VCE CHEMISTRY 2019

YEAR 12 TRIAL EXAM

Units 3/4

Reading time: 15 minutes

Writing time: 2 hours 30 minutes

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	7	7	95
			Total 125

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VCE Chemistry 2019 Year 12 Trial Exam Units 3/4

SECTION A – Multiple Choice Questions

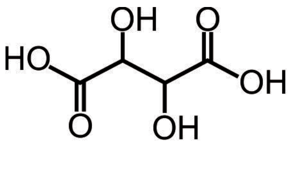
(30 marks)

Section A consists of 30 multiple-choice questions.
Choose the response that is **correct** *or* **best answers** *the question.*
A correct answer scores 1, an incorrect answer scores 0.
No mark is awarded if more than one answer is supplied for a question.
Indicate your choice on the answer sheet provided.

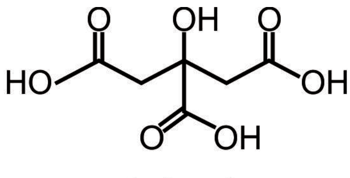
Question 1
The conversion of a carbonyl group to a carboxyl group would usually not be expected to be part of an organic reaction pathway for the production, from a hydrocarbon, of an
A. acid.
B. amine.
C. amide.
D. ester.

The information supplied below and in ***Figure 1*** *relates to four carboxylic acids and applies to both Questions 2 and 3.*

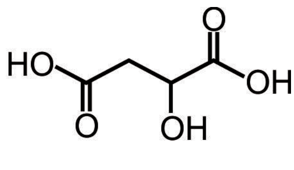
Ethanoic acid is the main ingredient in vinegars, whilst the carboxylic acids tartaric acid, citric acid and malic acid, all occur naturally in grapes, citrus fruits and apples, respectively. The molecular structures of three of these acids are represented in **Figure 1**.



tartaric acid



citric acid



malic acid

Figure 1

Question 2
Which of these acids might be expected to show the same number of peaks on its ^{1}H NMR spectrum as the amino acid aspartic acid?
A. Tartaric acid.
B. Citric acid.
C. Malic acid.
D. Ethanoic acid.

Question 3

In terms of IR spectra, in which of these absorption frequency bands would a peak be expected to appear on the spectra of only three of the acids?

A. 1680-1740 cm^{-1}
B. 1720-1840 cm^{-1}
C. 2500-3500 cm^{-1}
D. 3200-3600 cm^{-1}

Question 4

The electrolysis of an aqueous solution of copper(II) sulfate produces a metal at one electrode and the colour of the solution remains constant.
With respect to these observations, which of the following comments relating to the electrolysis cell used is **most** significant with respect to the operation of the cell?

A. The positive electrode is made of copper.
B. The positive electrode is made of iron.
C. The negative electrode is made of iron.
D. The negative electrode is made of copper.

Question 5

There is often a clear distinction between small scale laboratory synthesis and large scale industrial synthesis of a compound. In laboratory synthesis the costs of reagents may not be a significant factor, but in the chemical industry not only must the compound be prepared on a large scale, but also at a low cost.
Because it is abundant, green and inexpensive, oxygen, O_2, is the oxidant of choice in the chemical industry. However, a challenge arises when specific reactants can provide different products. For example, ethylene and air are the reactants for the industrial production of both ethanal and ethylene oxide. **Figure 2** represents the structure of ethylene oxide.

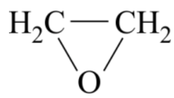


Figure 2

Which of the following is likely to be the most significant determinant in which product is obtained?

A. Temperature.
B. Pressure.
C. Relative amounts of reactants used.
D. Catalyst used.

Question 6
The oxidation of organic substrates by iron(II) and hydrogen peroxide is called the "Fenton chemistry". The Fenton reagent, defined as a mixture of hydrogen peroxide, H_2O_2, and iron(II) ions, is currently accepted as one of the most effective methods for the oxidation of organic pollutants in wastewater by hydroxyl radicals, very powerful oxidants, which are produced in the Fenton reaction.
In the Fenton reaction, each hydrogen peroxide molecule is reduced by Fe^{2+} to a hydroxyl radical and one other species. This gives a total of three product species in the overall equation.
The three product species should be
A. Fe^{3+}, O_2, $2H^+$
B. Fe^{2+}, OH^-, OH^-
C. Fe^{3+}, $\bullet OH$, OH^-
D. Fe^{3+}, $\bullet OH$, $\bullet OH$

Question 7
Table 1 shows part of the nutrition information for a 22.0 g serving of a brand of peanut butter.

