

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:

$$n = \frac{m}{M} = \frac{1000}{2} = 500 \text{ mol}$$

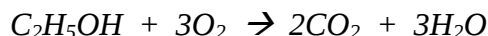
$$n(\text{O}_2) = 250 \text{ mol}$$

$$m = n \times M = 250 \times 32 = 8000 \text{ g or } 8.0 \text{ kg}$$

Question 5

Answer: A

Explanation:



500 mL 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 $2500 - 2000 = 500 \text{ mL}$.

Question 6

Answer: A

Explanation:

$$2500 \text{ kg} \rightarrow 64\,000 \text{ kJ}$$

$$\text{So, } 1 \text{ kg} \rightarrow 64\,000 / 2500 = 25.6 \text{ MJ kg}^{-1}$$

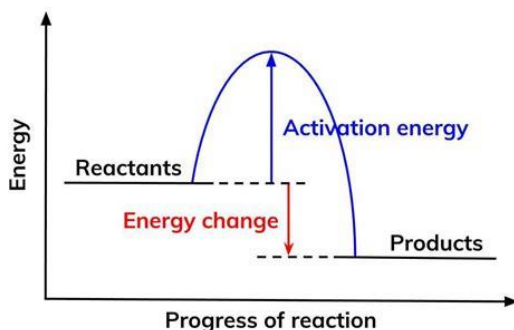
Question 7

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 $362 - 282 = 80 \text{ kJmol}^{-1}$.



Question 8

Answer: D

Explanation:

$$\text{CH}_4 + \frac{3}{2}\text{O}_2 \rightarrow \text{CO} + 2\text{H}_2\text{O}$$
$$n = \frac{m}{M} = \frac{50}{16} = 3.125 \text{ mol}$$
$$n(\text{O}_2) = \frac{3}{2} n(\text{CH}_4) = 4.69 \text{ mol}$$
$$v = n \times 24.8 = 4.69 \times 24.8 = 116\text{g}$$

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:

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

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 $t = 4 \text{ min}$.

Question 16

Answer: C

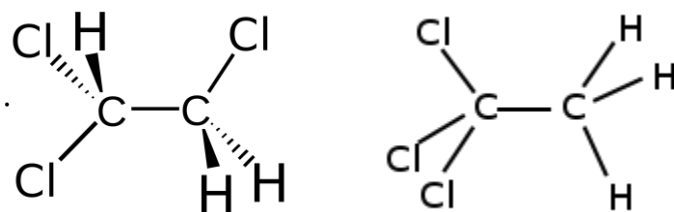
Explanation:

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

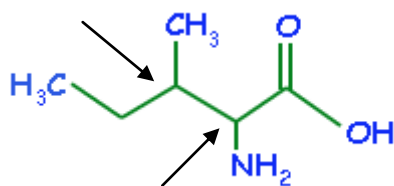
Explanation:

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:

$$n = m/M = 1.05 / 122 = 0.00861 \text{ mol}$$

$$1 \text{ mol} \rightarrow 3227 \text{ kJ, so } 0.00861 \text{ mol} \rightarrow 0.00861 \times 3227 = 27.8 \text{ kJ}$$

$$3.45 \text{ }^{\circ}\text{C} \rightarrow 27.8 \text{ kJ so, } 1^{\circ}\text{C} \rightarrow 27.8/3.45 = 8.05 \text{ kJ}^{\circ}\text{C}^{-1}$$

Question 29

Answer: B

Explanation:

The pathway from A to C to D gives 72% yield. ($0.8 \times 0.9 = 0.72$ 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

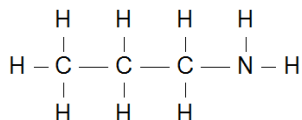
c. CH_2NH_2^+

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 $200 \times 1.897 = 379.4\text{J}$ for 8.82g *

For 1g, energy released is $379.4/8.82 = 43.0 \text{ kJ g}^{-1}$ *

2 marks

- b. i. $\text{C}_{19}\text{H}_{32}\text{O}_{2(l)} + 26\text{O}_{2(g)} \rightarrow 19\text{CO}_{2(g)} + 16\text{H}_2\text{O}_{(l)}$

ii. 43.0 kJ in 1g

so 1000 kJ will use $1000/43 = 23.3 \text{ g}^*$

$n = m / M = 23.3/292 = 0.0796 \text{ mol}^*$

$n(\text{CO}_2) = 19n(\text{C}_{19}\text{H}_{32}\text{O}_2) = 1.51 \text{ mol}^*$

$V = nRT / P = (1.51 \times 8.31 \times 323) / 100 = 40.6 \text{ L}^*$

iii. biodiesel is renewable.

