Solution Pathway

Below are sample answers. Please consider the merit of alternative responses.

Note: *Teachers will need to provide the VCAA data booklet, unmarked, for student use during this Exam.*

SECTION A: Multiple-choice Answers

Question 1 Answer: D

Strong oxidising agents have *weak* conjugated reducing agents (A incorrect) and the stronger the reductant the more *negative* the E^0 value (B, C incorrect).

Question 2 Answer: A

n(HCOOH) = 1.150 / 46 = 0.025 mol

n(NaOH) = n(HCOOC) = 0.025 mol

c(NaOH) = n/v = 0.025 / 0.02495 = **1.00 mol L^{-1} (M)**

Question 3 Answer: C

A standard solution is prepared by dissolving accurately measured mass of a primary standard (using an **analytical balance**) in an accurately measured volume (**volumetric flask**).

Question 4 Answer: B

Since the long hydrocarbon chains in triglycerides are very non-polar, they do no dissolve in water (A incorrect).

The main structural component in plants is the polysaccharide *cellulose* (B correct).

Glucose and fructose are both monosaccharides with the same molecular formula but different atom connectivity. They are structural isomers but not stereoisomers (C incorrect).

NAD^+ (vitamin B_3) is a coenzyme but together with the enzyme would *decrease* the activation energy of the reaction (D incorrect).

Question 5 Answer: D

A – incorrect: compounds X, Y and Z are isomers of pentane but due to different degree of branching have different strength of dispersion forces between molecules and therefore *different* boiling points.

B – incorrect: they are all non-polar.

C – incorrect: cis-trans isomers can only occur if molecule contains a C-C double bond.

D – correct: flash point is the lowest temperature at which a liquid's vapour will ignite. Molecules with the weakest dispersion forces will have the lowest flash point. Compound Z has the highest degree of branching therefore having the weakest dispersion forces and therefore the lowest flash point.

Question 6 Answer: B

A – incorrect: Compound X is symmetrical and has three different hydrogen and C environments and therefore three peaks each in ^{13}C and ^{1}H-NMR.

B – correct: Compound Y has 2 methyl groups in the same chemical environment resulting in the same chemical shift in both spectra. All other carbons and hydrogen atoms are in a different environment and therefore each give a different signal (peak). 2-methylbutane therefore has 4 signals in ^{13}C-NMR and 4 signals in the proton NMR.

C – incorrect: the hydrogen atoms in the four methyl groups are all in the same environment resulting in one peak in proton NMR. Carbon NMR will have two signals: one due to carbons in the four $-CH_3$ groups occupying the same chemical environment and the centre carbon occupying a second different environment.

D – incorrect: see B

Question 7 Answer: D

Percentage yield = actual yield / theoretical yield x 100%

$n(CH_3COCH_3)$ = 65 / 58.1 = 1.119 mol

$n(CHCl_3) = n(CH_3COCH_3)$ = 1.119 mol

$m(CHCl_3)$ = 1.119 x 119.4 = 133.6 g

%yield ($CHCl_3$) = 130 g / 133.6 g x 100 = **97%**

Question 8 Answer: A

Since in the chemical reaction the total mass of reactants is equal to the total mass of reactants, the molar masses can be replaced with the masses of reactants and products.

Atom economy = mass of desired product / mass of all reactants x 100

42.4 / 100 = 130 g / x

x = 130 / 0.424 = 306.6 = **307 g**

Question 9 Answer: A

Activation energy for reverse reaction = 640 - ΔH = 640 – 360 = + 280

Question 10 Answer: C

A, B – incorrect: AgCl is a precipitate and cannot be used as electrolyte solution, introducing a tin rod as electrode will introduce additional cell reaction and may not produce 0.65V.

D – incorrect: using KCl as salt bridge solution may lead to a precipitation of AgCl in half cell containing $AgNO_3(aq)$, $Sn^{4+}(aq)$ also needed to complete oxidation reaction in other half cell.