	Average Quantity per serving	**% Daily intake per serving**
Energy	569 kJ	7 %
Protein	5.2 g	10 %
Fat, total	11.3 g	16 %
– saturated	2.3 g	10 %
Carbohydrate, total	3.0 g	1 %
– sugars	1.9 g	2 %

Table 1

The **minimum** amount of energy, in kJ, in a 500 g jar of peanut butter, that must be supplied by other nutrients in the peanut butter would be
A. 14.5 kJ
B. 101 kJ
C. 330 kJ
D. 555 kJ

Question 8
Tung oil or China wood oil is a drying oil obtained by pressing the seed from the nut of the Tung tree (*Vernicia fordii*). Tung oil can be used to polish wooden floors since it hardens upon exposure to air, and the resulting coating is transparent and has a deep, almost wet look.
Tung oil is a triglyceride which contains a mixture of α-eleostearic, stearic and linoleic acids, all of which have the same number of carbon atoms in each molecule.
Fatty acids are attributed an iodine number which indicates the mass of I_2 required to react with 100 g of the fatty acid. The iodine number of α-eleostearic acid is 273.9.
The total number of double bonds in a molecule of α-eleostearic acid is
A. one.
B. two.
C. three.
D. four.

Question 9
A motor-vehicle air bag contains a mixture of sodium azide NaN_3, KNO_3, and SiO_2. When the car undergoes a head-on collision, a series of chemical reactions inside the gas generator produce gas (N_2) to fill the airbag and convert NaN_3, which is highly toxic, to harmless gas. During a collision the signal from the deceleration sensor ignites the gas-generator mixture by an electrical impulse, creating the high-temperature condition necessary for NaN_3 to decompose. The nitrogen gas that is generated then fills the airbag. The purpose of the KNO_3 and SiO_2 is to convert the highly reactive and potentially explosive sodium metal, formed when sodium azide decomposes, to a harmless material.
The reactions occurring when the airbag deploys are represented by the equations:

$2NaN_3 \rightarrow 2Na + 3N_2$

$10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$

$Na_2O + SiO_2 \rightarrow Na_2SiO_3$

$K_2O + Na_2O + SiO_2 \rightarrow K_2Na_2SiO_4$

How many of these reactions are redox reactions?

A. One.
B. Two.
C. Three.
D. Four.

Question 10
Phenylalanine is an essential amino acid and needs to be part of our diet. Phenylalanine is the source of a non-essential amino acid in the body. Liver cells contain the enzyme phenylalanine hydroxylase which promotes the addition of a hydroxyl group. Which of the amino acids below would be produced from phenylalanine?

A. Cysteine.
B. Serine.
C. Threonine.
D. Tyrosine.

Question 11

Taurine, 2-aminoethanesulfonic acid, is an amino sulfonic acid found naturally in meat, fish, dairy products and human milk. In the body, taurine contributes to cell electrolyte balance, formation of bile salts, central nervous system function and regulation of immune health. Some studies suggest that using taurine as a supplement might enhance athletic performance. Other studies suggest that taurine combined with caffeine might improve mental performance. This combination is present in many 'energy' drinks. Some energy drinks also contain guarana which is, on average, 4.65 % caffeine (m/m).

The structure of taurine is shown in **Figure 3**.

M_r(caffeine) = 194.2 g mol^{-1})

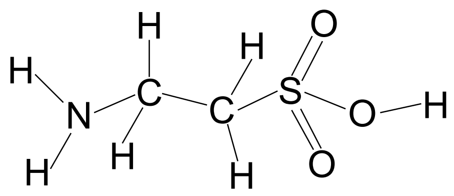


Figure 3

An energy drink in which the taurine to caffeine content is in the ratio 12.5 to 1 by mass contains 6.39 ×10^{-3} mol of taurine. What mass of guarana would be needed to source the caffeine in the drink?

A. 1.37 g
B. 64 mg
C. 0.640 g
D. 137 mg

Question 12

Many factors can affect the rate of a chemical reaction. Collision theory allows us to consider the impact of individual factors based on the assumption that for a reaction to occur, effective collisions between reactant particles must occur. The particles must collide with enough energy, known as the activation energy, to break bonds and initiate reaction.

