CHEMISTRY

Units 3&4 - Written examination

TSSM™
Creating VCE Success

(TSSM's 2016 trial exam updated for the current study design)

SOLUTIONS

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

Question 1

Answer: C

Explanation:

$n(N_2)$ = PV/RT = ((1.5x101.3) x 0.50)/(8.31 x 300) = 0.030 mol
n (N atoms) = 0.030 x 2 = 0.060 mol
n (CH_4) = 0.060/5 mol
V (CH_4) = ((0.060/5) x 8.31 x 300) / (1.5x101.3) = 0.20 L

Question 2

Answer: D

Explanation:

$\Delta T = q/(Cm) = 1584/(60 \times 2.4) = 11$ °C
Final temperature = 23 + 11 = 34 °C

Question 3

Answer: D

Explanation:

Zinc ions are a weak oxidant and Lead solid is a weak reductant and therefore the arrangement on the electrochemical series is non-spontaneous.

Question 4

Answer: C

Explanation:

Primary cells cannot be recharged

Question 5

Answer: C

Explanation:

Mass spectroscopy does not provide information on bond types.

Question 6

Answer: A

Explanation:

The use of a standard curve is used to allow HPLC to be quantitative.

Question 7

Answer: B

Explanation:

The tripeptide is G – G – G, where two water molecules are eliminated when the peptide links have formed. The molar mass of glycine is 75 g mol^{-1}, so a tripeptide will be three times this, subtract the two water molecules = $75 \times 3 - (2 \times 18) = 189$ g mol^{-1}

Question 8

Answer: A

Explanation:

Enzymes are proteins.

Question 9

Answer: D

Explanation:

Must form one mole of water and from correct equation.

Question 10

Answer: D

Explanation:

$n(K_2Cr_2O_7) = c \times V = 0.1 \times 0.02 = 0.002$ mol

$n(\text{ethanol}) = \frac{3}{2}\, n(K_2Cr_2O_7) = \frac{3}{2} \times 0.002 = 0.003$ mol

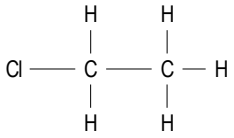
$c(\text{ethanol}) = \frac{0.003}{0.016} = 0.188$ M

Question 11

Answer: C

Explanation:

Chloroethane will have two different hydrogen environments; one with a triplet and the other a quartet.



Question 12

Answer: B

Explanation:

$K = [H_2][I_2]/[HI]^2 = (0.60 \times 0.07)/ (1.9 \times 1{,}9) = 0.011$
This value is lower than the equilibrium constant so the reaction will continue to move forward to create more H_2 and I_2.

Question 13

Answer: D

Explanation:

The longest carbon chain is 6 carbons long making the base of this molecule hexane. Numbering needs to start on the ethyl group on the left side – this leads to the third carbon having two methyl groups; 3,3-dimethylhexane

Question 14

Answer: C

Explanation:

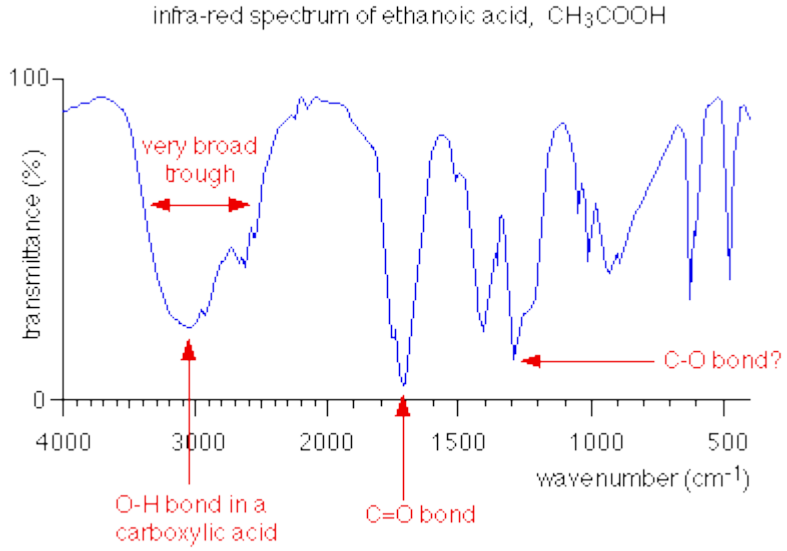
The first reaction between propene and water will produce propanol. The propanol can react with ethanoic acid in the second reaction to form propylethanoate.

