# CHEMISTRY

## Units 3 & 4 – Written examination

## 2019 Trial Examination

## ***SOLUTIONS***

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

**Question 1**

*Answer:* A

*Explanation:*

Biodiesel is produced from the reaction of fatty acids and methanol. The fatty acids can be obtained by hydrolysis of triglycerides.

**Question 2**

*Answer:* D

*Explanation:*

Ethanol can be obtained by the fermentation of plant matter, methane from the anaerobic breakdown of plant material, hydrogen from the electrolysis of water using a renewable energy source and biodiesel from waste triglycerides.

**Question 3**

*Answer:* D

*Explanation:*

Batteries have a very high energy efficiency. (although they have a low energy density)

**Question 4**

*Answer:* B

*Explanation:*

$n = \frac{m}{M} = \frac{1000}{2} = 500$ mol
$n(O_2) = 250$ mol
m = n X M = 250 x 32 = 8000 g or 8.0 kg

**Question 5**

*Answer:* A

*Explanation:*

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$
500mL of ethanol reacts with 1500 mL of oxygen to give a total of 2000 mL.
2500 mL of gases are produced, making an increase of 2500 – 2000 = 500 mL.

**Question 6**

*Answer:* A

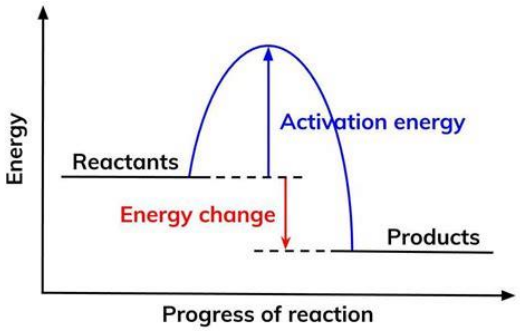
*Explanation:*

2500 kg → 64 000 kJ
So, 1kg → 64 000 / 2500 = 25.6 MJ $kg^{-1}$

**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:* D

*Explanation:*

$CH_4 + {}^3/_2O_2 \rightarrow CO + 2H_2O$
$n = \frac{m}{M} = 50/16 = 3.125$ mol
$n(O_2) = \frac{3}{2} n(CH_4) = 4.69$ mol
$v = n \times 24.8 = 4.69 \times 24.8 = 116g$

**Question 9**

*Answer:* C

*Explanation:*

When discharging, the lead electrode has a negative charge. During recharging, the electrons go in the opposite direction and as they are being "pushed" onto the lead electrode, it still has a negative charge.

**Question 10**

*Answer:* B

*Explanation:*

The weakest reductant is D as it is not oxidized by any of the solutions. The strongest oxidant is $D^{3+}$ as it is reduced by all of the reductants.

**Question 11**

*Answer:* C

*Explanation:*

The anode reaction involves oxidation. As the cell is an alkaline cell, the equation should have $OH^-$ in it rather than $H^+$.

**Question 12**

*Answer:* C

*Explanation:*

The graph will not shift or change shape unless the temperature is changed. A catalyst lowers the activation energy so the line shifts to the left.

**Question 13**

*Answer:* C

*Explanation:*

$K^I = K^{-3} = 1/20000^3 = 1.25 \times 10^{-13}\ M^{-6}$

**Question 14**

*Answer:* B

*Explanation:*

At 10 min, some CO is removed and at 14 min the pressure is decreased.

**Question 15**

*Answer:* D

*Explanation:*

K will only change when the temperature is changed. The temperature changes at t = 4 min.

**Question 16**

*Answer:* C

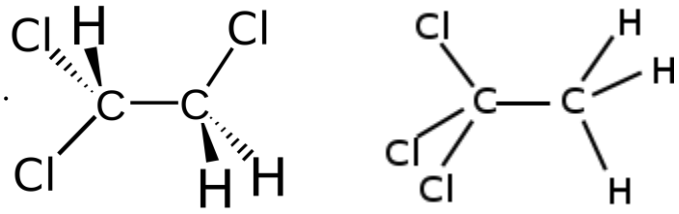
*Explanation:*

When pure oxygen is provided, the equilibrium in equation 1 is driven to the right which decreases the concentration of haemoglobin. This means that equation 2 shifts to the left, decreasing the concentration of carboxyhaemoglobin.