Question 11 Answer: B

Q = Ixt = 0.05/1000 x 365 x 24 x 60 x 60 = 1576.8 C

$n(e^-)$ = Q/F = 1576.8 / 96500 = 0.01634 mol

n(Cd) = ½ $n(e^-)$ = 0.00817 mol

m(Cd) = 0.00817 x 112.4 = **0.918 g**

Question 12 Answer: C

For a spontaneous reaction to occur the strongest oxidising agent reacts with the strongest reducing agent.

No reaction will occur between Cu(s) and $H^+(aq)$ because the oxidising agent, $H^+(aq)$, is below the reducing agent, Cu(s), in the electrochemical series.

Question 13 Answer: C

Measurements are precise because they are in close agreement (concordant), but not accurate as they are not very close to the true value of 25.00 g.

Question 14 Answer: D

A, B, – incorrect: paper and thin layer chromatography are ideal for qualitative analysis but are not ideal as large – scale purification method as only small amounts are used and compounds are not eluted from the stationary phase.

C – incorrect: NMR spectroscopy is an analytical technique to identify the structure of a molecule, not for the separation of mixtures into its components.

D – column chromatography is the **most** suitable technique for large-scale purification as larger amounts of a mixture can be applied, separated into its components and fractions can be eluted easily from the stationary phase.

Question 15 Answer: B

Fuel cells have a high efficiency as they convert chemical energy directly into electrical energy. (statement I incorrect)

The reaction occurring at the cathode is the reduction reaction and the oxidant consumes electrons. (statement II correct)

Hydrogen gas is the fuel and undergoes oxidation reaction at the anode, producing electrons. Its oxidation number increases from 0 to +1. (statement III correct)

Question 16 Answer: A

In this cell, hydrogen gas is the fuel and undergoes oxidation reaction at the anode, which is negative.

Question 17 Answer: C

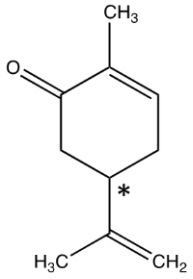
The semistructural formula for compound C is CH_3COCH_2OH. It does not contain the -COOH functional group and therefore is not a carboxylic acid. Compound A is formic acid (methanoic acid), HCOOH, Compound B is ethanoic acid, CH_3COOH, and compound D is propanoic acid, CH_3CH_2COOH.

Question 18 Answer: B

The correct IUPAC name is **3-methylhex-3-ene**. Longest carbon chain: 6 carbons, double bond at third carbon, methyl side chain coming off third carbon.

Question 19 Answer: A

1 chiral centre (*)



Question 20 Answer: B

Using the calibration curve, the absorbance reading for 'X' was 0.45 which gives a concentration of 0.3 mg/mL = 30 mg / 100 mL.

Question 21 Answer: D

'Diet' coke – incorrect – 78 mg per 150 mL = 52 mg per 100 mL
Pepsi Max - – incorrect – 74 mg per 200 mL = 35 mg per 100 mL
'Diet' pepsi - – incorrect - 578 mg per 1.25 L = 46 mg per 100 mL
Red Bull *zero* – correct - 99 mg per 330 mL = **30 mg per 100 mL**

Question 22 Answer: C

Reaction is an endothermic reaction. As temperature increases, the forward reaction is favoured to partially counteract the increase in temperature.

The equilibrium constant, K_c, increases with increasing temperature for an endothermic reaction.

Question 23 Answer: A

The addition of CH_2Cl_2, a product, will increase the number of CH_2Cl_2 molecules and therefore lead to an increase of successful collisions, which will lead to an instant increase the reverse reaction. Consequently, more reactants are produced (CH_4 and CCl_4) from the CH_2Cl_2 molecules. As the concentration of reactants increases and more frequent collisions occur between these molecules, the rate of the forward reaction (formation of CH_2Cl_2) also increases. Ultimately, the rates of forward and reverse reactions become equal again and a new equilibrium is established.

Decrease in pressure would lead to an instant decrease of both forward and reverse reactions. The volume increase would mean decrease in concentration of reactants and products and therefore decrease in rate of forward and reverse reaction.