Which of the following statements related to collision theory is **incorrect**?

A. All collisions with energy greater than the activation energy lead to effective collisions.
B. Higher reactant concentrations increase the frequency of successful collisions but not the proportion of collisions that are successful.
C. Higher reactant temperature increases both the frequency of successful collisions and the proportion of collisions that are successful.
D. Decreasing the surface area of reactants has a similar effect on reaction rate as increasing reactant concentrations.

Question 13

Lithium-ion cells have solid electrodes which allow for the intercalation of lithium ions, i.e. lithium ions can become part of the electrodes without significantly affecting the structure. During operation some lithium ion batteries have lithium intercalated graphite as one electrode material, and a lithium intercalated transition metal oxide, such as MnO_2, as the other. The electrolyte is a lithium salt.

The overall discharge equation for these lithium-ion cells may be represented as

$Li_xC_6(s) + Li_{1-x}MnO_2(s) \quad \rightarrow \quad C_6(s) + LiMnO_2(s)$

In this representation, xLi^+ is part of both the oxidation and reduction half-equations.

Part of one cell of the battery during discharging is represented below in **Figure 4**.

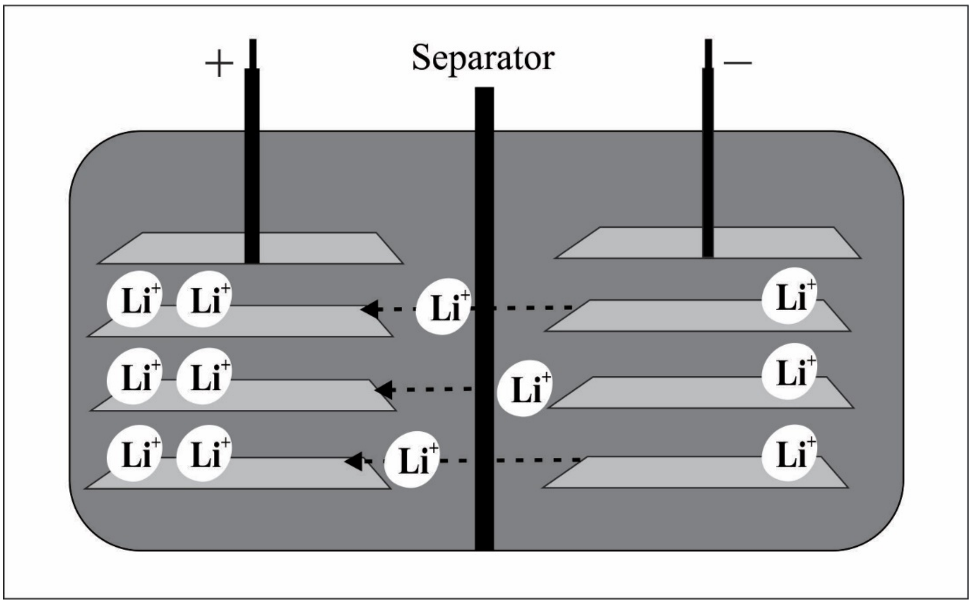


Figure 4

The half-equation for the reaction at the negative electrode during recharging would be

A. $Li_xC_6(s) \rightarrow xLi^+(aq) + C_6(s) + xe^-$

B. $xLi^+(aq) + C_6(s) + xe^- \rightarrow Li_xC_6(s)$

C. $Li_{1-x}MnO_2(s) + xLi^+(aq) + xe^- \rightarrow LiMnO_2(s)$

D. $LiMnO_2(s) \rightarrow Li_{1-x}MnO_2(s) + xLi^+(aq) + xe^-$

Question 14

Folic acid, the synthetic form of Vitamin B_9, is added to bread to reduce the likelihood of birth defects that may result from folate deficiency in pregnant women.
The structure of folic acid is represented below in **Figure 5**.