**Question 17**

*Answer:* B

*Explanation:*



**Question 18**

*Answer:* D

*Explanation:*

The alcohol section contains 3 carbons so is the propyl part of the name and the carboxylic acid section has 4 carbon atoms so is the butanoate part of the molecule.

**Question 19**

*Answer:* D

*Explanation:*

As the titration involves a strong base and a weak acid, the equivalence point will be at a pH of over 7. Phenolphthalein is the only indicator listed that changes colour at a pH of above 7.

**Question 20**

*Answer:* A

*Explanation:*

The pipette is used for NaOH so needs to be washed with NaOH. The conical flask is washed with water as you don't want to add any more base to its contents. The burette is used for vinegar so needs to be washed with vinegar.

**Question 21**

*Answer:* A

*Explanation:*

The amino acids with the highest polarity (those with extra COOH groups or OH groups) are more soluble in a polar mobile phase so have a shorter retention time. For option D, cysteine has the highest peak height but the amount of amino acid is determined by the area under the peak.

**Question 22**

*Answer:* D

*Explanation:*

Oleic acid is an omega-9 amino acid with a cis configuration around one double bond (trans fats are synthesised). Oleic acid is more likely to be oxidised than lauric acid as unsaturated fatty acids are more reactive than saturated fats.

**Question 23**

*Answer:* C

*Explanation:*

Glutamine contains two $NH_2$ groups which would each gain a proton to form $NH_3^+$ and only one COOH group which would lose a proton to form $COO^-$.

**Question 24**

*Answer:* B

*Explanation:*

Vitamin C cannot be made in the body and is not easily stored. It is insoluble in fat tissue and a polar molecule. Vitamin D is synthesised by the body after exposure to UV radiation.

**Question 25**

*Answer:* A

*Explanation:*

Vitamin C provides hydrogen atoms which can react with any free radicals that are formed. (Vitamin C can assist the action of enzymes but in this case it is acting as a co-enzyme not an antioxidant)

**Question 26**

*Answer:* A

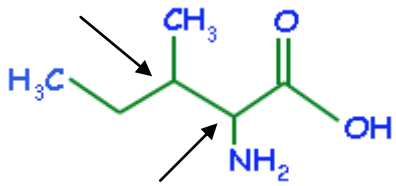
*Explanation:*

Breaking of peptide links breaks the primary structure. The hydrogen bonds holding the helix together are part of the secondary structure. The shape of the protein is part of the tertiary structure and the bonds between polypeptides are part of the quaternary structure.

**Question 27**

*Answer:* C

*Explanation:*




C2 and C3 are chiral centres

**Question 28**

*Answer:* B

*Explanation:*

n = m/M = 1.05 / 122 = 0.00861 mol
1 mol → 3227 kJ, so 0.00861 mol → 0.00861 x 3227 = 27.8 kJ
3.45 °C → 27.8 kJ so, 1°C → 27.8/3.45 = 8.05 kJ°C$^{-1}$

**Question 29**

*Answer:* B

*Explanation:*

The pathway from A to C to D gives 72% yield. (0.8 x 0.9 = 0.72 or 72%)

**Question 30**

*Answer:* D

*Explanation:*

A stoppered test tube might explode when heated. A Bunsen burner would ignite vapours. Reducing ventilation would affect people in the Chemistry classroom. Small quantities of chemicals would reduce exposure.

## SECTION B: Short-answer questions

### Question 1 (7 marks)

**a.** 59

1 mark

**b.** **i.** amine/amide
**ii.** alkane or alkyl group or hydrogen atom

2 marks

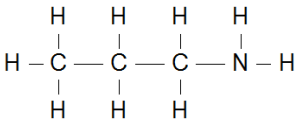
**c.** $CH_2NH_2^+$

1 mark

**d.** 3 carbon environments

**e.**

mark



1 mark

**f.** The middle carbon atom has 5 neighbouring H atoms so is split N+1 = 6 ways.

1 mark

**Question 2 (11 marks)**

**a.** Calibration factor is 200kJ for 1°C
For 1.897°C, energy released is 200 x 1.897 = 379.4J for 8.82g *
For 1g, energy released is 379.4/8.82 = 43.0 kJ $g^{-1}$ *

2 marks

**b.** **i.** $C_{19}H_{32}O_{2(l)} + 26O_{2(g)} \rightarrow 19CO_{2(g)} + 16H_2O_{(l)}$
**ii.** 43.0 kJ in 1g
so 1000 kJ will use 1000/43 = 23.3 g*
n = m / M = 23.3/292= 0.0796 mol*
$n(CO_2) = 19n(C_{19}H_{32}O_2) = 1.51$ mol*
V = nRT / P = (1.51 x 8.31 x 323) / 100 = 40.6 L*
**iii**. biodiesel is renewable.

