2024

VCE

Chemistry

Trial Examination

ANSWERS

Kilbaha Education

Quality educational content

Kilbaha Education (Est. 1978) (ABN 47 065 111 373) **PO Box 3229** **Cotham Vic 3101** **Australia**	**PayID: 47065111373** **Email:** kilbaha@gmail.com **Tel: (03) 9018 5376** **Web:** https://kilbaha.com.au

Section A – Multiple-choice questions 1 mark for each correct answer = **30 marks**

Question	Answer
1	C
2	B
3	C
4	B
5	A
6	D
7	B
8	C
9	D
10	D
11	A
12	D
13	A
14	B
15	C

Question	Answer
16	B
17	A
18	A
19	C
20	D
21	D
22	B
23	A
24	B
25	C
26	C
27	A
28	D
29	B
30	A

Question 1 Correct answer: C

No calculation is necessary – the values from the Data Book Sections 14 and 15 can be compared directly. The heat of combustion of natural gas is listed as 54 kJ g^{-1} which is higher than the other fuels.

Question 2 Correct answer: B

All equations are correctly balanced. Option B has states matching those of the Data Book Section 13 and is the correct answer. Option C does not list a negative value and, therefore, cannot be correct. Option A should show water as a liquid and the value in option D should be 5760 kJ mol^{-1}.

Question 3 Correct answer: C

10 mol of propan-1-ol will produce 30 mol of CO_2 gas.
The volume of 30 mol at SLC is 30 x 24.8 = 744 L.
The energy released is 10 x 2020 = 20200 kJ

Question 4 Correct answer: B

Data Book Section 12. Energy released = 37 x 2 = 74 kJ = 74000 J
q= 4.18 x 1200 x ΔT = 74000 => ΔT = 74000/(4.18 x 1200) = 14.75 = 14.8 ºC

Question 5 Correct answer: A

Data Book Section 1.
The two relevant half-equations are (on the electrochemical series)
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$ => Cl_2 is the strongest oxidising agent. (+1.36 V)

Question 6 Correct answer: D

The half-equations occurring are

$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$ and $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

Cl^- ions are formed in this reaction requiring cations (positive) to move from the salt bridge into the chlorine half-cell to maintain neutrality.

Question 7 Correct answer: B

By definition, reduction always occurs at the cathode, independent of whether it is a galvanic cell or an electrolytic cell.

Question 8 Correct answer: C

Y and Z^+ will not react spontaneously because $E^0(Y^{2+}) > E^0(Z^+)$. Therefore, a power supply is required. The nitrate ions are spectator ions.

$$Y^{2+}(aq) + 2e^- \rightarrow \mathbf{Y(s)}$$
$$\mathbf{Z^+(aq)} + e^- \rightarrow Z(s)$$

Question 9 Correct answer: D

Catalysts become 'poisoned' during use – covered in byproducts or corrosion. Cleaning the catalyst restores the surface, increasing the exposed surface area of the catalyst.
Option A is not correct – yes, the catalyst lowers the activation energy but the act of cleaning the catalyst does not.

Question 10 Correct answer: D

When the volume is halved, the pressure is increased. The rates of the forward and back reactions will be greater as the reduced volume increases the frequency of collisions. The system moves toward the side with the smaller number of particles, in this case the reactant, so there will be a smaller amount of bromine. Despite favouring the back reaction, the brown intensity will be greater than at the first point of equilibrium due to the decrease in volume. When the volume is halved, the brown intensity initially doubles and then decreases only a little when the new equilibrium is reached.
This can be a surprise for students – the brown intensity is higher at the second point of equilibrium despite the back reaction being favoured.

Question 11 Correct answer: A

N_2O_4 was added to an empty reactor. The forward reaction needs to be favoured as the system moves toward equilibrium. At the 1 minute mark, the system has yet to reach equilibrium so the forward reaction still needs to be favoured.
The concentration fraction, *Q*, will be lower than *K* until equilibrium is reached.

Question 12 Correct answer: D

The original $[N_2O_4]$ is n/V = 2/2 = 1.0 M.