Adding an inert gas will have no effect on the rate of the reaction as it will not change any of the concentrations of reactants and products.

Question 24 Answer: C

The equilibrium constant, K_c, is only affected by temperature. The increase of concentration of reactants and products will not change K_c.

Question 25 Answer: B

Vitamin D is one of the only vitamins which can be synthesised in the human body (skin).

Question 26 Answer: A

This optimal temperature for enzymes in the human body is around 37.5 C (human body temperature). Above this temperature the enzyme structure begins to break down (**denature**) since at higher temperatures intra- and intermolecular bonds are broken as the enzyme molecules gain even more kinetic energy.

Question 27 Answer: D

All amino acids are in the data book. Cysteine (cys) contains a polar -SH functional group, tryptophan contains a polar -NH group in its side chain, arginine contains a polar $-NH_2$ group. Valine contains a non-polar $-CH(CH_3)_2$ side chain.

Question 28 Answer: C

Fats and oils belong to the larger class of biomolecules called lipids. They contain triglycerides, which contain an ester functional group (-COO) and a long fatty acid tail. Therefore, compound III belongs to lipids.

Compound I is a vitamin (does not contain ester functional group).

Compound II is glycerol (see data book), which contains hydroxyl groups.

Compound IV is a fatty acid (does not contain ester functional group).

Question 29 Answer: A

Propanoic acid is soluble in water due to being able to form hydrogen bonds with water molecules. All the other compounds are insoluble / not miscible in water. (1-decanol – long non-polar hydrocarbon part, heptane and tetrachloromethane are non-polar).

Question 30 Answer: B

Biodiesel molecules derived from plants contain C-C double bonds.

A – incorrect: due to C-C double bonds, hydrocarbon chains contain 'kinks' / bends, which makes the packing of these molecules more difficult / less dense. Therefore, weaker dispersion forces between molecule, therefore *lower* melting point.

B – correct: C-C double bonds in the molecule make biodiesel more susceptible to reaction with oxygen, which leads to biodegradation.

C – incorrect: molecules with C-C double bonds are *unsaturated* molecules.

D – biodiesel molecules contain an ester functional group / polar bonds that allow these molecules to form dipole – dipole interactions with polar water molecules. Biodiesel molecules are therefore *more* hygroscopic than nonpolar petrodiesel.

SECTION B

Question 1 (7 marks)

a. 3 x 1 = **3 marks**

*Hexane – **not** suitable. Pigments have a **low** affinity to hexane and therefore **do not move**.* **1 mark**

*Ethanol - **not** suitable. All pigments have the **same high** affinity to ethanol and travel with the solvent, but **no** separation.* **1 mark**

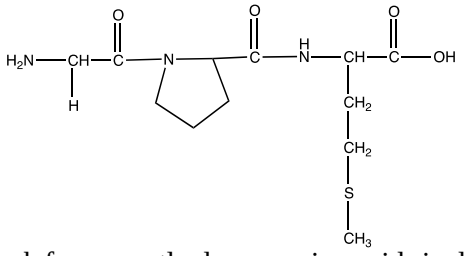
*Diethyl ether – pigments undergo **adsorption and desorption to a different degree** and therefore a **separation is achieved**.* **1 mark**

b. **i**. R_f *– retardation factor* **1 mark**

ii Pigment 1: *Carotene* 1 mark each = **3 marks**
Pigment 2: *Chlorophyll B*
Pigment 3: *Xanthrophyll 2*

Question 2 (11 marks)

a. **3 marks**



1 mark for correctly drawn amino acids including side chains, 1 mark for correct peptide bond, 1 mark for -NH_2 and -COOH at either ends (closed bonds).

b. *Alpha helix* **1 mark**

c. $H_2NCH(CH_2OH)COOH + HCl \rightarrow {}^{+}H_3NCH(CH_2OH)COOH + Cl^{-}$ **2 marks**