Question 15

Answer: A and C

Explanation:

An absorption band around 3300 cm^{-1} corresponds to a hydroxyl group. Molecule C is the only alternative that has an – OH(alkanol)



Question 16

Answer: B

Explanation:

Hippuric acid has a benzene group on the left end, then a – CO-NH- amide group and a carboxyl group (COOH) on the right hand end.

Question 17

Answer: B

Explanation:

From the Data Book. Benzoic acid has a formula C_6H_5COOH. When this reacts with the amine group on glycine, hippuric acid and water are formed.

Question 18

Answer: A

Explanation:

The second reaction is the reverse of the first. The equilibrium constant will be the reciprocal of the first. The reciprocal of 0.005 is 200

Question 19

Answer: C

Explanation:

Equation 1 + 2 x reverse of equation 2 + 2 x equation 3
-622 + (2 x 188) + (2 x -286) = -818

Question 20

Answer: B

Explanation:

Enzymes denature at high temperatures. Denaturation causes the enzyme to lose the shape that catalyses a particular reaction so the rate drops.

Question 21

Answer: D

Explanation:

Each of the hydrocarbon chains comes from a different fatty acids. The top chain contains 18 carbon atoms and it is saturated => stearic.
The second fatty acid has 18 carbon atoms and one double bond matching oleic acid.
The third fatty acid has 16 carbon atoms and is saturated => palmitic acid

Question 22

Answer: A

Explanation:

The reaction is exothermic so a decrease in temperature will favour the forward reaction and a higher yield.

Question 23

Answer: C

Explanation:

The reverse is more likely to be used in a coal-fired power station – kinetic energy to mechanical energy, where the steam turns a turbine.

Question 24

Answer: C

Explanation:

Energy per mole of carbon is 394 kJ

$n(\text{carbon}) = \frac{1000}{394} = 2.54$ mol

mass = 2.54 x 12 = 30.5 g

Question 25

Answer: C

Explanation:

From the electrochemical series, the two relevant half-equations are
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$
Therefore Pb^{2+} will react with Fe; lead ions are reduced (oxidant) and iron is oxidised (reductant)

Question 26

Answer: D

Explanation:

Pb^{2+} ions are converted to lead metal. The potassium ions move into this cell to replace the positive ions removed.

Question 27

Answer: C

Explanation:

In a fuel cell, oxygen will react at the cathode. Ethanol will react at the anode in this cell. Option C is a correctly balanced half-equation for ethanol.

Question 28

Answer: D

Explanation:

Electrons will flow from the anode to the cathode in either type of cell

Question 29

Answer: B

Explanation:

The half equations occurring are
$Al^{3+} + 3e \rightarrow Al$ and
$2O^{2-} \rightarrow O_2 + 4e^-$
In balancing the electrons, 4 mole of aluminium will form for each 3 mole of oxygen gas

Question 30

Answer: A

Explanation:

In the electrolysis of brine, hydrogen forms at the cathode and chlorine forms at the anode.
$H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ (In a dilute aqueous solution, oxygen gas will form at the anode. However in a concentrated solution, chlorine forms.)
The OH^- formed combines with Na^+ to form sodium hydroxide as a third product.

SECTION B : Short-answer questions

Question 1 (11 marks)

a. $q = C\ m\ \Delta T = 4.18 \times 100 \times (23.1 - 16.5) = 2759$ J*

b. $CF = E/\Delta T = 2759/(23.1\text{-}16.5) = 418$ J/°C* = 0.418 kJ/°C*

c. $2HNO_3\ (aq) + Na_2CO_3\ (s) \rightarrow 2NaNO_3\ (aq) + H_2O\ (l) + CO_2\ (g)$**

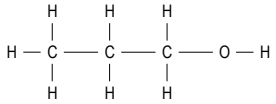
d. $E = CF \times \Delta T = 0.418 \times (21.2 - 17.4) = 1.59$ kJ*
1.59 kJ/ 0.0075 mol HNO_3 (limiting reactant)*
$\Delta H = -212$ kJ/mol*

e. The result of this experiment will be too high* due to the current calculation assuming all of the heat energy is absorbed by the water*. Some of the heat of the reaction will be absorbed into the calorimeter and raise the temperature of the water.*