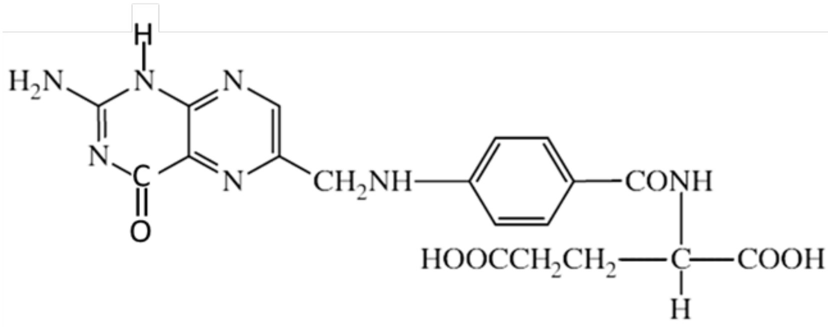


Figure 5

Folic acid

A. has fewer functional groups than vitamin C.

B. is less soluble in water that vitamin D_3.

C. has the same number of oxygen atoms in each molecule as a dipeptide formed from threonine and glutamic acid.

D. will have a peak at 3560 cm^{-1} on its IR spectrum.

Question 15
Atrazine is a systematic herbicide used to slow growth of new plant tissue by preventing photosynthesis or the generation of energy by plants. In Australia, atrazine is mainly used to control weeds in summer crops like sorghum, maize and sugarcane, as well as canola, in pastures and on golf courses.
The World Health Organisation (WHO) has set a safe level of atrazine in drinking water at 0.002 mg L^{-1}.
High performance chromatography was used to analyse atrazine levels in a dam which receives pasture runoff water after rain. A set of atrazine standards is prepared and analysed via the chromatograph to establish the calibration curve given in **Figure 6**.

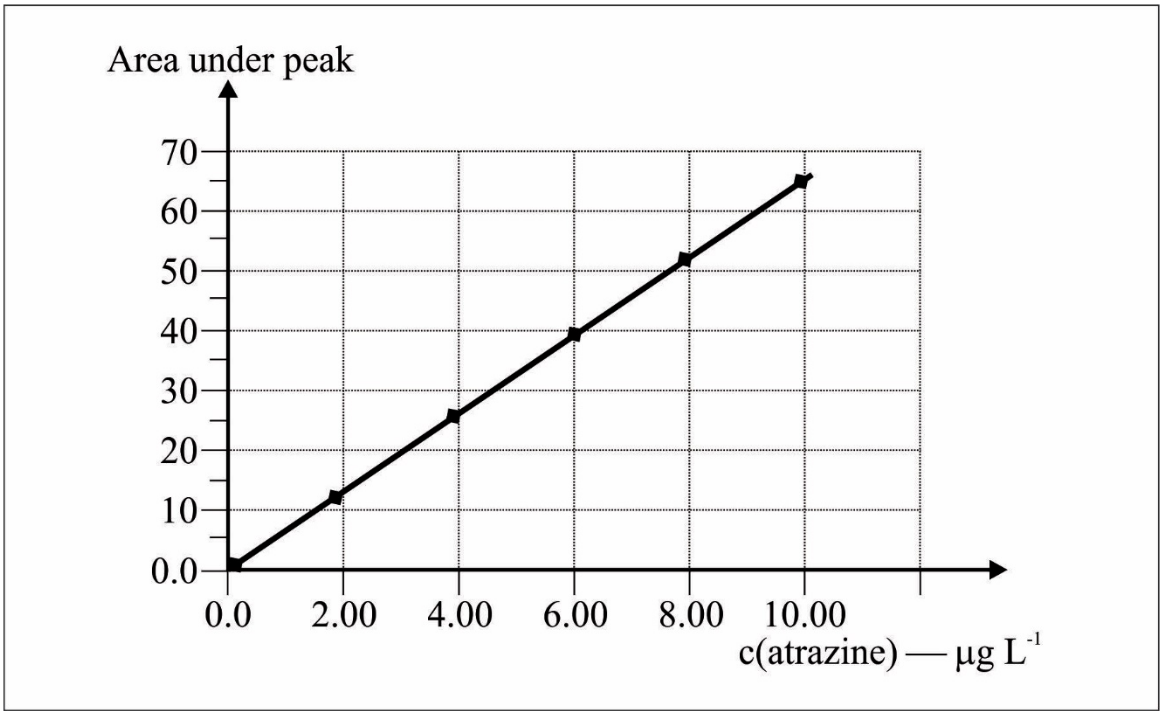


Figure 6

A sample of water from the dam was collected after rain and a 10 mL aliquot was diluted to 500 mL.
The dilute sample was analysed using the calibrated chromatograph and produced a peak area of 47.5 at the retention of atrazine.
The molecular formula of atrazine is $C_8H_{14}NCl_5$.
The factor by which the dam water exceeded the WHO safe level of atrazine in drinking water is closest to

A. 36
B. 50
C. 95
D. 180

Question 16
A key factor in the economic production of a useful product depends on a good yield of intermediate X formed as part of the production pathway.
Table 2 shows approximate values for the percentage yield of intermediate X at various temperatures and pressures.