If the $[NO_2]$ moves to 0.4 at equilibrium, the $[N_2O_4]$ drops by half that amount, 0.2. (ratio of 1:2 in equation).

Equilibrium $[N_2O_4]$ = 1.0 – 0.2 = 0.8 M

The value of *K* for the forward reaction is $K = \frac{[NO_2]^2}{[N_2O_4]}$ = $(0.4)^2/0.8$ = 0.2 M.

The value for the reverse reaction is 1/K = 1/0.2 = 5 M^{-1}.

Question 13 Correct answer: A

The reaction at the cathode must be reduction, thereby ruling out options B and C.

The product needs to be hydrogen gas as H^+ is reduced, thus the answer is A. This half-equation can be found on the electrochemical series. Data Book Section 1.

Question 14 Correct answer: B

The deposition of tin occurs in two stages but the overall equation is

$Sn^{4+} + 4e^- \rightarrow Sn$

$n(e^-)$ = 24100/96500 = 0.2497 mol

n(Sn) = 0.2497/4 = 0.0624 mol

Question 15 Correct answer: C

The titres fluctuate significantly. Of the alternatives offered, option C is a plausible explanation. When a titration requires heat, the rate of the reaction is slow. This would make it difficult to pick the endpoint as the reaction might not be complete. Reproducibility is not relevant as the experiment is not being tested by another party. There is no evidence of systematic errors.

Question 16 Correct answer: B

The molecule is a ketone and contains seven carbon atoms in the longest chain. Numbering starts on the right hand side, giving 3-methylheptan-4-one.

Question 17 Correct answer: A

Reaction is: $C_3H_7Cl + NH_3 \rightarrow C_3H_7NH_2 + HCl$

Atom economy = $\frac{M(C_3H_7NH_2)}{M(C_3H_7Cl)+M(NH_3)} \times 100$ = 59/(78.5+17) x 100 = 61.8%

Question 18 Correct answer: A

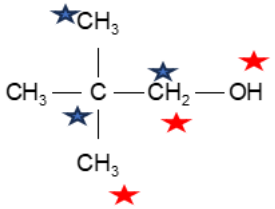
Butan-1-ol can react with $Cr_2O_7^{2-}$ to form butanoic acid. The testing of the compound in the question shows it is an acid due to its reaction with sodium hydrogen carbonate to produce the gas carbon dioxide. Butan-2-ol cannot be correct as it will form a ketone which does not react with sodium hydrogen carbonate.

Question 19 Correct answer: C

The relevant environments are marked on the diagram:

★ = carbon environments

★ = hydrogen environments



Question 20 Correct answer: D

The iodine number is not affected by the transesterification.

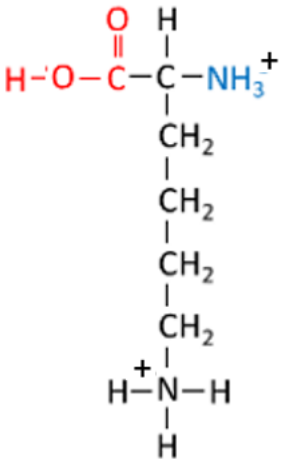
Therefore, the number of C=C double bonds is 3 x 0.2 = 0.6 mol.

There are 3 double bonds in each triglyceride molecule.

Mass iodine (I_2) reacting = 0.6 x 2 x 126.9 = 152.3 g

Question 21 Correct answer: D

Lysine contains two amino groups. In acidic conditions both of these groups will accept a H^+ proton, giving the molecule a 2+ charge as shown below.

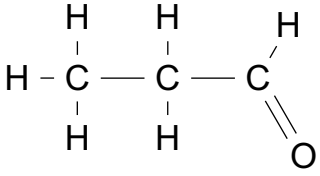


Question 22 Correct answer: B

Starch is a polysaccharide, as is glycogen. When we consume starch, the glycosidic links are hydrolysed and glucose molecules form. A condensation reaction reforms the glycosidic bonds between glucose but the product this time is glycogen.

