CHEMISTRY

Units 3 & 4 – Written examination

TSSM™
Creating VCE Success

(TSSM's 2008 trial exam updated for the current study design)

SOLUTIONS

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

Question 1

Answer: B

Explanation:

n (N_2) = m/M = 76/(2 x 14.0) = 2.71 mol
PV=nRT
P = nRT/V = (2.71 x 8.31 x (-37 + 273))/ 1.5
= 3548 kPa
= 3548/101.3 = 35.1 atm

Question 2

Answer: D

Explanation:

n (H_2O) = m/M = 1.00/18.0 = 0.0556 mol
Latent heat of fusion = energy required to transform 1 mol of solid water in liquid water
1 mol ice requires 6.0 kJ of energy
0.0556 mol of ice requires x kJ of energy
X = 6.0 x 0.0556 = 0.334 kJ = 334 J
Therefore not enough energy has been provided to convert all the ice into water, some will still remain solid.

Question 3

Answer: B

Explanation:

$ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$
Option A is correct for an acidic solution, while options C and D don't balance.

Question 4

Answer: B

Explanation:

Overall equation: 5 CH_3CH_2OH (aq) + 4 MnO_4^- (aq) + 12 H^+ (aq) → 5 CH_3COOH (aq) + 4 Mn^{2+} (aq) + 15 H_2O (l)
n (MnO_4^-) = n (ethanol)/5 x 4 = 0.02/5 x 4 = 0.016 mol = n ($KMnO_4$)
V ($KMnO_4$) = n/c = 0.016/0.02 = 0.8 L = 800 mL

Question 5

Answer: D

Explanation:

NMR, IR and MS provide qualitative structural data

Question 6

Answer: D

Explanation:

Options A, B and C are correct, while Option D is incorrect as peaks will not always have even numbered values of m/z, eg Ammonia (NH_3) has a parent peak of 17.

Question 7

Answer: B

Explanation:

Wavenumber is proportional to energy, therefore the order of increasing energy is:
C=C (1610 – 1680)
C=O (170 – 1750)
C-H (2850 – 3300)
O-H (alcohol) (3200 – 3550)
Wavenumbers are taken straight from Data booklet

Question 8

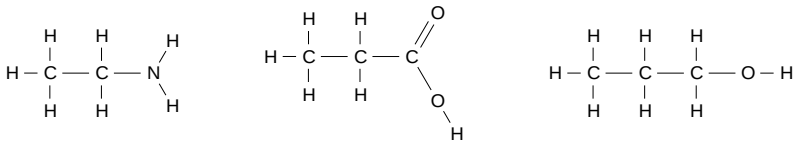
Answer: A

Explanation:

All H's are the same => 1 peak only on ^{1}H NMR. There are two different carbon environments CO and CH_3 => 2 peaks on ^{13}C NMR

Question 9

Answer: A



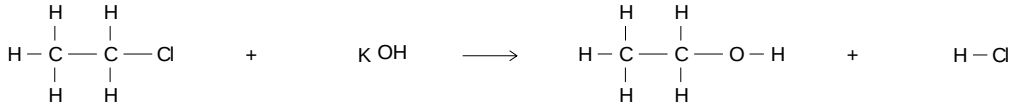
Explanation:

The first molecule is ethylamine. There is no need for a 1- as there are no other possibilities. The second molecule is propanoic acid. Again there is no need for a 1 -. The third molecule is 1-propanol; the 1- is needed to distinguish this from 2-propanol.

Question 10

Answer: B

Explanation:

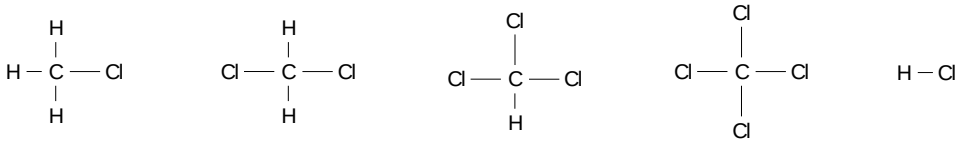


Question 11

Answer: D

Explanation:

The substitution of chlorine continues, forming a range of chlorinated compounds. HCl is also a product



Question 12

Answer: A

Explanation:

Propane. Substitution adds a Cl atom and then KOH substitutes an –O – H group.