Temperature (°C)	Pressure (kPa)	% of X at equilibrium
400	2.00×10^5	36.3
400	3.00×10^5	49.2
400	4.00×10^5	56.5
300	2.00×10^5	62.8
500	2.00×10^5	17.6

Table 2

Based on these data, the balanced thermochemical equation for the production of X shows
A. $\Delta H < 0$ and more particles on the reactant side.
B. $\Delta H > 0$ and more particles on the reactant side.
C. $\Delta H < 0$ and fewer particles on the reactant side.
D. $\Delta H > 0$ and fewer particles on the reactant side.

Question 17
Figure 7 shows a representation of a galvanic cell operating under standard conditions.

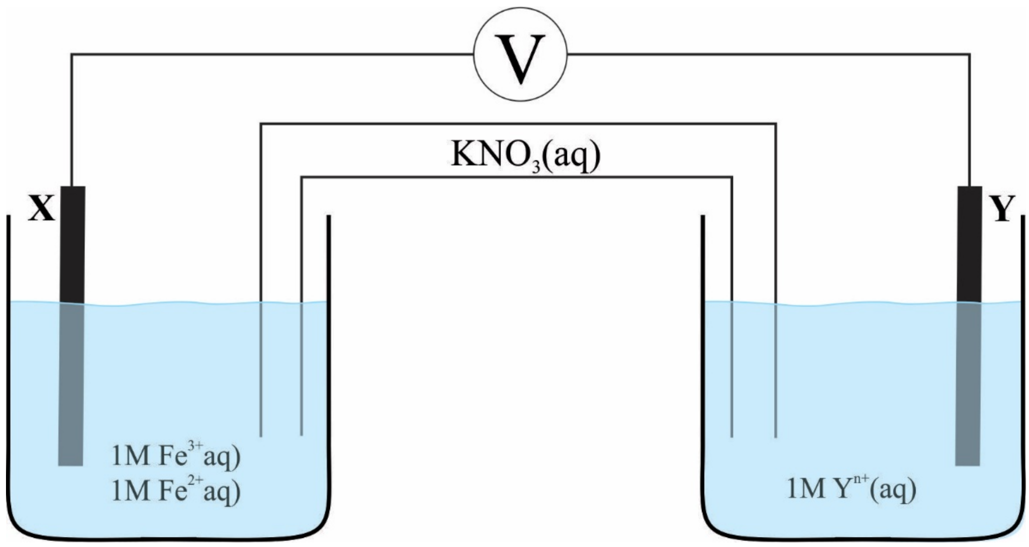


Figure 7

The cell generates an operating voltage of 0.91 V and $K^+(aq)$ ions move into the half-cell containing Y.
The elements X and Y are most likely to be
A. X - iron, Y - tin.
B. X - iron, Y - gold.
C. X - carbon, Y - tin.
D. X - carbon, Y - gold.

Question 18

0.182 g of a pure carboxylic acid was added to water to make up 25.0 mL of solution. This solution was titrated with 0.120 M NaOH(aq) to the phenolphthalein endpoint. A titre of 17.2 mL was required.

The carboxylic acid was

A. methanoic acid.
B. ethanoic acid.
C. propanoic acid.
D. methylpropanoic acid.

Question 19

Glycoproteins are involved in most processes occurring in body cells with roles in our immune systems, protection of our bodies, communication between cells, and our reproductive systems.

A simplified structure of a glycoprotein is represented in **Figure 8**.

