CHEMISTRY

Unit 3 – Written examination 1

2008 Trial Examination

SOLUTIONS

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

Question 1

Answer: C

Explanation:

$10 - 3.61 = 6.39$ g $CuSO_4$ $\quad \frac{6.39}{159.5} : \frac{3.61}{18} = 0.0400 : 0.200 = 1:5$

Question 2

Answer: C

Explanation:

Mass oxygen = $0.1685 - 0.14 = 0.0285g$

$$n(O) = \frac{0.0285}{16} = 0.00178\,mol$$

$$n(M) = 2 \times 0.00178 = 0.00356$$

$$M = \frac{m}{n} = \frac{0.14}{0.00356} = 39.3 \Rightarrow \text{metal is potassium}$$

Question 3

Answer: B

Explanation:

$$n(O) = \frac{0.0285}{32} = 0.00089\,mol$$
$$V = n \times 22.4 = 0.01995 = 0.02$$

Question 4

Answer: B

Explanation:

$$c = 0.45 \Rightarrow n \text{ in 1 litre} = 0.45 \times 1 = 0.45\,mol$$
$$n(Cl) = 2n(MgCl) = 2 \times 0.45 = 0.90\,mol$$
$$mass(Cl) = 0.9 \times 35.5 = 32\ \text{gL}^{-1}$$

Question 5

Answer: D

Explanation:

Oxidation number Fe = +3 in $FeCl_3$
Oxidation number Fe = +3 in Fe_2O_3
Oxidation number Fe = +3 in FeN

Question 6

Answer: A

Explanation:

$NH_4^+(aq) + S^{2-}(aq) \rightarrow NH_3(aq) + HS^-(aq)$
The NH_4^+ donates a H^+, forming NH_3. This is the definition of an acid. Also, the sulphide ion (S^{2-}) accepts and H^+ and thus behaves as a base.

Question 7

Answer: B

Explanation:

The concentration needs to change by a factor of 10 if the pH is drop by one numerical unit. 90 mL of water is added so that the volume goes from 10 to 100, representing a factor of 10.

Question 8

Answer: C

Explanation:

$n(NaOH) = 0.15 \times 0.2 = 0.003\,mol$
$n(ethanoic) = 0.003$
$c(ethanoic) = \frac{n}{V} = \frac{0.003}{0.02} = 0.15$
original concentration = $0.15 \times \frac{250}{10} = 3.75\,M$

Question 9

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 10

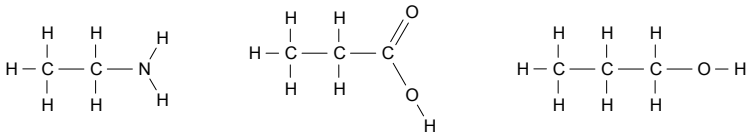
Answer: D

Explanation:

There will be many absorptions but there will definitely be C-H, C = O, O – H and these correspond to 3400, 3000 and 1100.

Question 11

Answer: A



Explanation:

The first molecule is aminoethane. 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 12

Answer: D

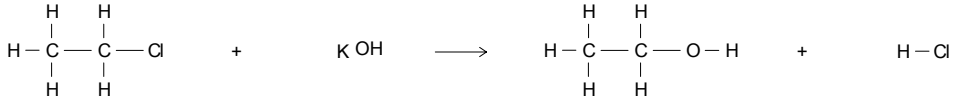
Explanation:

The temperature rises until $69^\circ C$ is reached. The temperature remains at $69^\circ C$ until all the hexane has evaporated. It will then go up to 107° where it will stay while the octane boils away.

Question 13

Answer: B

Explanation:

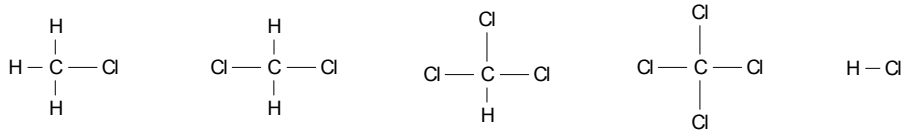


Question 14

Answer: D

Explanation:

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



Question 15

Answer: A

Explanation:

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

Question 16

Answer: C

Explanation:

2-chloropropane will form as well as 1-chloropropane. These two isomers can be separated by fractional distillation.

Question 17

Answer: B

Explanation:

Lysine has a molecular formula $C_6H_{14}O_2N_2$, which gives the empirical formula in the question.