1 mark for correct reactants and products, 1 mark for correct amino acid **cation**

d. **i.** One of the following: *meat, fish, eggs, legumes* **1 mark**

ii. *condensation* **1 mark**

iii. $C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$ **2 marks**

1 mark for correct reactants and products, 1 mark for correctly balanced and states

iv. *energy* **1 mark**

Question 3 (11 marks)

a. *CF = VIt / ΔT = 1.55 x 7.00 x 180 / (25.65 – 24.60) =* ***1.86 x 10^3 J ºC^{-1}*** **2 marks**
1 mark correctly calculating the energy (VIt) and temperature change, 1 mark for correctly calculating CF in J ºC^{-1}.

b. *E = CF x ΔT = 1.86 x 10^3 x (40.50 – 25.65) = 27.6 kJ / 1.605 g * =* ***17.2 kJ g^{-1}*** *** **2 marks**
1 mark for correctly calculating the energy released.
1 mark for correctly calculating the energy per gram of biscuit (***kJ g^{-1})*** *to 3 sig fig.*

c. Energies available for each food group are in the data book (Table 13) **2 marks**

Per 100 g of biscuit: carbohydrates: 62.0 g x 16 *kJ g^{-1} = 992 kJ, protein: 7.50 g x* 17 *kJ g^{-1} = 127.5 kJ, Fat: 19.6 g x 37 kJ g^{-1} = 725.2*

Energy value = (992 + 127.5 + 725.2) / 100 = ***18 kJ g^{-1}***
1 mark for correctly calculating the energy per gram for each food group.
1 mark for correctly calculating energy value in ***kJ g^{-1}*** *(*2 sig fig).

d. Two of the following: 1 mark for each correct response **2 marks**

- *Not all nutrients from the food are absorbed by the body after digestion.*
- *Not all food may be digested, cellulose cannot be digested.*
- *Cellulose cannot be digested but contributes to heat when combusted in calorimeter.*
- *Incomplete oxidation of nutrients, such as fibre.*
- *Not all heat released by oxidation of food will be available for use in cells.*

e. **i.** *Weigh the biscuit sample, place in oven to dry for a certain amount of time, then re-weigh. If mass is unchanged then the sample is dry.* **1 mark**

ii. *Calculated heat of combustion would have been* ***lower*** (1 mark) *because the original* ***mass*** *of the biscuit* ***was too high*** (1 mark) *due to inclusion of water* **2 marks**

Question 4 (14 marks)

a. $C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$ **2 marks**

1 mark for correct reactants and products, 1 mark for correct balanced equation and states.

b. **i.** *m(ethanol) = 0.785 x 400 L = 314 kg* **1 mark**
n(ethanol) = 314 x10^3 g / 46.1 gmol^{-1} = 6.811 x 10^3 mol **1 mark**
n(O_2) = 3x n(ethanol) = 3 x 6.811 x 10^3 = 2.043 x 10^4 mol **1 mark**
V(O_2) = 24.8 x 2.043 x 10^4 = 506 759 L = ***0.507 ML*** (3 sig fig) **1 mark**

ii. *m(ethanol) = 1000g / 46.1 = 21.7 mol* **1mark**
energy released per mol = 1238 kJ,
energy released per kg = 1238 x 21.7 = ***26.9 MJ*** (3 sig fig) **1 mark**

iii. 1 mol of ethanol releases **5** moles of greenhouse gases (at 500K water will be gas)
*V = nRT / p = **5** x 8.31 x 773 / 101.3 = 317 L* **1 mark**
317L release 1.235 MJ x L release 1 MJ = 317/ 1.235 = **257 L** **1 mark**
Note: ignore sig fig here

iv. Any two of the following: 1 mark each **2 marks**
nitrogen oxides, ozone, carbon monoxide, methane

v. Both statements are correct. 1 mark each **2 marks**

1. *To keep up with large amounts of plants (e.g. sorghum), required land will be cultivated for plant growth and therefore natural habitats will be destroyed. Also, less land will be available for growing resources for food.*
2. *Bioethanol is NOT carbon neutral as energy is required in growing, transport and refining of fuel. This also contributes to emission of CO_2.*

