = n(\text{Fe}) \times 2 = 0.0896 \times 2 = 0.179 \text{ mol}^*$

$Q = n(\text{e}^-) \times F = 0.179 \times 96500 = 17293 \text{ C}^*$

$Q = I \times t$

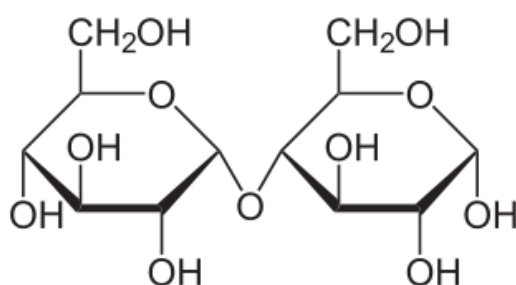
$T = Q/I = 17293/20 = 865 \text{ sec}^*$

4 marks

Total 6 marks

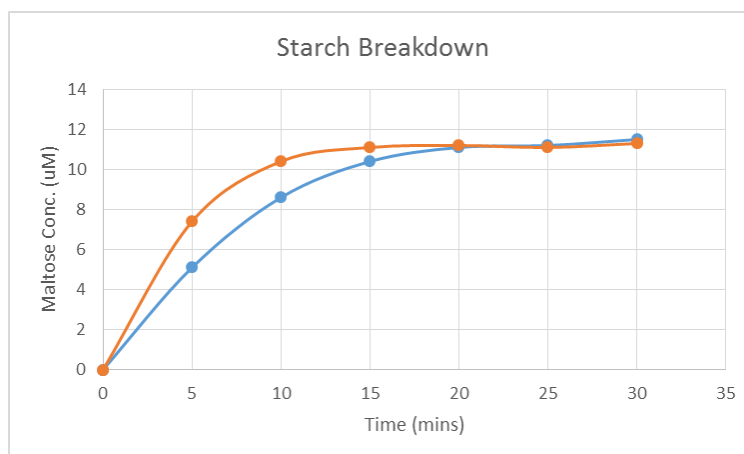
Question 7

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. $CF = \frac{VIt}{\Delta T} = \frac{3.6 \times 5.8 \times 4 \times 60}{3.2} = 1570 J^{\circ}C^{-1} \quad **$
(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 °C (depending upon reading of graph)*

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

$$n(\text{CuSO}_4) = \frac{5}{159.5} = 0.0313 \text{ mol}^*$$

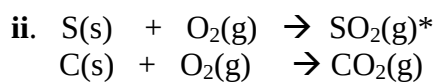
$$\Delta H = \frac{10205}{0.0313} = -326 \text{ kJ mol}^{-1}^*$$

1 + 3 = 4 marks

Total 10 marks

Question 9

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



1 + 1 = 2 marks

b. i. in the generator? mechanical $\rightarrow$ electrical *

ii. in the boiler chemical potential $\rightarrow$ 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	$2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$	$2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^-$
cathode: half equation	$\text{Mg}^{2+}(\text{l}) + 2\text{e}^- \rightarrow \text{Mg}(\text{l})$	$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$
products	$\text{Mg}(\text{l}), \text{Cl}_2(\text{g})$	$\text{H}_2, \text{O}_2, \text{H}^+(\text{aq}), \text{OH}^-(\text{aq})$

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 *

$$V = nx22.4 \text{ at STP} = 5.5 \times 22.4 = 123 \text{ L} *$$

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