CHEMISTRY

Units 3 & 4 – Written examination

2020 Trial Examination

SOLUTIONS

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

Question 1

Answer: C

Explanation:
Biodiesel molecules contain polar C=O groups which can form diploe-dipole bonds with neighbouring molecules.

Question 2

Answer: B

Explanation:
Heating an enzyme will not disrupt the covalent bonds in the primary structure but will disrupt the bonds in the secondary, tertiary and quaternary structures.

Question 3

Answer: C

Explanation:
Vitamin C is polar, it cannot act as an enzyme and cannot be produced by sunlight. It acts as an antioxidant where it interrupts the propagation of free radicals.

Question 4

Answer: D

Explanation:
The extra hydrogen gas will shift the equilibrium to the right and the higher pressure pushes the particles closer together which increases the number of successful collisions between molecules.

Question 5

Answer: A

Explanation:
The equation is reversed so the sign on the ΔH is reversed. The equilibrium constant is the reciprocal value.

Question 6

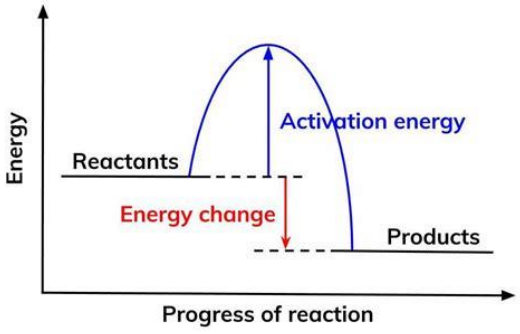
Answer: A

Explanation:
100g → 4 861kJ
1 mol weighs 128g,
1 mol → 4 861 × 1.28 = 6 222kJ

Question 7

Answer: A

Explanation:
Activation energy of reverse reaction is the activation energy shown plus the energy change.
Therefore, the activation of the reverse reaction is 362-282 = 80 $kJmol^{-1}$.



Question 8

Answer: C

Explanation:
Cathode; $Cu^{2+} + 2e^- \rightarrow Cu$
Anode; $Cu \rightarrow Cu^{2+} + 2e^-$

Question 9

Answer: A

Explanation:

- A is below B on the electrochemical series
- C is below D on the electrochemical series
- D is below A on the electrochemical series

Question 10

Answer: B

Explanation:
I^- would be oxidized to I_2 and H_2O would be reduced to OH^- and H_2, so the pH would increase overall.

Question 11

Answer: B

Explanation:
$CaCO_3$ is a solid so is removed from the equilibrium system. This would shift the equilibrium of all reactions to the right.

Question 12

Answer: C

Explanation:
Methanol becomes methyl and propanoic acid becomes propanoate. Water is also produced in the reaction.

Question 13

Answer: C

Explanation:
2-methylpropene will react with ammonia to form a mixture of 2-methylpropan-2-amine and 2-methylpropan-1-amine.

Question 14

Answer: A

Explanation:
Heating the mixture would result in the curve shifting to the right. The activation energy does not change its position. While the average kinetic energy of the particles increases, there is still a spread of energies so D is incorrect.

Question 15

Answer: D

Explanation:
The tallest peak is the base peak. A m/e reduction of 39 is required and it will not have a charge. The peak at m/e of 41 has the positive charge.

Question 16

Answer: D

Explanation:
$3Cu_{(s)} \rightarrow 3Cu^{2+}_{(aq)} + 6e^-$
$2NO_3^-{}_{(aq)} + 8H^+_{(aq)} + 6e^- \rightarrow 2NO_{(g)} + 4H_2O_{(l)}$
$2NO_3^-{}_{(aq)} + 8H^+_{(aq)} + 3Cu_{(s)} \rightarrow 2NO_{(g)} + 4H_2O_{(l)} + 3Cu^{2+}_{(aq)},$

Question 17

Answer: D

Explanation:
Oxidation numbers in brackets; H_2S (-2), S_8 (0), $Na_2S_2O_3$ (+2), H_2SO_3 (+4), H_2SO_4(+6)

Question 18

Answer: A

Explanation:
The negative electrode is the anode where oxidation occurs.
$CH_4O_{(g)} + H_2O_{(l)} \rightarrow CO_{2(g)} + 6H^+_{(aq)} + 6e^-$

Question 19

Answer: C

Explanation:
The catalyst adsorbs the reactants which enables bonds to break more easily and reform. It is a heterogeneous catalyst and is not consumed in the reaction.