Question 2 (11 marks)

a. $\frac{60}{12} : \frac{26.6}{16} : \frac{13.3}{1} = 5 : 1.66 : 13.3 = 3:1:8$ **

Empirical formula C_3H_8O *



3 marks

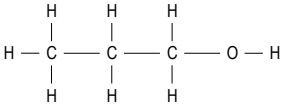
b. **i**. There is no absorption band around 1700 cm^{-1} 1 mark

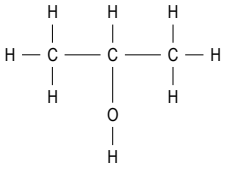
ii. The broad band is around 3300 cm^{-1} matching a –OH (alkanol) rather than an –OH (acid) 1 mark

c. **i**. Molar mass = 60 = empirical formula of C_3H_8O
molecular formula = C_3H_8O 1 mark

ii. The base peak has a m/z ratio of 31. This is characteristic of a primary alkanol. CH_2OH^+ 1 mark

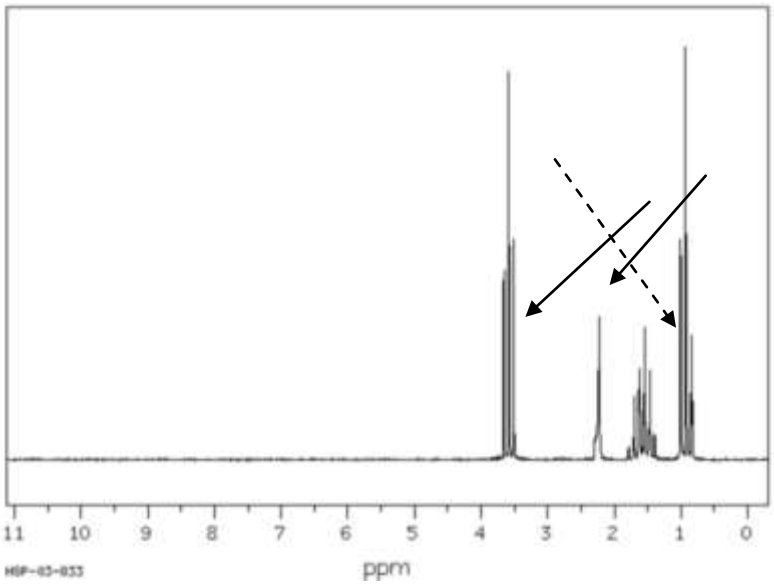
d.





2 marks

e.

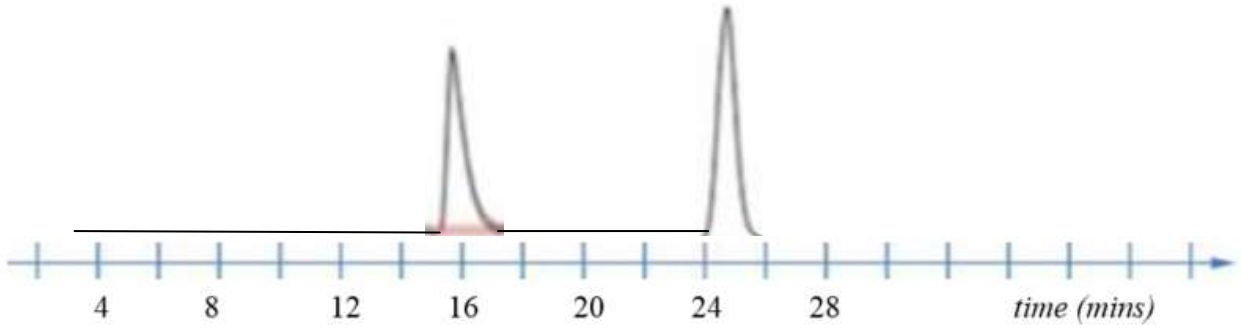


The molecule in question is propan-1-ol and not propan-2-ol*. Propan-1-ol has four different hydrogen environments whereas propan-2-ol would have three.*