1 + 4 + 1 = 6 marks

- c. i. ester

ii. $\text{C}_{18}\text{H}_{30}\text{O}_2 + \text{CH}_4\text{O} \rightarrow \text{C}_{19}\text{H}_{32}\text{O}_2 + \text{H}_2\text{O}$

1 + 1 = 2 marks

- d. Biodiesel ($\text{C}_{19}\text{H}_{32}\text{O}_2$) 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. $n = m / M = 28.8/158 = 0.183 \text{ mol}^*$

$c = n / V = 0.183/0.250 = 0.729\text{M}^*$

2 marks

- b. $\text{C}_2\text{H}_5\text{OH}_{(aq)} \rightarrow \text{CH}_3\text{CHO}_{(aq)} + 2\text{H}^+_{(aq)} + 2\text{e}^-^*$

$\text{MnO}_4^-_{(aq)} + 8\text{H}^+_{(aq)} + 5\text{e}^- \rightarrow \text{Mn}^{2+}_{(aq)} + 4\text{H}_2\text{O}_{(l)}^*$

$5\text{C}_2\text{H}_5\text{OH}_{(aq)} + 2\text{MnO}_4^-_{(aq)} + 6\text{H}^+_{(aq)} \rightarrow 2\text{Mn}^{2+}_{(aq)} + 8\text{H}_2\text{O}_{(l)} + 5\text{CH}_3\text{CHO}_{(aq)}^*$

3 marks

- c. Average titre = 11.12 mL

$n = c \times v = 0.729 \times 0.01112 = 0.00811 \text{ mol}^*$

$n(\text{C}_2\text{H}_5\text{OH}) = 2.5n(\text{MnO}_4^-) = 0.0203 \text{ mol in } 20\text{mL}^*$

in 100ml there would be $0.0203 \times 100/20 = 0.101 \text{ mol}$

mass in 100 ml = $0.101 \times 46 = 4.66\%^*$

3 marks

- d. Alcohol oxidises over time.

1 mark

Question 4 (10 marks)a. $K_c = [\text{PCl}_5] / [\text{PCl}_3] [\text{Cl}_2]^*$

	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

*

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

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)

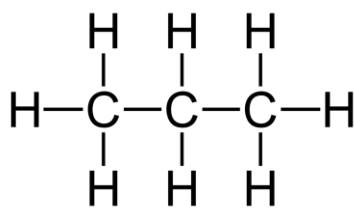
3 marks

- 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.*

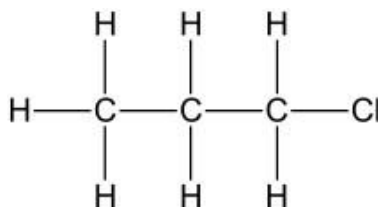
2 + 2 = 4 marks

Question 5 (11 marks)

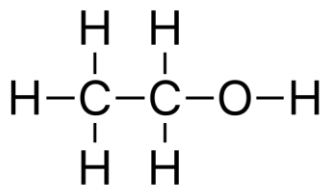
a. Structure A



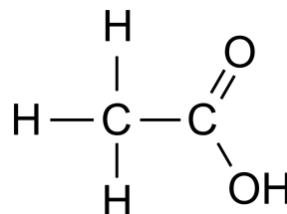
Structure C



Structure F



Structure H

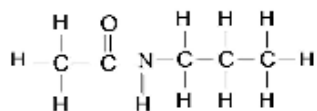


4 marks

- 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) $\text{C}_2\text{H}_5\text{OH}_{(\text{aq})} + 3\text{H}_2\text{O}_{(\text{l})} \rightarrow 2\text{CO}_{2(\text{g})} + 12\text{H}^+_{(\text{aq})} + 12\text{e}^-$
 ii. positive electrode (cathode) $\text{O}_{2(\text{g})} + 4\text{H}^+_{(\text{aq})} + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}_{(\text{l})}$

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. $\text{C}_{12}\text{H}_{22}\text{O}_{11(\text{aq})} + \text{H}_2\text{O}_{(\text{l})} \rightarrow 2\text{C}_6\text{H}_{12}\text{O}_{6(\text{aq})}$
 ii. $\text{C}_6\text{H}_{12}\text{O}_{6(\text{aq})} \rightarrow 2\text{CO}_{2(\text{g})} + 2\text{C}_2\text{H}_5\text{OH}_{(\text{aq})}$

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. $2\text{Cl}^-_{(\text{g})} \rightarrow \text{Cl}_{2(\text{g})} + 2\text{e}^-$
 ii. $2\text{H}_2\text{O}_{(\text{l})} + 2\text{e}^- \rightarrow 2\text{OH}^-_{(\text{aq})} + \text{H}_{2(\text{g})}$

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. $n = v/24.8 = 10\,000 / 24.8 = 403 \text{ mol}$
 $n(e^-) = 2n(\text{Cl}_2) = 403 \times 2 = 806 \text{ mol}$
 $Q = n \times 96500 = 77\,800\,000 \text{ C}$
 $I = Q/t = 77\,800\,000 / 3600 = 21\,600 \text{ A}$

4 marks

Question 9 (9 marks)

- a. $0.5 \times 28 \times 37 = 518$
 $0.5 \times 8 \times 17 = 68$
 $0.5 \times 55 \times 16 = 440$
 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. $E = m \times c \times \Delta T = 30\,000 \times 4.18 \times 75 = 9\,410\,000 \text{ J}^*$
 energy to be produced = $9\,410\,000 \times 100/20 = 47\,000\,000 \text{ J}$ or $47\,000 \text{ kJ}^*$
 butane produces 49.7 kJ from 1g
 So for 47 000kJ mass is $47\,000 / 49.7 = 946 \text{ g}^*$

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