Question 23 Correct answer: A

Propanal has three hydrogen environments and the ratio of areas under the peaks will be 1:2:3, matching the data on the spectrum. The high shift of the aldehyde group is another clue. The molecule cannot be propanoic acid, as it would contain a singlet peak.



Question 24 Correct answer: B

Ethyl ethanoate hydrolyses to ethanol and ethanoic acid. Ethanol has a lower boiling point than ethanoic acid due to the extra hydrogen bonding in ethanoic acid. The ethyl ethanoate is gone as the question says complete hydrolysis.

Question 25 Correct answer: C

The balanced equation for the reaction is required

$C_2H_2O_4(aq) \rightarrow 2CO_2(g) + 2H^+(aq) + 2e^-$

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

==========

$5C_2H_2O_4(aq) + 2MnO_4^-(aq) + 6H^+(aq) \rightarrow 10CO_2(g) + 2Mn^{2+}(aq) + 8H_2O(l)$

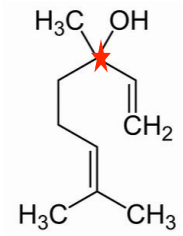
$n(KMnO_4) = c \times V = 0.1 \times 0.01 = 0.001$ mol

$n(\text{oxalic acid}) = 0.001 \times 5/2 = 0.0025$ mol

$c(\text{oxalic acid}) = n/V = 0.0025/0.02 = 0.125$ M

Question 26 Correct answer: C

The carbon atom marked is a chiral carbon and it is also the site of a tertiary alcohol. The tertiary alcohol will not be oxidised.



Question 27 Correct answer: A

A scientific investigation should study at least one independent and one dependent variable but it does not need to study more than one. The other three options can all be found in the discussion of Area of Study 3 in the study design.

Question 28 Correct answer: D

Ethanol is acting as a competitive inhibitor. Due to its similar shape and properties it can occupy the enzyme active site. The enzyme is then not available to convert methanol to methanal.

Question 29 Correct answer: B

The heat of combustion of ethanol is listed in Section 13 of the Data Book as 1370 kJ mol^{-1}. As the volume of water used increases, the experimental value becomes more consistent and closer to this value. The data suggests that the use of an increased volume of water leads to more accurate results. (Obviously a lot of energy is lost to the surroundings in this experiment.)

Question 30 Correct answer: A

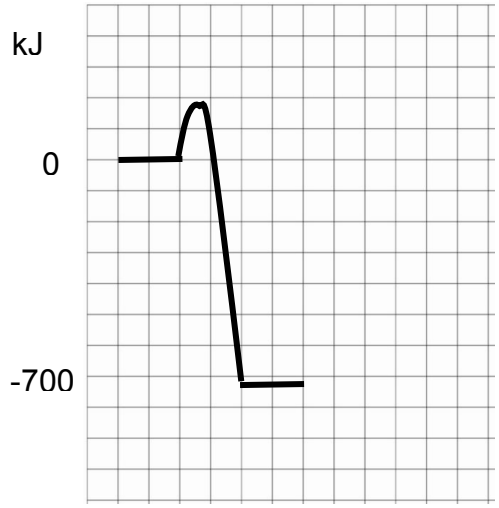
The values obtained for the last three trials, when the same volume is used, are very consistent. The consistency of results is referred to as precision. The results are precise but not accurate as the real value is much higher. This experiment does not test reproducibility.

END OF SECTION A

Section B: Short answer questions (* = 1 mark to the maximum for the question)

Question 1 (12 marks)

a. $CH_3OH(l) + 1.5O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ (or double coefficients) 1 mark



*Graph needs to show exothermic reaction.

Height of activation energy not assessed.