2 marks

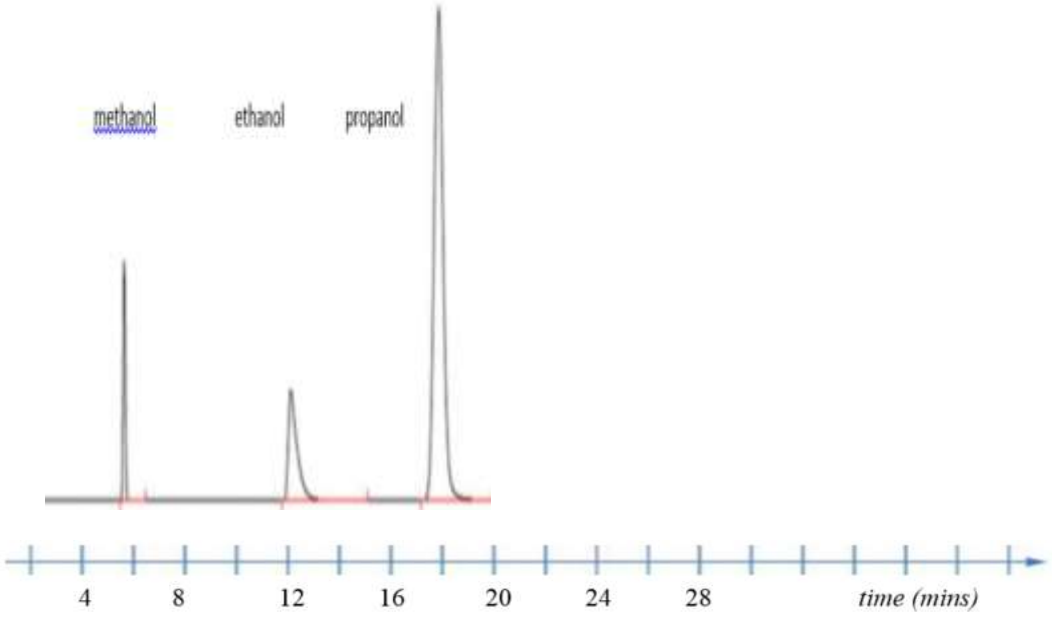
Question 3 (4 marks)

a. **i**. no peak methanol, ethanol twice size*, propanol ½ size* 2 marks



ii. Half the concentration should lead to half the area = 3960 units 1 mark

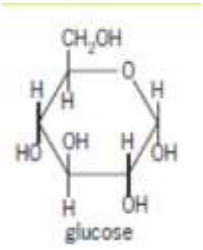
b. Same peaks but lower retention times 1 mark



Question 4 (12 marks)

Reaction A

a. i.



1 mark

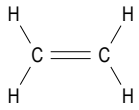
ii. $C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$ 1 mark

iii. A renewable fuel can be replenished in a reasonable period of time.

1 mark

Reaction B

b. i.



1 mark

ii. $C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(aq)$ 1 mark

Reaction C

c. i. $C_{18}H_{36}O_2 + C_2H_6O - H_2O \rightarrow C_{20}H_{40}O_2$ 1 mark

ii. $C_{20}H_{40}O_2(l) + 29O_2(g) \rightarrow 20CO_2(g) + 20H_2O(g)$

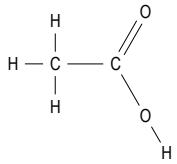
1 mark for correct products and states, 1 mark for balancing