Question 13

Answer: D

Explanation:

Electroplating cells convert electrical energy back into chemical energy.

Question 14

Answer: C

Explanation: O

||

NH_2 is amine and C –O - is an ester

Question 15

Answer: A

Explanation:

Biodiesel is an ester formed from the reaction of methanol and a fatty acid. Proteins have a - NH – CO- bond and carbohydrates have an ether bond C – O – C

Question 16

Answer: C

Explanation:

A drop in temperature will lower the rate. Addition of water will dilute the reaction, causing a drop in concentration and therefore decreasing the number of collisions.

Question 17

Answer: A

Explanation:

The extra water will dilute the solution, making the rate of reaction lower. Therefore the rate of evolution of gas will decrease.

Question 18

Answer: D

Explanation:

The reaction is exothermic, therefore decreasing the temperature will push the reaction to the right.

Question 19

Answer: A

Explanation:

The K value of the reverse reaction is the reciprocal of the forward reaction. The only way a number and its reciprocal are equal, is if the number is 1.

Question 20

Answer: A

Explanation:

The reaction is exothermic, so the back reaction is favoured. Therefore the nitrogen and oxygen have increased and the NO has decreased. The NO decreases by twice the amount due to the balancing of the equation.

Question 21

Answer: C

Explanation:

Natural gas contains a mixture of low molecular mass alkanes. Methane is the most likely.
Fuel cells can use gases other than hydrogen; nuclear power uses nuclear fission.

Question 22

Answer: A

Explanation:

The sequence is chemical energy to thermal energy of coal. This is converted to thermal energy of steam. Steam turns the turbine (mechanical energy) and electricity is produced.

Question 23

Answer: C

Explanation:

$$n(ethanol) = \frac{0.6}{46} = 0.013mol$$
$$energy = 0.013 \times 1364 = 17.79kJ$$
$$CF = \frac{energy}{\Delta T} = \frac{17790}{11.7} = 1520\,J\,{}^{o}C^{-1}$$

Question 24

Answer: D

Explanation:

$n(H_2) = \frac{2.4}{2} = 1.2mol$

The reaction requires 2 H_2 molecules to produce 484 kJ

$\frac{1.2}{2} = 0.6mol$

$energy = 0.6 \times 484 = 290kJ$

Question 25

Answer: D

Explanation:

The Fe^{3+} forms Fe^{2+} , while the iodide ions are converted to I_2. The iodide reaction is oxidation and it releases electrons.

$2I^- \rightarrow I_2 + 2e^-$

The electrons flow to the other cell.

Question 26

Answer: D

Explanation:

The only answer that could possibly work is D. $Q = It = 10 \times 145 \times 60 = 87000$ coulomb.

$\frac{87000}{96500} = 0.9mol$

In A, the voltage could be any value, it is the current that is more significant.
No metal would have an oxidation number that leads to 0.15 mole.

Question 27

Answer: A

Explanation:
The power supply pushes electrons to the negative electrode. The electrons will allow a reduction reaction to occur.

Question 28

Answer: B

Explanation:

Copper ions and iodide ions are the strongest oxidant and the strongest reductant in both cells. Therefore water will not react, so the products are the same in both cases, copper and iodine.
$Cu^{2+} + 2e^- \rightarrow Cu$ $2I^- \rightarrow I_2 + 2e^-$

Question 29

Answer: C

Explanation:

Reduction occurs at the cathode therefore cannot be B or D, and A is not a balanced half equations as it is has a charge of -8 on the left side and +8 on the right side of the equation

Question 30

Answer: C

Explanation:

Fuel cells require porous electrodes for the gases to pass through and they utilise a continuous supply of reactants.