ΔH of 726 kJ needed from Section 13 of the Data Book* 2 marks

b. **i**. anode: $CH_3OH(l) + H_2O(l) \rightarrow CO_2(g) + 6H^+(aq) + 6e^-$ 1 mark

cathode: $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ 1 mark

ii. n(methanol) = 1000/726 = 1.38 mol*

allowing for inefficiency, n(methanol) = 1.38 x 100/72 = 1.91 mol*

m(methanol) = 1.91 x 32 = 61.2 g* 3 marks

iii. $n(CO_2)$ = n(methanol) = 1.91 mol

V = 1.91 x 24.8 = 47.4 L 1 mark

c. Biogas can be made from waste biomass. Therefore, it is helping solve a waste problem. Consequently, the production of biomethanol from this biogas is a sustainable process, placing no long term stresses on scarce resources*. The CO_2 absorbed when the biomass is formed will also help compensate for subsequent CO_2 emissions*. In contrast, when methanol is made from natural gas, scarce resources are used, placing pressure on limited reserves. The use of natural gas will also lead to greater CO_2 emissions.*

3 marks

Question 2 (8 marks)

a. **i.** anode half-equation: $VO^{2+}(aq) + H_2O(l) \rightarrow VO_2^{+}(aq) + 2H^{+}(aq) + e^{-}$ 1 mark

ii. cathode half-equation: $V^{3+}(aq) + e^{-} \rightarrow V^{2+}(aq)$ 1 mark

iii. overall equation: $V^{3+}(aq) + VO^{2+}(aq) + H_2O(l) \rightarrow V^{2+}(aq) + VO_2^{+}(aq) + 2H^{+}(aq)$

1 mark

iv. In VO^{2+} the vanadium oxidation state = 4+

In VO_2^{+} the vanadium oxidation state = 5+ 1 mark

b. **i.** A vanadium flow battery does not need a continuous supply of fuel like the fuel cell does because it regenerates its fuel during the recharge cycle. 1 mark

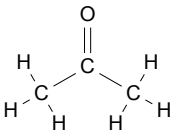
ii. The electrodes in a fuel cell are also catalysts for the reactions occurring. They usually contain expensive metals. The vanadium flow cell electrodes do not need to act as catalysts and are made from cheaper materials. 1 mark

c. The temperature* of the cell will impact the voltage. The vanadium ion concentrations and sulfuric acid concentrations also.* The cell might also have some internal resistance.*

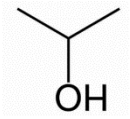
2 marks

Question 3 (6 marks)

a. Compound E contains 3 carbons but is not acidic => it is propanone.*

Oxidation of a secondary alcohol forms a ketone. * 

2 marks

b. 

propan-2-ol 1 mark

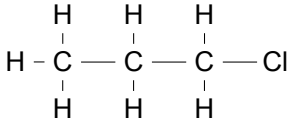
c. **i.** Two possible ways of showing the equation are:

$C_3H_6 + H_2O \rightarrow C_3H_8O$ and $CH_2CHCH_3 + H_2O \rightarrow CH_3CHOHCH_3$

It is not essential to show the catalyst H_3PO_4/H^{+} above the arrow 1 mark

ii. No need for a calculation – atom economy of an addition reaction is 100%

1 mark

d. 

Compound C is 2-chloropropane.

An isomer is 1-chloropropane. 1 mark

Question 4 (11 marks)

a. **i**. The third element is chlorine.* The pattern on the end of the spectrum is characteristic of chlorine and is caused by its two isotopes ^{35}Cl and ^{37}Cl. The difference of 2 in mass and the higher intensity of the lighter parent ion are the characteristics of chlorine atoms.* 2 marks

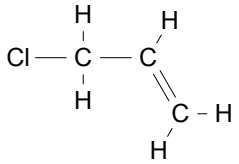
ii. The relative atomic mass of Cl is 35.5. Subtracting this from 76.5 gives 41, matching C_3H_5. Molecular formula is likely to be C_3H_5Cl. 1 mark

b. Absorption 1: Absence of a broad peak between 2500 and 3500 cm^{-1} rules out the presence of a -OH bond. Data Book Section 22. 1 mark