2 marks

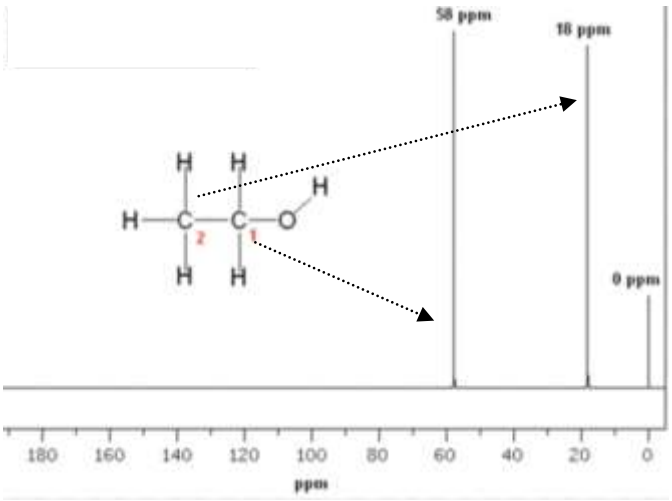
Reaction D

d. i. $Cr_2O_7^{2-}(aq)$ 1 mark

ii. 1 mark



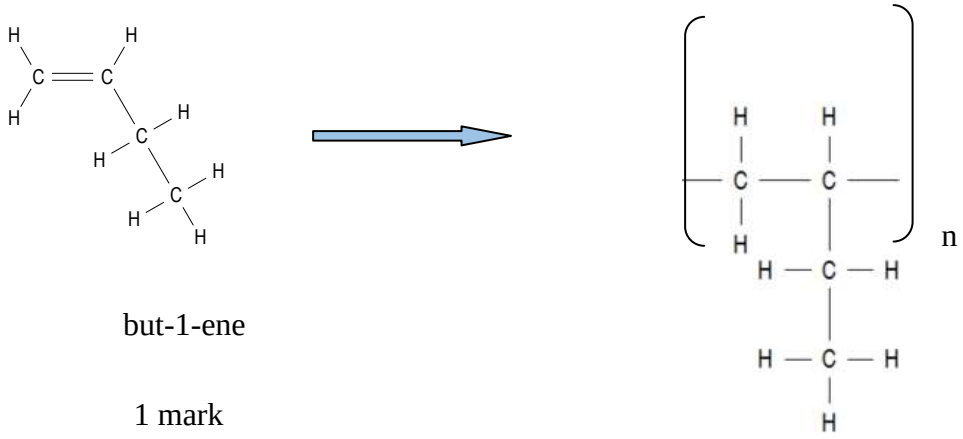
e. Two different carbon environments as shown below. The shift for a CH_2-OH carbon is given in the data book as around 50 - 90 ppm, and CH_3 at 8-25ppm.



. 2 marks

Question 5 (5 marks)

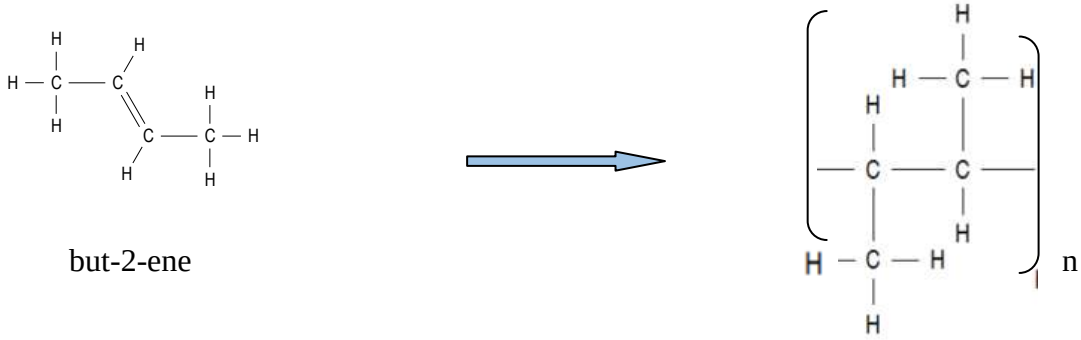
a. **i**. 2 marks



but-1-ene

ii. addition 1 mark

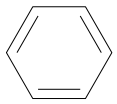
b. 2 marks



but-2-ene

Question 6 (7 marks)

a. C (1 molecule glucose + 1 molecule fructose – water) 1 mark

b. **i**. D  1 mark

ii. $2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(g)$ 1 mark

c. molecule A is aspartic acid 1 mark

d. molecule E is glycerol.

1 mark

e. molecule B is formed from stearic acid and methanol

$C_{18}H_{36}O_2 + CH_4O - H_2O \rightarrow C_{19}H_{38}O_2$

f. molecule F is linoleic acid. It contains two double bonds. 1 mark

Question 7 (8 marks)

a.