Question 5 (13 marks)

a. i. *$n(CH_3NH_2) = 0.173 \times 0.02000 = 3.46 \times 10^{-3}$ mol* **1 mark**
at equivalence point: $n(CH_3NH_2) = n(HCl) = 3.46 \times 10^{-3}$ mol **1 mark**
*$V(HCl) = 3.46 \times 10^{-3} / 0.115 = 0.03009$ L = **30.1 mL*** (3 sig fig) **1 mark**

ii. The equivalence point is at pH = 6. For table of indicators see data book. **2 marks**

Accept: *methyl red* colour change: *yellow to red* (basic pH to acidic pH) or
Bromothymol blue *blue to yellow*
1 mark for correct indicator, 1 mark for correct colour change.

b. i. *1-propanol* or *propan-1-ol* **1 mark**

ii. *NaOH* or *OH^-* or *H_2O and catalyst* **1 mark**

iii. *CH_3CH_2COOH* **1 mark**

iv. *Oxidation* **1 mark**

v. *$CH_3CH_2COOH(l) + NH_3(g) \rightarrow CH_3CH_2CONH_2(aq) + H_2O(l)$* **1 mark**
1 mark for correct reactants and products.

c. Students should refer to data book, page 12. **3 marks**

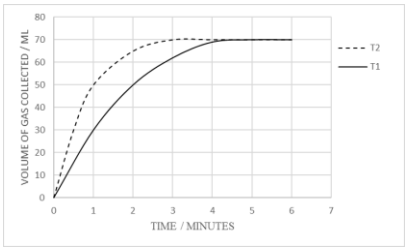
Type of proton	Chemical shift / ppm	Peak area	Splitting pattern
C**H**$_3$-	0.9	3	triplet
CH$_3$-C**H**$_2$-CH$_2$-	1.8	2	Sextet / multiplet
-C**H**$_2$-Cl	3.0– 4.5	2	triplet

1 mark per correct row 3x1 = 3 marks, minus ½ mark for each incorrect entry

Question 6 (10 marks)

a. $n(O_2) = 0.070 / 24.8 = 0.0028226$ mol **1 mark**
$n(H_2O_2) = 2x\ n(O_2) = 2 \times 0.0028226$ mol $= 0.005645$mol **1 mark**
$c\ (H_2O_2) = 0.005645 / 6.50/1000 =$ **0.868 mol L^{-1} (3 sig fig)** **1 mark**

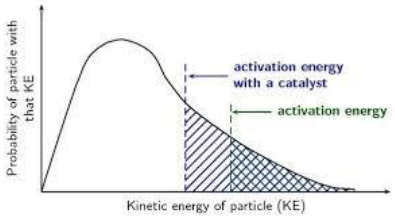
b. **1 mark** for correct graph. See T1 graph on right.
After 4 minutes the volume of collected oxygen gas should not change.



c. **i.** The rate increases with increasing temperature.
Steeper gradient for curve T2 and *70 mL should be reached faster* **1 mark**

ii. Increasing temperature leads to an increase of kinetic energy. *More particles will have energies that are greater than or equal to the activation energy* (1 mark) hence *proportion of successful / fruitful collisions also increases* (1 mark). **2 marks**

d. **1 mark** for correctly showing E_A's for uncatalyzed and catalysed reaction on graph (see below).



A *catalyst (MnO_2) lowers the activation energy of a reaction* by providing an alternative reaction pathway (1 mark). Hence *a greater proportion of particles* will *have energies greater than or equal to the lower activation energy* (1 mark).