Question 18

Answer: B

Explanation:

The complementary bases are thymine with adenine and cytosine with guanine

Question 19

Answer: C

Explanation:

NH_2 is amino and $\begin{matrix} O \\ \| \\ C-O- \end{matrix}$ is an ester

Question 20

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

SECTION B – Short answer questions

** indicates 1 mark*

Question 1

a. Calculate the number of mole of Na_2CO_3

$n = c \times V = 0.05 \times 0.0156 = 0.00078 mol$ *

1 mark

b. n(acid) if monoprotic = $2n(Na_2CO_3) = 2 \times 0.00078 = 0.00156 mol$

$$c = \frac{n}{V} = \frac{0.00156}{0.025} = 0.0624$$

$$\text{original} = 0.0624 \times \frac{250}{20} = 0.78M$$

If the acid is ..	concentration of diluted acid	concentration of original acid
Monoprotic	0.0624	0.78 *
Diprotic	0.0312	0.39 *
Triprotic	0.0208	0.26 *

1 mark for each correct row

3 marks

c. Stable, available in high purity, non reactive with air and carbon dioxide, cheap, known formula, soluble. (2 marks for any two of the above)

2 marks

d. This is probably a strong acid*. A wide transition would suggest a weak acid titration with a weak base.*

2 marks

e. $pH = -\log(0.78) = 0.11$*

1 mark

f. Poor choice. AAS works better with metal ion solutions, not acids*

1 mark

Total 10 marks

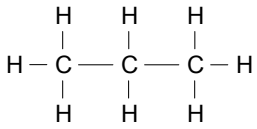
Question 2

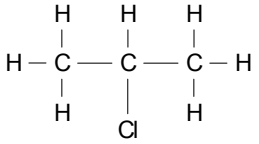
a.

i. and

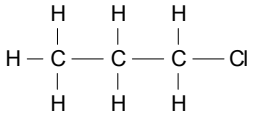
ii.

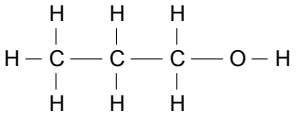
1 mark for each structure correct



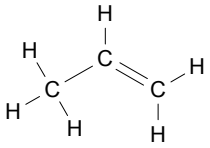


A propane B 2-chloropropane





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.*

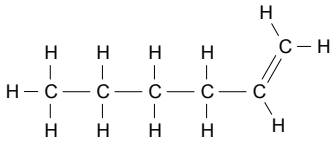
1 + 1 + 1 = 3 marks

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.

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

ii. $CaCl_2(aq)$ or $Ca^{2+}(aq)$*

1 + 1 = 2 marks

b.

i. $n(CaCl_2) = \frac{0.976}{111} = 0.00879\ mol$ *

ii. $n(CaCO_3) = n(CaCl_2) = 0.00879$ *

iii. $m(CaCO_3) = n \times M = 0.00879 \times 100 = 0.897g$ *

$\% = \frac{0.897}{2} \times \frac{100}{1} = 43.9\%$ *

2 + 1 + 2 = 5 marks

c.

i. mass of $CaCl_2$ low so % $CaCO_3$ low*

ii. mass of $CaCl_2$ low so % $CaCO_3$ low*

iii. mass of $CaCl_2$ high so % $CaCO_3$ high*

1 + 1 + 1 = 3 marks
Total 10 marks

Question 5

a.

i. $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH=CHCH_2CH_2CH_2CH_2CH_2CH_2CH_2COOH$*

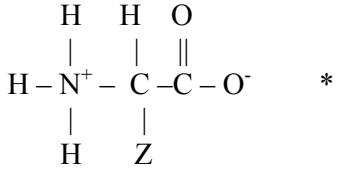
ii. $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH=CHCH_2CH_2CH_2CH_2CH_2CH_2CH_2COOCH_3$*

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

1 + 1 + 1 = 3 marks

b.

i.



*

ii. An amino acid with - SH in the Z group i.e. cysteine*

iii. An amino acid with hydrophobic Z group such as $–CH_3$ i.e. alanine*

iv. An amino acid with two acid or amine groups i.e. glutamine or glutamic acid*

1 + 1 + 1 + 1 = 4 marks
Total 7 marks

Question 6

a.

i. disease marker*

ii. high temperatures would cause the protein to denature*. This changes its properties.

iii. The infrared spectrum is like a fingerprint – it is unique for each substance. A molecule can be identified this way*

1 + 1 + 1 = 3 marks

b.

i. Sugar, phosphate and base branch*

ii. No –the base molecule can differ*. There are 4 possible base molecules*

iii. Condensation polymerisation*

1 + 2 + 1 = 4 marks

Total 7 marks