$C_{15}H_{29}COOCH_2$
|
$C_{15}H_{29}COOCH + 3H_2O \rightarrow 3$ .. $C_{15}H_{29}COOH$*... + ...$C_3H_8O_3$*.....
|
$C_{15}H_{29}COOCH_2$

2 marks

b. Dehydration OR Use of preservatives

1 mark

c. An antioxidant is a substance that slows the rate of oxidation*. This is the opposite effect of a catalyst which are there to speed up reactions*,

2 marks

d. $C_{15}H_{29}COOH$ (aq) + NaOH (aq) → $C_{15}H_{29}COONa$ (aq) + H2O (l)

n (NaOH) = c x v = 0.130 x 0.0194 = 0.00252 mol *

n ($C_{15}H_{29}COOH$) = n (NaOH) = 0.00252 mol *

m ($C_{15}H_{29}COOH$) = n x M = 0.00252 x 254 = 0.641 g *

% hydrolysed = 0.641/3.21 x 100 = 20.0% *

4 marks

Question 8 (9 marks)

a. 3 marks

The reaction is endothermic so forward reaction is favoured =>

K increased, red intensity greater and $[Fe^{3+}]$ lower

Impact upon K	higher
Impact on red intensity	greater
Impact on $[Fe^{3+}]$	lower

b. 3 marks

This increases the Fe^{3+} level, the system moves forward to oppose this change=>

Red intensity greater. K is unchanged as temperature is unchanged

$[Fe^{3+}]$ is higher than before the change as extra Fe^{3+} was added to the solution

Impact upon K	none
Impact on red intensity	greater
Impact on $[Fe^{3+}]$	higher

c. 3 marks

Reaction opposes the addition of water by favouring the reverse reaction to make more particles =>

K unchanged as temperature constant

Red intensity lower due to the initial dilution

$[Fe^{3+}]$ lower due to initial dilution being more significant than the partial change

Impact upon K	none
Impact on red intensity	lower
Impact on $[Fe^{3+}]$	lower

Question 9 (7 marks)

a. 3 marks

$n(CaCO_3) = \frac{1}{100} = 0.01$ mol $\quad n(HCl) = c \times V = 1 \times 0.02 = 0.02$ mol

This is the stoichiometric ratio needed for the reaction *

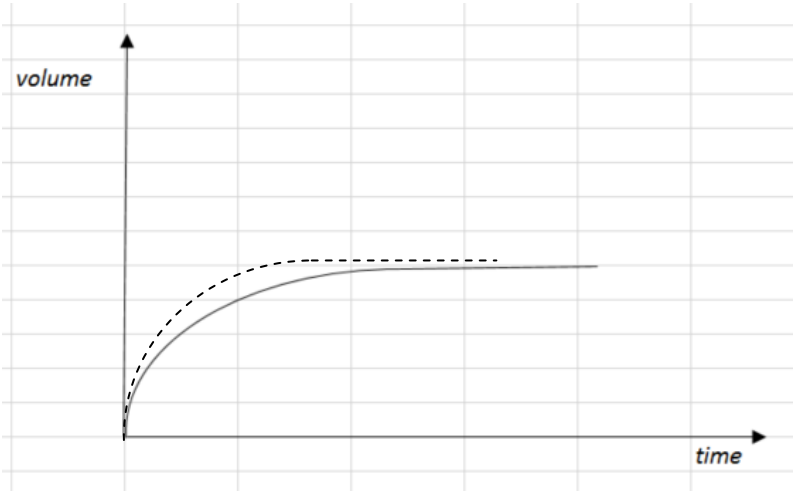
$n(CO_2) = 0.01$ mol *

$V = n \times 24.5 = 0.01 \times 24.5 = 0.245$ L *

b. **i**. The rate grows quickly at first as the concentrations are high* and collisions high. As the reaction proceeds the reactants are used up and their concentrations decrease and collisions decrease. 2 marks

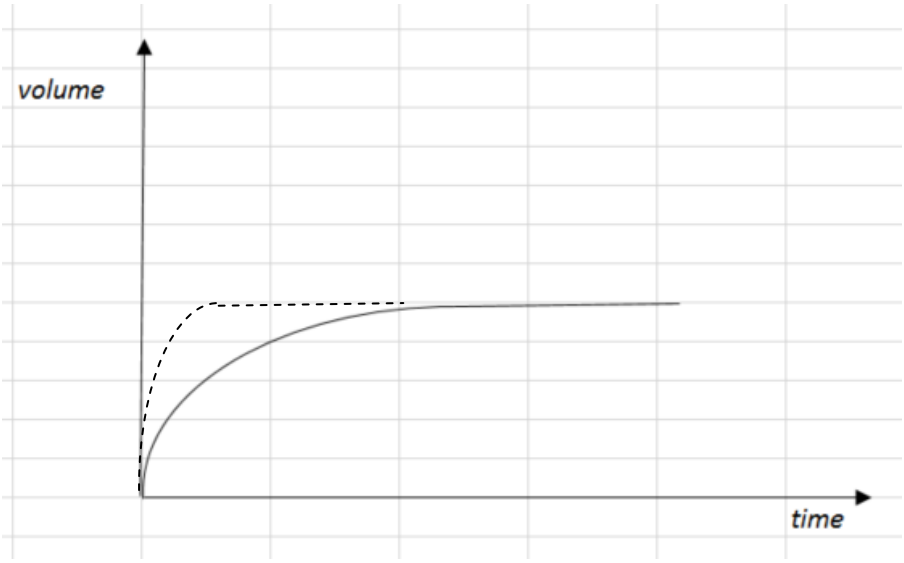
ii. The rate of evolution of gas is faster but the final volume is unchanged as the calcium carbonate is the limiting reagent.