Question 7 (8 marks)

a. $Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$ **1 mark**

b. $n(Ni) = (4.098 - 3.746) / 58.7 = 0.352 / 58.7 = 0.00599$ mol **1 mark**

c. **i.** $Q = It = 2.00 \times 10 \times 60 = 1200$ C **1 mark**

ii. $N(e^-) = Q /$ charge on one electron $= 1200 / 1.6 \times 10^{-19} = 7.50 \times 10^{21}$ **1 mark**

iii. $n(e^-) = 2 \times n(Ni) = 2 \times 0.00599 = 0.01199$ mol **2 marks**
N_A = number of electrons / number of moles of $e^- = 7.50 \times 10^{21} / 0.01199 =$ ***6.25 x 10^{23} mol^{-1}***

d. *Experimentally determined N_A by student is* ***slightly larger*** (1 mark) *than N_A (6.02×10^{23} mol^{-1})*
reason: *some Ni(s) may have fallen off during electrolysis* (1 mark)
(less weight = less n_{Ni} = less n_{e^-} = larger N_A) **2 marks**
Accept any other acceptable reasons which could lead to a decrease in mass of electrode. But electrode not totally dry would lead to lower N_A.

Question 8 (4 marks)

a. *Exothermic reaction* therefore *decreasing the temperature would shift equilibrium to the right (1mark) dissolving more CO_2 gas in water (1 mark) making the drink bubblier*. **2 marks**

b. $CO_2(g) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H^+(aq)$ or **2 marks**
$CO_2(g) + H_2O(l) \rightleftharpoons CO_3^{2-}(aq) + 2H^+(aq)$
As a bottle is opened, $CO_2(g)$ escapes from it (removing reactant) shifting equilibrium to the left to partially compensate for the loss of $CO_2(g)$ hence decreasing $[H^+(aq)]$ and increasing the pH
1 mark for correct equation forming $H^+(aq)$ ions.
1 mark for correct explanation of why pH increases.

Question 9 (5 marks)

a. *Vitamin C interrupts propagation of free radicals* (1 mark) (do not accept "stop" formation of free radicals) *by donating hydrogen atoms to radicals*

Hydroxyl functional groups (1 mark) facilitate this process (structure of vitamin C is available in data book) **2 marks**

b. One of the following: **1 mark**
- *perceived less safe by consumers*
- *can be detrimental to health if level of BHA in food is not regulated / too high.*

c. Two of the following: **2 marks**
- *nitrogen gas is an inert gas and filling the bags with nitrogen instead of air will prevent chemical reaction / oxidative rancidity from happening*
- *prevent the chips from oxidizing, which is part of what makes them go stale / rancid*
- *prevent chips to react with moisture from air and becoming soggy*
- *gas also gives the chips a cushion protecting the chips from damage during transportation.*
- *foil is a good barrier for light, which would speed up the rancidity process.*

Question 10 (7 marks)

a. *Pb: 0, PbO_2: +4, $PbSO_4$: +2;* **1 mark**
1 mark for all three oxidation numbers assigned correctly.
Need sign for mark. Do not accept notations such as 4+, 2+ or IV, II.

b. Negative/–/anode $Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-$ or $Pb(s) \rightarrow Pb^{2+}(aq) + 2e^-$
Positive/+/cathode $PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$
or $PbO_2(s) + 4H^+(aq) + 2e^- \rightarrow Pb^{2+}(aq) + 2H_2O(l)$
or $PbO_2(s) + H_2SO_4(aq) + 2H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$

1 mark each for correct half equation of oxidation and reduction reaction. **2 marks**

c. When the cell is recharged, the reverse reaction takes place. Sulfuric acid is produced / water is used up and therefore *concentration of sulfuric acid increases.* **1 mark**

d. *Decreasing order: Z, Y, X* or *Z > Y > Z* **1 mark**

Z is a stronger reducing agent than Y and/or X **or** *Z most reactive as it can reduce/displace both* Y^{2+} *and* X^{+}*;* **1 mark**

Y is a stronger reducing agent than X but not Z **or** *Y in the middle (of the three) as it can reduce/displace* X^{+} *but not* Z^{2+} **1 mark**

Accept converse argument. Do not accept: Z^{2+}, Y^{2+}, X^{+} *for Z, Y and X.*