Absorption 2: Absence of a sharp peak around 1750 cm^{-1} rules out the presence of a carbonyl group C=O. Data Book Section 22. 1 mark

c. i. 3 peaks = 3 environments 1 mark

ii. The compound is unlikely to have a - CH_3 group.* The lack of peaks with low shift values* on both the carbon and proton-NMR would suggest no methyl group.
Data Book Section 23.
2 marks

d. **i**.  2 marks

3-chloroprop-1-ene has the molecular formula C_3H_5Cl. It has 3 carbon environments and 3 hydrogen environments. The carbon atom with the Cl atom will match the doublet hydrogen environment as it has one neighbouring hydrogen atom. The shift values on the carbon-NMR are consistent with the presence of a halogen and a C=C double bond.
Data Book Section 23.

ii. 3-chloroprop-1-ene 1 mark

Question 5 (8 marks)

a. Cell A: $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$ 1 mark

Cell B: $H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$ 1 mark

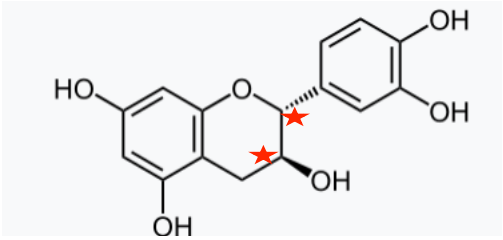
Cell C: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ 1 mark

b. All three cells have the same cathode reaction $Cu^{2+} + 2e^- \rightarrow Cu(s)$, hence all three cathodes increase in mass. 1 mark

c. Cell C will operate at the lowest voltage as the reaction at each electrode uses the same atoms, Cu(s), and ions, $Cu^{2+}(aq)$, This only needs a very low voltage. 1 mark

d. It is unlikely that the same mass of copper will be obtained in each cell*. The voltage applied is the same but the charge in each cell is calculated using Q = It. *The resistance in each electrolyte will differ so the currents will differ. When the currents differ, the number of mole of electrons will differ and, therefore, the mass obtained*. If the cells were all connected in series the current through each would be the same and the mass obtained the same. 3 marks

Question 6 (8 marks)



a. Catechin has two chiral carbons as marked on the diagram. 2 marks

b. Catechin has a large number of hydroxyl groups.* It will be a very polar molecule and best extracted with a polar solvent such as water or ethanol.* 2 marks

c. The several forms of catechin are likely to be different enantiomers*. It is common for different enantiomers to act differently in the body. The different spatial orientation of the functional groups between enantiomers makes them seem like completely different molecules to the body* (to enzyme sites in particular) 2 marks

d. The enzyme inhibitor needs to block* the active site of the enzyme catechin oxygenase. This prevents the catechin occupying the site* and being degraded and losing effectiveness. 2 marks

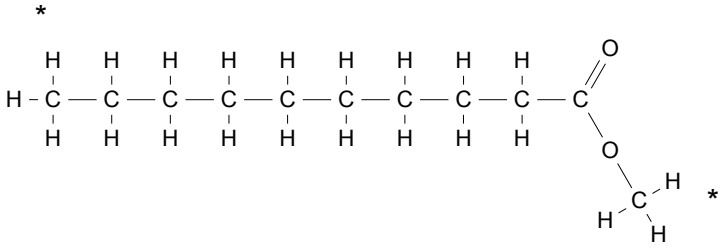
Question 7 (9 marks)

a. **i.** Capric acid is a saturated fat. It has no C=C double bonds to react with iodine.

Data Book Section 21.

1 mark

ii.

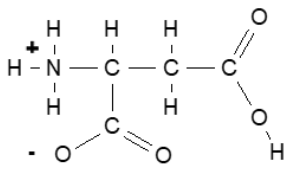


2 marks

iii. Lipase breaks* the ester bond when a triglyceride enters the large intestine. The rate of the reaction is maximised at a particular temperature when the pH is 8.*

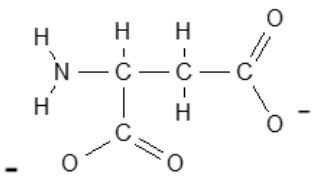
2 marks

b. **i.**



Data Book Section 20. 1 mark

ii.

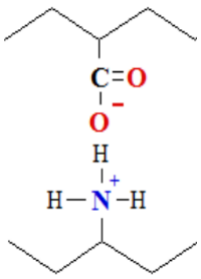


1 mark

iii. Aspartic acid can form ionic bond with basic amino acids such as lysine.