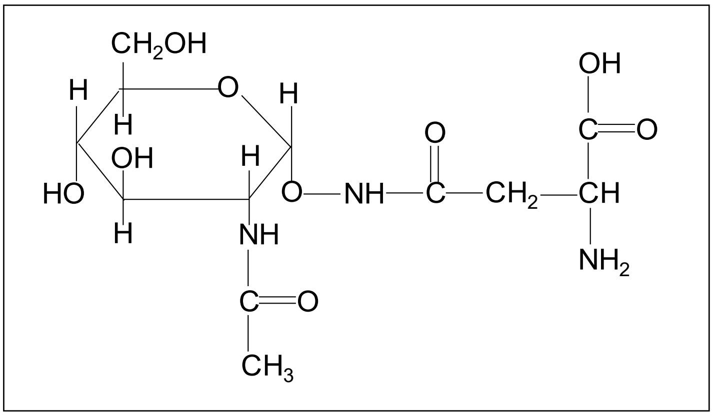


Figure 8

According to this structure, the glycoprotein might be expected to be produced in a reaction pathway involving

A. glucose, ammonia, ethanoic acid, asparagine.
B. glucose, ethyl amine, water, glutamine.
C. glucose, ethyl amide, glutamine.
D. glucose, ammonia, methanoic acid, asparagine.

Question 20
Cetane, also known as hexadecane, is a liquid that ignites easily under compression. The cetane rating, or cetane number, is a measurement of the quality of performance of diesel fuel compared to cetane itself which is assigned a cetane number of 100. In effect, the cetane number measures how quickly a fuel starts to burn under diesel engine conditions. Cetane numbers of biodiesels range from around 45 to 60 with animal-fat based sources having higher cetane numbers than vegetable sources.
Cetane numbers improvers are added to many diesel and biodiesel fuels. One such improver is known as 2-ehn and has the molecular structure shown in **Figure 9**.

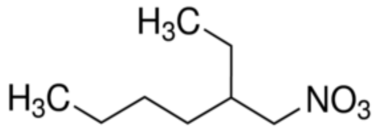


Figure 9

2-ehn molecules decompose to release free radicals which enhance oxidation.
Which of the following statements based on this information is **least** accurate?

A. Vegetable oil sourced biodiesels burn less easily than animal fat sourced biodiesels which have the same number of carbon atoms.
B. Vegetable oil sourced biodiesels have lower cetane numbers because of the stronger intermolecular attraction compared to animal sourced biofuels with the same number of carbon atoms in their molecules.
C. The molecular formula of 2-ehn is $C_8H_{17}NO_3$.
D. Vegetable oil sourced biodiesels have lower cetane numbers because their molecules contain C=C double bonds.

Question 21
Whilst modern electric cars depend on a bank of lithium ion batteries as their power source, most also have a 12 V lead acid battery to power up the controller, lights, windscreen wipers and ABS (Anti-lock Braking System). The overall equation for an operating lead-acid battery is
$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$.
As a result of a lead-acid battery being recharged,

A. the pH increases, and chemical energy is converted to electrical energy.
B. there is an oxidation number increase in the half-cell containing the (+) electrode.
C. the masses of all electrodes increase.
D. both electrodes become coated with lead(II) sulfate.

Question 22

The heat of combustion of ethanol was investigated by several students, each using the same calibrated bomb calorimeter setup and following the same method, with the mass of ethanol as the independent variable. The energy released by each ethanol sample was determined from the calibration factor and the measured temperature change.
The following set of information was produced.

Mass of ethanol	Energy released
0.447 g	10.6 kJ
1.034 g	24.5 kJ
0.795 g	18.8 kJ

Table 3

Based on the information in **Table 3**, the calculated value for the heat of combustion of ethanol was

A. accurate and reliable.
B. accurate but not reliable.
C. reliable but not accurate.
D. neither accurate nor reliable.

Question 23

Most electric vehicles cover between 8 and 10 km per kilowatt-hour (kWh) of electricity used in charging the lithium-ion batteries. 1 kWh is equivalent to 3.60 MJ of energy.
If an electric car with average electricity usage of 8.9 km kWh^{-1} and a petrol driven car with 25 per cent efficiency were both driven 400 km, what volume of petrol would be consumed in the journey?
Assume both cars use the same amount of energy, petrol is octane and its density is 703 g L^{-1}.

A. 13.5 L
B. 19.2 L
C. 27.1 L
D. 38.4 L

Question 24
The graph in **Figure 10** relates to the production of ethanol by fermentation.