Question 20

Answer: A

Explanation:
The time taken is the dependent variable. As there is calcium carbonate left at the end of the reaction, it is in excess.

Question 21

Answer: B

Explanation:
By recording the mass lost over time, the rate of reaction can be determined. Collecting the carbon dioxide gas would be appropriate if the rate of production was measured rather than just the total amount of carbon dioxide.

Question 22

Answer: B

Explanation:
$n(Cr) = 0.010\ mol$
$n(e^-) = 3n(Cr) = 0.030\ mol$
$n(O_2) = 1/4n(e^-) = 0.0075\ mol$
$m(O_2) = n\ X\ M = 0.0075\ X\ 32 = 0.24\ g$

Question 23

Answer: B

Explanation:
Water is a stronger oxidant than magnesium ions so magnesium cannot be reduced by an aqueous solution. While water would be a stronger reductant than chlorine, by using a concentrated solution of magnesium chloride, chloride would react in preference to water.

Question 24

Answer: A

Explanation:
Both carboxyl groups are deprotonated so the overall charge is -2. Note that the amino group will not be protonated in a high pH environment.

Question 25

Answer: C

Explanation:
The secondary structure is maintained by hydrogen bonds only.

Question 26

Answer: D

Explanation:
The lower the glycaemic index, the slower the rate of digestion. Fructose has to be converted to glucose before metabolism can take place. Amylose does not have a branched structure so is metabolised more slowly. The highly branched structure contains gaps which enables digestion to occur at a faster rate.

Question 27

Answer: B

Explanation:
An essential amino acid must be consumed as it cannot be made by the human body. All amino acids can be metabolised by the body and they do not act as co-enzymes.

Question 28

Answer: B

Explanation:
Aspartame has 2 chiral centres, contains an ester and carboxylic acid functional group, is much sweeter than glucose and contains a secondary amide group.

Question 29

Answer: D

Explanation:
The induced fit model involves the enzyme adjusting the shape of its active site. A co-enzyme may or may not be required and the enzyme still only acts over a small range of pH and temperature.

Question 30

Answer: B

Explanation:
The vitamins are mainly non-polar so will not dissolve in water. The longer hydrocarbon chain in MK-7 would mean that the chains would tangle with each other and increase the viscosity. These vitamins could not be produced by the human body and the arrangement around each bond is cis.

SECTION B: Short-answer questions

Question 1 (14 marks)

a. A fuel derived from living matter

1 mark

b. **i.** $C_6H_{12}O_{6(aq)} \rightarrow 2C_2H_5OH_{(aq)} + 2CO_{2(g)}$

ii. $C_2H_{4(g)} + H_2O_{(g)} \xrightarrow{H_3PO_4 \text{ and } 300°C} C_2H_5OH_{(g)}$

1 + 1 = 2 marks

c. Energy is used to harvest*, transport* and process* the raw material. (any 2*)

2 marks

d. n = m/M = 300 × 1000 / 342 = 877mol*
n(glucose) = n(sucrose) = 877 mol*
m = n × M = 877 x 180 = 157,895g or 158kg*

3 marks

e. **i.** V(octane) = 60 x 0.75 = 45L
m(octane) = 45 x 0.703 = 31.6kg
E = 31.6 x 47.9 = 1510 MJ*
V(ethanol) = 60 x 0.25 = 15L
m(ethanol) = 15 x 0.789 = 11.8kg
E = 11.8 x 29.6 = 349 MJ*
Total energy = 1860MJ*

ii. n(ethanol) = m/M = 11 800/46 = 256.5mol*
$n(CO_2)$ = 2n(ethanol) = 2 x 256.5 = 513mol*
V= n x 24.8 = 513 x 24.8 = 12 700L*