SECTION B – Short answer questions

** indicates 1 mark*

Question 1

a. $C_{17}H_{33}COOH$ (l) + CH_3OH (l) → $C_{17}H_{33}COOCH_3$ (l) + H_2O (l)
1 mark each for correct reactants and products

2 marks

b. i. E = c x m x ΔT * = 4.18 x 50.0 x (26.2 – 18.4)
= 1.63×10^3 J*

2 marks

ii. $C_{17}H_{33}COOCH_3$ (l) + $27O_2$ (g) → $19CO_2$ (g) + $18H_2O$ (g)
1 mark for correct equation, 1 mark for correct balancing

2 marks

iii. n ($C_{17}H_{33}COOCH_3$) = m/M = 1.00/ (19 x 12.0 + 36 x 1.0 + 2 x 16.0)
= 0.00338 mol*
Therefore 0.00338 mol → 1.63×10^3 J
1 mol → x J
x = 1.63×10^3 / 0.00338 = 4.82×10^5 J = 482 kJ
ΔH = -482 kJ/mol*

2 marks

iv. Lower*, as a lot of heat energy will be lost during heating of the water in an open system*.

2 marks

c. Carbon neutral means that there is no nett gain in carbon to the environment.

2 marks

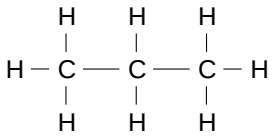
Question 2

a.

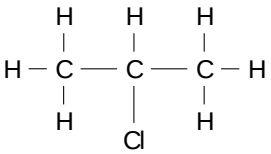
i. and

ii.

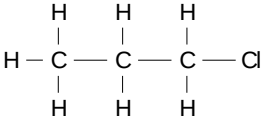
1 mark for each structure correct



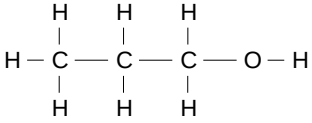
A propane



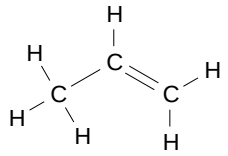
B 2-chloropropane



C 1-chloropropane



D 1- propanol (or propan-1-ol)



E propene

2 marks for all molecules named correctly, 1 mark for 2, 3 or 4 correct, 1 or less correct receives zero marks

iii. A → B substitution *

E → D addition*

5 + 2 + 2 = 9 marks

b.

i. ^{1}H NMR or infrared* – NMR probably better. Mass spec not easy to distinguish

ii. 2-chloropropane will have only two sets of peaks in NMR as the CH_3 groups are identical*. 1-chloropropane would have three sets of peaks, as each group of hydrogens (or carbons) has a different environment.*

1 + 2 = 3 marks

c. 2-propanol

1 mark

Total 13 marks

Question 3

a.

i. gas or gaseous state*

ii. It is bombarded with a beam of electrons – this makes it positively charged*

iii. The mass and the charge of the ion.*

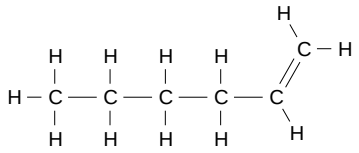
1 + 1 + 1 = 3 marks

b. It loses atoms to form different fragments i.e. losing one chlorine will change its mass*. Chlorine has two isotopes, therefore there are different possible masses for each fragment depending upon which isotope is present*

2 marks

c.

i. *



ii. The parent molecular ion should have the same mass for both molecules – they are structural isomers*

iii. 1-hexene has a methyl group, CH_3. This will have a mass of 15. Cyclohexane will not have the same peak.* (parent molecule -15, also correct)

iv. All carbons have the same arrangement of hydrogens in cyclohexane. The ^1H NMR will have only one peak*. The 1-hexene will have a peak for CH_3, a peak for CH_2 and a peak for CH. *

v. 1-hexene will have a C = C double bond absorption that cyclohexane does not have; 1600 -1700 cm^{-1} *

1 + 1 + 1 + 2 + 1 = 6 marks

Total 11 marks

Question 4

a. Compound A could be either 1 or 2 chloropropane or 1 or 2 propanol.

1 mark

b. A non-polar stationary phase means that the more non-polar molecule will spend longer in the column, and the more polar a molecule is the less time it will spend in the column*. Any of the above are more polar than propene and will therefore spend less time in the column*.

2 marks

c. CH_2CHCH_3 (g) + HCl (aq) → $CH_3CHClCH_3$ or $CH_2ClCH_2CH_3$ (aq)
OR
CH_2CHCH_3 (g) + H_2O (l) → $CH_3CHOHCH_3$ or $CH_2OHCH_2CH_3$ (aq)
(catalyst = H_3PO_4 and 400 °C)

2 marks

d. Compare R_t values of known standards*. Spike the sample with a known standard and look for an increase in peak height*.