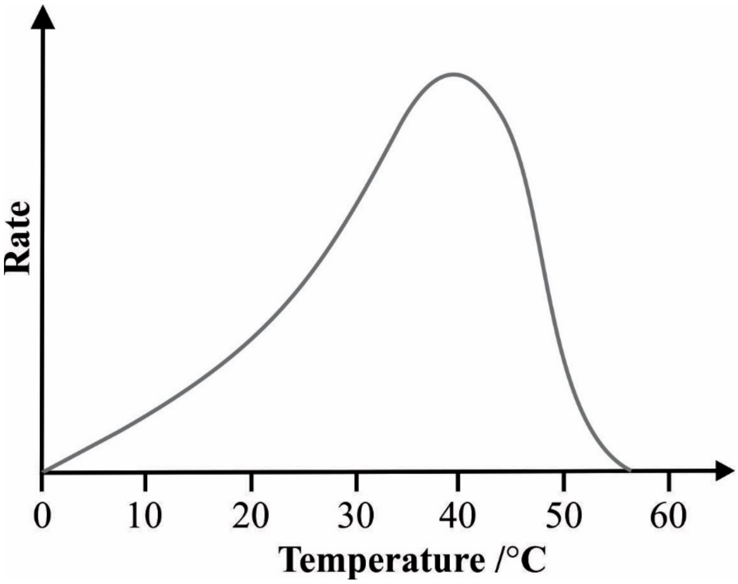


Figure 10

Which of the following statements is **not** a valid interpretation of this graph?

A. The rate of reaction at 50°C is approximately the same as the rate of reaction at 20°C.
B. Colliding particles have approximately the same energy at 20°C and 50°C.
C. The decrease in reaction rate after 40°C is due to a major enzyme structural change.
D. The increase in rate up to 40°C is not due solely to the structure of the enzyme.

Question 25
In an experiment to determine the value of Faraday's constant, a current of 1.62 A is passed through a one molar solution of copper (II) chloride for 581 seconds. At the end of that time, the negative electrode was weighed. Its mass was found to have increased by 0.306 g. Comparing the value of Faraday's constant determined from these data with the value provided in ***Table 4 of the VCE Chemistry Data Book***, which of the following experimental errors could explain the difference?

A. Negative electrode was not dried before being weighed after the electrolysis.
B. Ammeter used to register the current was reading too low by 0.03 A.
C. Stopwatch used to register time was turned off a few seconds after the electrolysis was stopped.
D. Mole ratio of $n(e^-)$:$n(Cu)$ was assumed to be 1:1.

Question 26
Known amounts of compounds X, Y and Z are added to the same container and allowed to reach equilibrium as indicated in **Figure 11**.

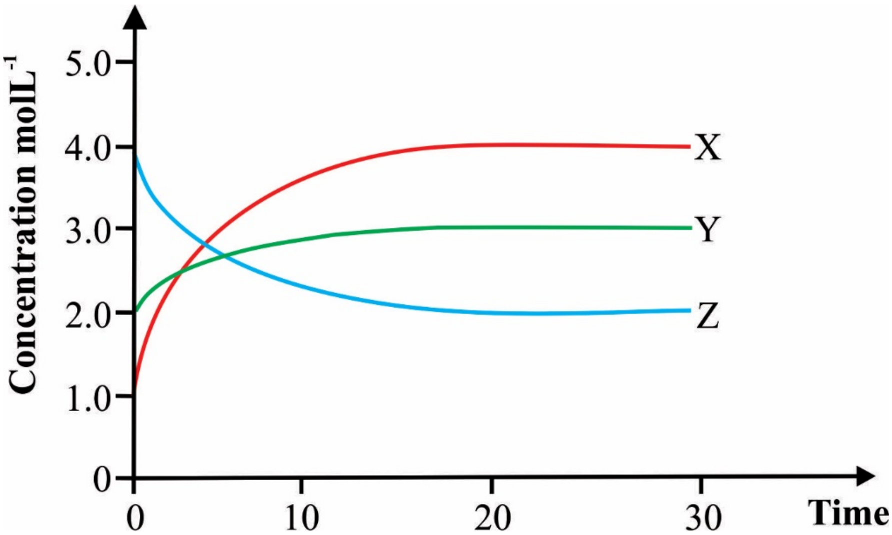


Figure 11

According to the information implied by and shown on the concentration-time graphs, the value of the equilibrium constant for the reaction described by the concentration changes is

A. 0.021 M^2
B. 0.13 M^{-1}
C. 6.0 M
D. 48 M^2

Question 27
Levulinic acid is a platform chemical and is often an intermediate in the production reagents.
The structure of a levulinic acid molecule is shown in **Figure 12**.