3 + 3 = 6 marks

Question 2 (8 marks)

a. $K_c = [PCl_5] / [PCl_3] [Cl_2]$*

	PCl_5	Cl_2	PCl_3
Initial	0.833	0	0
Change	0.333	0.33	0.33
equilibrium	0.50	0.33	0.33

K_c = 0.50 /(0.33 x 0.33) = $4.6M^{-1*}$

3 marks

b.

	Direction of equilibrium shift	Effect on rate of reaction
Increase in temperature	left	Increase
Decrease in pressure	left	Decrease
Addition of a catalyst	No change	Increase

(1/2 mark for each correct response)

3 marks

c. The equilibrium will shift left* to partly compensate for the loss of Cl_2.*

2 marks

Question 3 (9 marks)

a. B: 2-chloropropene
C: cis-1-chloropropene
F: butanoic acid

3 marks

b. **i.** F
ii. D,E,F
iii. A,C
iv. A,B,C
v. A,C
vi. E,F

6 x 1 = 6 marks

Question 4 (5 marks)

a. MH
b. e.g. KOH
c. $Ni(OH)_{2(s)} + OH^-_{(aq)} \rightarrow NiOOH_{(s)} + H_2O_{(l)} + e^-$
d. $Ni(OH)_{2(s)} + M_{(s)} \rightarrow MH_{(s)} + NiOOH_{(s)}$
e. The cell is a secondary cell as it can be recharged. (It is not a fuel cell as there is no fuel or oxygen)

Question 5 (9 marks)

a. n (benzoic acid) = n/M = 1.476/122 = 0.120 mol*
E = n x ΔH = 0.120 x 3227 = 39.04 kJ*
C.F. = E / ΔT = 39.04 / 3.00 = 13.0 kJ/°C*

3 marks

b. E = CF x ΔT = 13.0 x 1.75 = 22.75 kJ for 1.06g*
For 1.00g, E = 22.75 / 1.06* = 21.5 kJg^{-1*}

3 marks

c. Starch is formed form the polymerization of α-glucose where all CH_2OH side groups align in the same direction*. Cellulose is formed from the polymerization of β-glucose where the CH_2OH side groups alternate in an up and down direction.*

2 marks

d. An excess of oxygen is required to ensure that the reaction goes to completion.

1 mark

Question 6 (8 marks)

a. i.A: aspartic acid

ii. B: alanine

iii. C: leucine

Reason: Aspartic acid has 3 polar groups so is most attracted to the mobile phase. Alanine has 2 polar groups and leucine has a non-polar side chain so is least attracted to the mobile phase. (1 mark for each response if appropriate explanation given)

3 marks

b. i. This will result in a longer retention time as the molecules have further to go.

ii. This will result in a shorter retention time and the molecules are pushed along more quickly.

iii. This will result in a shorter retention time and the particles will move more quickly due their greater kinetic energy.

3 x 1 = 3 marks

c. Prepare standard solutions of B and measure the peak area that each solution produces when analysed using HPLC.* A graph of concentration v peak area can be constructed and then used to relate the peak area of B to the concentration of B.*

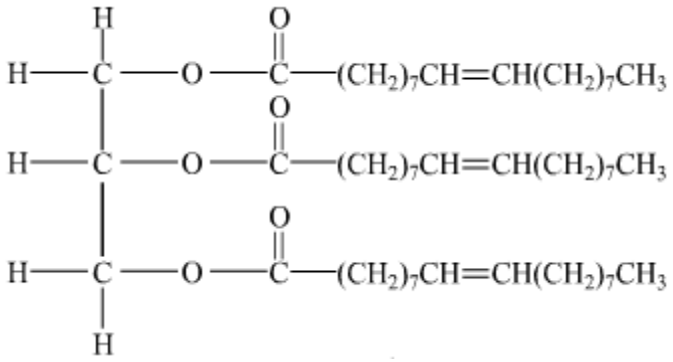
2 marks

Question 7 (10 marks)

a. $2C_{17}H_{33}COOH(l) + 51O_2(g) \rightarrow 36CO_2(g) + 34H_2O(l)$

1 mark

b. i.