1 mark



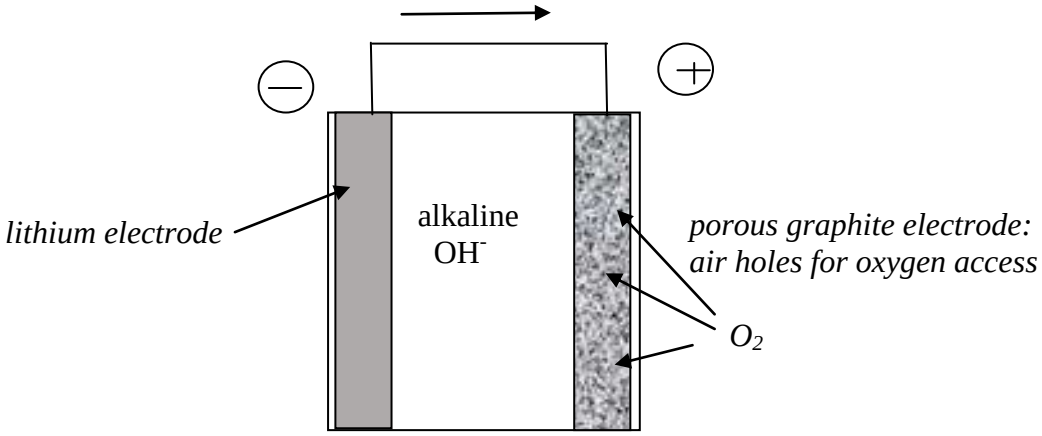
c.

1 mark



The rate of evolution is faster still as the average kinetic energy is higher due to the temperature increase.

Question 10 (7 marks)



a.

3 marks

Anode: $Li(s) \rightarrow Li^+(aq) + e^-$

Cathode: $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

Overall: $4Li(s) + O_2(g) + 2H_2O(l) \rightarrow 4Li^+(aq) + 4OH^-(aq)$

b. **i**. see diagram (lithium is oxidized = anode = -ve). 1 mark

ii. see diagram 1 mark

c. 1 mark

i. $4Li^+(aq) + 4OH^-(aq) \rightarrow 4Li(s) + O_2(g) + 2H_2O(l)$

ii. Oxygen 1 mark

Question 11 (10 marks)

a. **i**. A molten solution is formed by melting an ionic solid. It is a liquid and contains no water.

1 mark

ii. If an aqueous solution is used, there is the possibility of water reacting instead of magnesium and chloride ions. From the electrochemical series it can be shown water is in fact the strongest oxidant and the strongest reductant in an aqueous solution of $MgCl_2$. Therefore the products would be hydrogen and oxygen gases.

Anode: oxygen gas 2 marks

Cathode: hydrogen gas

iii. It takes considerable heat energy to melt large quantities of an ionic salt. 1 mark

b. Anode: $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$ 2 marks

Cathode: $Mg^{2+}(l) + 2e^- \rightarrow Mg(l)$

c. 4 marks

$$n(\text{Mg}) = \frac{1000000}{24.3} = 41200 \text{ mol } *$$

$$n(\text{e}) = 2 \times n(\text{Mg}) = 2 \times 41200 = 82300 \text{ mol } *$$

$$Q = n(\text{e}) \times 96500 = 82300 \times 96500 = 7.94 \times 10^{9} *$$

$$t = \frac{Q}{I} = \frac{7.94 \times 10^{9}}{2500} = 3.18 \times 10^{6} \text{ s } *$$