Data Book Section 20.

An ionic bond forms between the amine group and the carboxyl group.



2 marks

Question 8 (11 marks)

a. **i**. type of fruit or vegetable 1 mark

ii. Vitamin C content 1 mark

b. $I_2(aq) + 2e^- \rightarrow 2I^-(aq)$

$C_6H_8O_6(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 2e^-$ 2 marks

c. The flask will initially have the colour of the fruit or vegetable. As the iodine is added it reacts with the vitamin C. Once the endpoint is reached, the iodine is in excess and it turns the starch indicator, and the flask contents, blue. The final colour is a blend of blue and the original.* The question refers to tomatoes – the likely initial colour is red and the final colour brown.* 2 marks

d. The experiment is too flawed for a comparison of the orange juice and the other fruits or vegetables.* A comparison requires an equal amount of each juice. 10 mL of a commercial orange juice is not comparable to 10 g of the other fruits*. The orange juice might have added vitamin C or antioxidants as well.* It might be heavily diluted. The iodine solution might not have been stable over the year * 3 marks

e. Use 10 g of pure orange, not a commercial juice.
Dilute the orange juice in the same way the other products are diluted.
Use fresh Kakadu plums.
Prepare fresh iodine solution (any 2 valid answers) 2 marks

Question 9 (12 marks)

a. **i**. The reaction is exothermic – if the temperature is too high, the yield will be low*. If the temperature is too low, the rate is too low*. 450 ºC is a suitable compromise that enables a viable yield at a reasonable rate. 2 marks

ii. the ratio of reactant molecules to product molecules is 3:2.* High pressure will favour the forward reaction*, increasing the yield. 2 marks

iii. a catalyst offers an alternative reaction path with a lower activation energy*. In this case, the effectiveness of the catalyst is maximised by layering it at several levels. This increases the surface area* the reactant gases are exposed to. 2 marks

iv. if the SO_3 produced is removed quickly from the reacting gases, the system moves in the forward direction to oppose this change*. The yield is therefore increased*. 2 marks

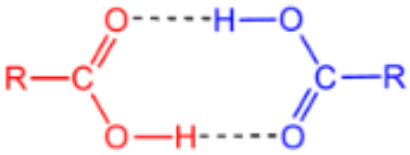
b. Several goals could be referenced. Sample answer: Goal 12: Responsible consumption and production.* Maximising the yield and minimizing energy consumption are examples of responsible practice.* Data Book section 26. 2 marks

c. Sample answer: Catalysis.* The use of vanadium pentoxide as a catalyst, and the structuring of the catalyst bed, are examples of the use of catalysis to minimize wastage and energy consumption.* 2 marks

Question 10 (5 marks)

Viscosity is the resistance to flow of a liquid. In some ways, it is a measure of the strength of the intermolecular bonds of the substance. *

Octane is a hydrocarbon molecule. The only forces between molecules are weak dispersion forces. Its viscosity is the lowest of the three molecules listed*. Ethanoic acid and octanoic acid are carboxylic acids, each one containing two oxygen atoms. The presence of oxygen adds dipoles to the structure, leading to strong hydrogen bonds between molecules*. These hydrogen bonds cause the viscosity of ethanoic acid and octanoic acid to be higher than that of octane.*



The viscosity of octanoic acid will be higher than ethanoic acid. There is a consistent trend in homologous series for the viscosity to increase with molecule size*. The extra molecule size adds dispersion forces to the hydrogen bonds, making the intermolecular bonding in octanoic acid higher than that of ethanoic acid.*

Total Marks = 90

End of Suggested Answers

2024 Kilbaha VCE Chemistry Trial Examination

Kilbaha Education (Est. 1978) (ABN 47 065 111 373) **PO Box 3229** **Cotham Vic 3101** **Australia**	**PayID: 47065111373** **Email:** kilbaha@gmail.com **Tel: (03) 9018 5376** **Web:** https://kilbaha.com.au