ii. ester

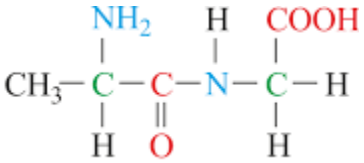
iii. Liquid. The molecule is monounsaturated where the kink in the middle of the chain spreads the adjacent chains further apart, lowering the melting point of the triglyceride.

1 + 1 + 2 = 4 marks

c. The diet lacks carbohydrates which can be oxidised easily to obtain energy.

1 mark

d. i.



Zwitterion form is also acceptable.

ii. There would be a gain of a H atom at the amine group as with the low pH in the stomach a H atom would be donated to the NH_2 group. Or in the zwitterion form the carboxyl group is reprotonated.

iii. dispersion forces
Hydrogen Bonds
ionic bonds
(any 2 accepted)

1 + 1 + 2 = 4 marks

Question 8 (7 marks)

a. Carbonyl

1 mark

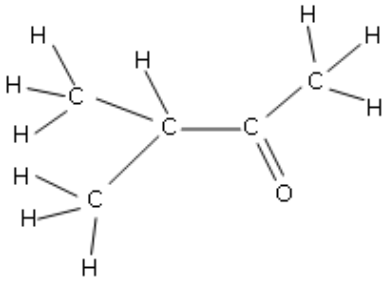
b. i. This could be formed due to two neighbouring CH_3 groups.

ii. There are no neighboring H atoms

1 + 1 = 2 marks

c. 5 carbon atoms (2 are identical, hence the 4 peaks in the C-NMR spectrum)

d. i.



ii. No chiral carbon atoms

1 + 1 = 2 marks

e. 3-methylbutan-2-ol

1 mark

Question 9 (8 marks)

a. $C_6H_8O_{6(aq)} \rightarrow C_6H_6O_{6(aq)} + 2H^+_{(aq)} + 2e^-$

1 mark

b. 18.98mL

1 mark

c. n = m/M = 0.258/(126.9 x 2) = 0.00102mol

c = n/V = 0.00102/0.25 = 0.00407M *

n(in aliquot) = c x v = 0.00407 x 0.02= 0.0000813mol *

n(vit C) = $n(I_2)$ = 0.0000813mol *

c (molarity) = n/v = 0.0000813/0.01898 = 0.00428M*

$c(gL^{-1}) = 0.00428 \times 176 = 0.753\ gL^{-1}$ *

5 marks

d. The orange juice is diluted so a greater volume is needed to reach the end point. A greater volume means a lower calculated concentration of vitamin C.

1 mark

Question 10 (12 marks)

a. **i.** n = m/M = $10^6/32$ = 31 250 mol *

V = nRT/P = 31 250 x 8.31 x73 / 50 = 3.79×10^5L *

ii. $n(e^-) = 4n(O_2)$ = 125,000 mol *

Q = 125 000 x 96 500 = 1.21×10^{10}C *

I = Q/t = 1.21×10^{10} / (1 x 60 x 60 x 24 x 365*) = 383A *

2 + 4 = 6 marks

b. An electrolysis cell would be constructed* with the rock heated so it becomes molten acting as the electrolyte*. The oxide ions would be oxidised to form oxygen at the anode* (and metal ions would be reduced at the cathode.)

3 marks

c. **i**. O_2

ii. $H_{2(g)} + 2OH^-_{(aq)} \rightarrow 2H_2O_{(l)} + 2e^-$

iii. OH^- (hydroxide ions)

3 x 1 = 3 marks