2 marks

Question 5

a.

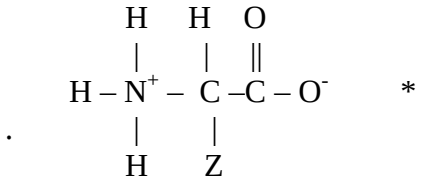
i. $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH=CHCH_2CH_2CH_2CH_2CH_2CH_2CH_2COOH$*

ii. $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH=CHCH_2CH_2CH_2CH_2CH_2CH_2CH_2COOCH_3$*

iii. $C_{19}H_{36}O_2\ (l) + 27O_2(g) \rightarrow 19CO_2(g) + 18H_2O(l)$*

1 + 1 + 1 = 3 marks

b.



*

1 mark

Total 4 marks

Question 6

Give concise explanations for each of the following.

a. Metals do not always form ions with the same charge.* Na^+, Ca^{2+} and Al^{3+} are three examples with different oxidation numbers. Each oxidation number requires a different number of electrons to form the metal i.e. 1 mole of electrons will only form ½ a mole of calcium $Ca^{2+} + 2e^- \rightarrow Ca$ *

2 marks

b. An increase in temperature often leads to a lower yield,* especially if the reaction is exothermic. The products might form quickly but the percentage yield might be much lower.*

2 marks

c. The calibration factor is determined from the formula $CF = \frac{energy}{\Delta T^*}$

The energy can be added by means other than electricity. A chemical reaction with a known ΔH can be used instead of electricity.*

2 marks

d. 1 mole of diesel contains more energy than 1 mole of ethanol but it also weighs significantly more than 1 mole of ethanol.* As fuel is sold per litre, the energy released per litre is fairly similar for both fuels.*

2 marks

Total 8 marks

Question 7

a. H – C ≡ C –H * 1 mark

b. For each space in the table, choose from **decrease**, **unchanged** or **increase**

change	value of K	equilibrium yield of ethyne	rate of reaction
decrease in temperature	decrease	decrease	decrease
increase in pressure	unchanged	decrease	increase
addition of a catalyst	unchanged	unchanged	increase

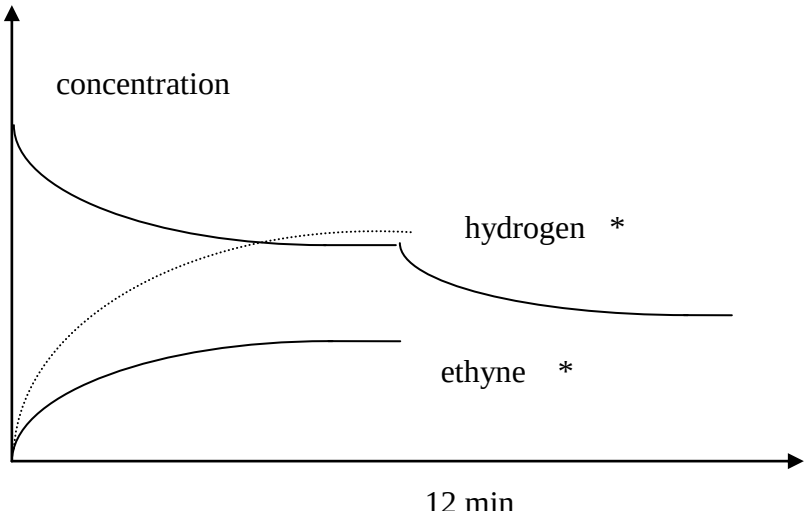
3 marks

* 1 mark for each row – the whole row must be correct

c.

i. And

ii.



iii. The amount of ethane has dropped after the 12 min mark. Therefore the amount of ethyne has increased. For an endothermic reaction, an increase in temp must have occurred. *