1 + 4 +1 = 6 marks

**c.** **i.** ester
**ii.** $C_{18}H_{30}O_2 + CH_4O \rightarrow C_{19}H_{32}O_2 + H_2O$

1 + 1 = 2 marks

**d.** Biodiesel ($C_{19}H_{32}O_2$) is more viscous. (Dipole - dipole bonds between molecules in biodiesel are stronger than the dispersion forces between molecules in petrodiesel)

1 mark

**Question 3 (9 marks)**

**a.** n = m / M = 28.8/158 = 0.183 mol*
c = n / V = 0.183/0.250 = 0.729M*

2 marks

**b.** $C_2H_5OH_{(aq)} \rightarrow CH_3CHO_{(aq)} + 2H^+_{(aq)} + 2e^-$ *
$MnO_4^-{}_{(aq)} + 8H^+_{(aq)} + 5e^- \rightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}$ *
$5C_2H_5OH_{(aq)} + 2MnO_4^-{}_{(aq)} + 6H^+_{(aq)} \rightarrow 2Mn^{2+}_{(aq)} + 8H_2O_{(l)} + 5CH_3CHO_{(aq)}$ *

3 marks

**c.** Average titre = 11.12 mL
n = c x v = 0.729 x 0.01112 = 0.00811 mol*
$n(C_2H_5OH) = 2.5n(MnO_4^-) = 0.0203$ mol in 20mL*
in 100ml there would be 0.0203 x 100/20 = 0.101 mol
mass in 100 ml = 0.101 x 46 = 4.66%*

3 marks

**d.** Alcohol oxidises over time.

1 mark

**Question 4 (10 marks)**

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

| | $PCl_3$ | $Cl_2$ | $PCl_5$ |
|---|---|---|---|
| Initial | 0.35 | 0.25 | 0 |
| Change | -0.05 | -0.05 | +0.05 |
| Equilibrium | 0.30 | 0.20 | 0.05 |

*

$K_c = 0.05 /(0.30 \times 0.20) = 0.83M^{-1}$*

3 marks

**b.**

| | Effect on yield of $PCl_5$ | Effect on equilibrium constant |
|---|---|---|
| Increase in temperature | decrease | decrease |
| Addition of a catalyst | no change | no change |
| Increase in pressure | increase | no change |

*(1/2 mark for each correct response)*

3 marks

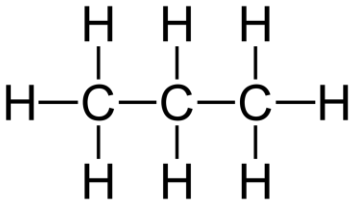
**c.** **i.** Increasing the pressure* increases the rate and yield. As the particles are closer together, they collide more frequently.*

ii. A decrease in temperature* increase the yield but decreases the rate as the particles are moving more slowly and collide with less energy so there is less chance of a reaction occurring.*

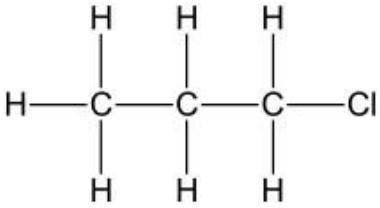
2 + 2 = 4 marks

**Question 5 (11 marks)**

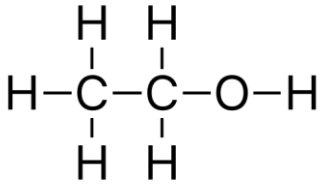
**a.** Structure A



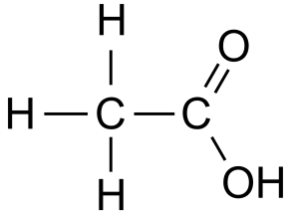
Structure C



Structure F



Structure H



4 marks

**b.** **i.** reagent B chlorine ($Cl_2$)

**ii.** substance D 1-aminopropane or propan-1-amine

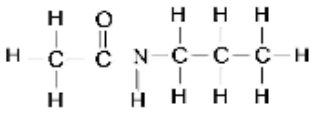
**iii.** substance E ethene

**iv.** substance G ethanol

**v.** substance I ethanoic acid

5 marks

**c.** **i.**



**ii.** secondary

1 + 1 = 2 marks

**Question 6 (9 marks)**

**a.** **i.** negative electrode (anode) $C_2H_5OH_{(aq)} + 3H_2O_{(l)} \rightarrow 2CO_{2(g)} + 12H^+_{(aq)} + 12e^-$

**ii.** positive electrode (cathode) $O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightarrow 2H_2O_{(l)}$

1 + 1 = 2 marks

**b.** **i.** The electrodes also act as catalysts.

**ii.** This increases the surface area of the electrodes increasing the rate of reaction.

1 + 1 = 2 marks

**c.** **i.** A fuel cell is more efficient than an internal combustion engine.

**ii.** The rate of reaction and therefore power output of the fuel cell is too low or they are too expensive.

1 + 1 = 2 marks

**d.** Ethanol has a lower energy content per gram than hydrogen. Other possible answers.

1 mark

**e.** **i.** $C_{12}H_{22}O_{11(aq)} + H_2O_{(l)} \rightarrow 2C_6H_{12}O_{6(aq)}$

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

1 + 1 = 2 marks

**Question 7 (9 marks)**

**a.** The substrate is the reactant in a chemical reaction.* It could be a dipeptide that will be broken down into two amino acids.* (many possible examples)

2 marks

**b.** Types of bonds include; ionic, ion-dipole, dispersion forces, hydrogen, dipole-dipole. (any 4 examples with 0.5 marks each)

2 marks

**c.** **i.** The shape is part of the tertiary structure that is formed by adjacent chains* forming ionic, ion-dipole, dispersion forces, hydrogen, dipole-dipole and/or covalent bonds.* (at least 3 examples needed for second mark)

**ii.** Yes.* An enzyme can have its shaped modified by a co-enzyme.*

**iii.** The enzymes would be denatured by acid in the stomach.* (or similar answer)

2 + 2 + 1 = 5 marks

**Question 8 (9 marks)**

**a.** i. $2Cl^-_{(g)} \rightarrow Cl_{2(g)} + 2e$-

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

1 + 1 = 2 marks

**b.** If the concentration of $Cl^-$ falls too low, $H_2O$ will be reduced in preference to $Cl^-$ * as it is a stronger reductant than $H_2O$ when the $Cl^-$ concentration is 1M.*

2 marks

**c.** The cation permeable membrane allows ions to move between the two half cells but prevents direct mixing of reactants and products.

1 mark

**d.** n = v/24.8 = 10 000 / 24.8 = 403 mol

$n(e^-) = 2n(Cl_2) = 403 \times 2 = 806$ mol

Q = n x 96500 = 77 800 000 C

I = Q/t = 77 800 000 / 3600 = 21 600 A

4 marks

**Question 9 (9 marks)**

**a.** 0.5 x 28 x 37 = 518

0.5 x 8 x 17 = 68

0.5 x 55 x 16 = 440

Total = 1026 kJ

2 marks

**b.** i. The GI value indicates how quickly a carbohydrate will be digested. This is compared to glucose which is given a GI value of 100. A high GI value indicates that the carbohydrate is ingested quickly.

ii. Amylopectin has a high proportion of side chains which makes it more soluble* and more easily hydrolysed, so it has a relatively high GI value.* (Amylose has few side chains which makes it less soluble so has a relatively low GI value.)

1 + 2 = 3 marks

**c.** i. butane as it has a greater energy per gram.*

ii. E = m x c x $\Delta$T = 30 000 x 4.18 x 75 = 9 410 000 J*

energy to be produced = 9 410 000 x 100/20 = 47 000 000 J or 47 000 kJ*

butane produces 49.7 kJ from 1g

So for 47 000kJ mass is 47 000 / 49.7 = 946 g *

1 + 3 = 4 marks

**Question 10 (6 marks)**

**a.** i. time

ii. temperature

iii. mass of maltose, volume of amylase. (only 1 needed)

3 marks

**b.** For example;

- Repeat the experiment
- Use a greater range of temperatures
- Record the colour intensity using a calorimeter

(any 2 reasonable suggestions)

2 marks

**c.** The student has not tested enough temperatures to conclude that the ideal temperature is just below 40C or only amylase was tested so other enzymes may behave differently.

1 mark