1 + 1 + 1 = 3 marks

d. Fuel cell – reacting with oxygen to form water. Rocket propulsion.*

1 mark

e. $2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$*

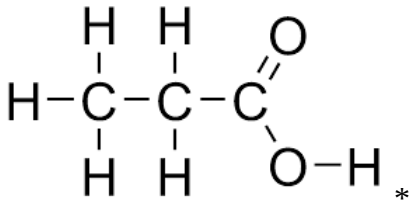
1 mark
Total 9 marks

Question 8

a. Compound A : Carboxyl*
Compound B: Ester linkage*

2 marks

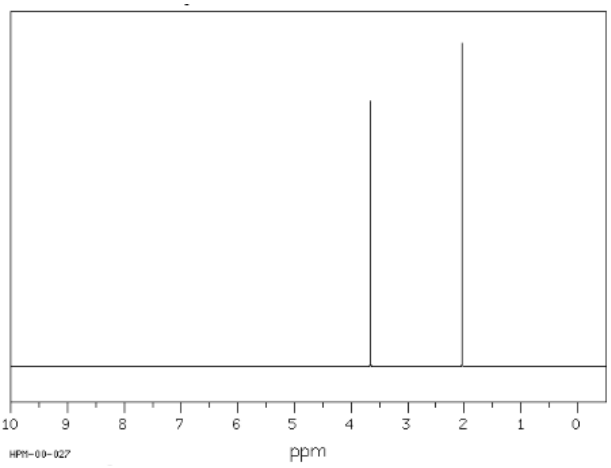
b. Propanoic acid*



2 marks

c. Compound B = Methyl ethanoate*
Reason: Peak at 59 is from CH_3COO^+ which is only from methyl ethanoate*
Base peak for compound B is CH_3CO^{+*}.
3 marks

d.



1 mark each for: correct peak position, correct heights, number of peaks and splitting.
4 marks

Question 9

a.

i. A and C*

ii. The activation energy in Graph A is lower. It represents the same equation with the use of a catalyst*

1 + 1 = 2 marks

b.

i. A, B, C and D. * The activation energy is always positive.

ii. D*

1 + 1 = 2 marks

c. $C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(g) \quad \Delta H = -2803 \text{ kJ mol}^{-1}$

$$n(O_2) = \frac{4.8}{32} = 0.15mol*$$

6 mole of oxygen produces 2803 kJ

Therefore $\frac{0.15}{6} = \frac{x}{2803}$

Therefore x = 70 kJ.

3 marks

Total 7 marks

Question 10

a. polarity
-ve
+ve*

1 mark

b. $V_2O_5(aq) + 2VO(aq) \rightarrow 2VO_2(aq) + V_2O_3(aq)$

1 mark

c. VO +2 V_2O_3 +3 V_2O_5 +5 VO_2 +4

½ mark each = 2 marks

d.

i. $E = VIt = 1.4 \times 3.5 \times 8 \times 60 \times 60^{*} = 141000\,*$ joule

ii. $Q = It = 3.5 \times 8 \times 60 \times 60 = 101000$ coulomb

$$n(e) = \frac{101000}{96500} = 1.04mol\,*$$
$$n(VO) = n(e) = 1.04mol\,*$$
$$mass(VO) = n \times M = 1.04 \times 66.9 = 69.9g\,*$$

2 + 2 = 4 marks
Total 8 marks

Question 11

a.

i. anode $4OH^-(l) \rightarrow O_2(g) + 2H_2O(g) + 4e^-$ *

cathode $K^+(l) + e^- \rightarrow K(l)$*

ii. anode +ve * cathode -ve *

2 + 2 = 4 marks

b. Potassium is very reactive in air and water*. A naked flame might be used to keep the potassium hydroxide molten. A naked flame near oxygen and liquid potassium is very dangerous. *

2 marks

c. $Q = It = 6.2 \times 4 \times 60 = 1488\,*$

$$n(e) = \frac{1488}{96500} = 0.0154$$
$$n(K) = n(e) = 0.0154$$
$$mass(K) = n \times M = 0.0154 \times 39.1 = 0.603g\,*$$

2 marks

d.

i. Some molten potassium and the oxygen are still in contact with their respective electrodes.* These can react spontaneously producing a galvanic cell.*

ii. $K(l) \rightarrow K^+(l) + e^-$ *

iii. –ve *

2 + 1 + 1 = 4 marks
Total 12 marks