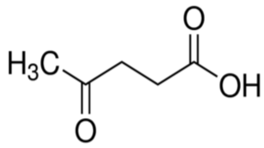


Figure 12

Recently it has been linked to a 'pink drink', the description given to a compound which may be used by surgeons to get cancerous cells in some tumours to show up under a blue light and allow better targeted treatment.
The compound in the 'pink drink' which enables this effect is known as 5-ALA, or 5-amino levulinic acid.
The semi-structural formula of 5-ALA is

A. $CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-CH_2CH_2-\overset{\overset{\displaystyle O}{\|}}{C}-NH_2$

B. $H_2N-\overset{\overset{\displaystyle O}{\|}}{C}-CH_2CH_2-\overset{\overset{\displaystyle O}{\|}}{C}-OH$

C. $H_2NCH_2-\overset{\overset{\displaystyle O}{\|}}{C}-(CH_2)_2-\overset{\overset{\displaystyle O}{\|}}{C}-OH$

D. $HO-\overset{\overset{\displaystyle O}{\|}}{C}-CH_2CH_2-\overset{\overset{\displaystyle O}{\|}}{C}-NH-CH_3$

Question 28
Two different changes were imposed on different samples of the same equilibrium mixture containing NO_2 and N_2O_4 described by the equation
$2NO_2(g) \rightleftharpoons N_2O_4(g)$.
The concentration-time graphs showing the impact of these changes are given in **Figure 13**.

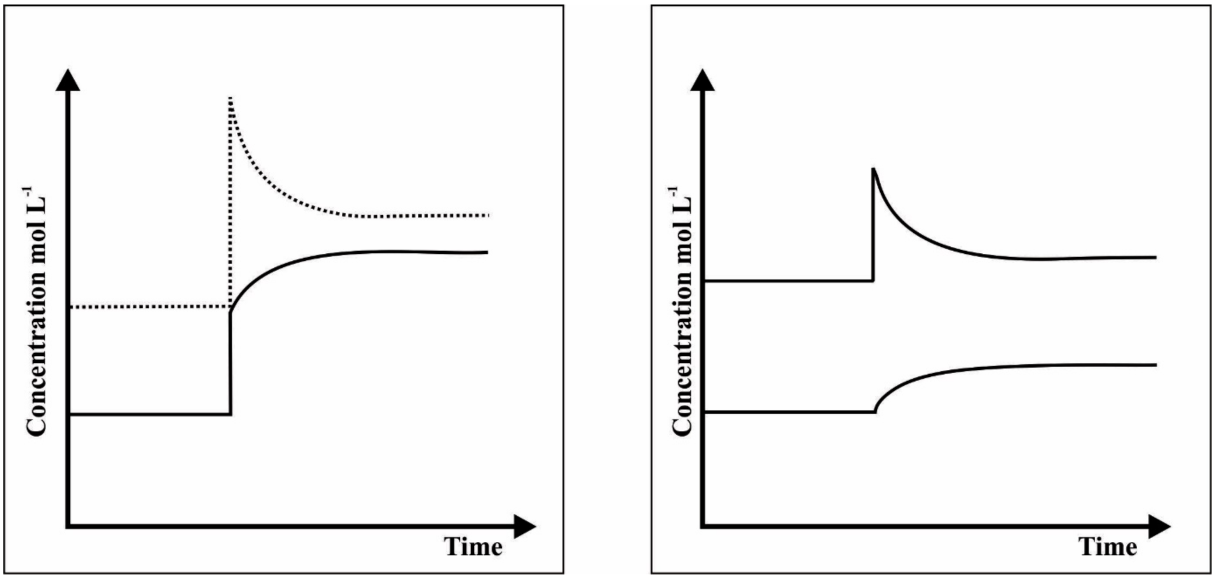


Figure 13

According to these graphs,

A. after both imposed changes, when the system has returned to equilibrium the $m(NO_2)$ present has increased relative to the amount present prior to the imposed change.

B. the imposed changes were doubling the volume in one case and adding N_2O_4 in the other.

C. the imposed changes were halving the volume in one case and adding NO_2 in the other.

D. after both imposed changes, as the system returns to equilibrium the rate of the forward reaction is less than the rate of the reverse reaction.

Question 29
The bond breaking and bond making associated with the combustion of hydrogen is represented in **Figure 14**.

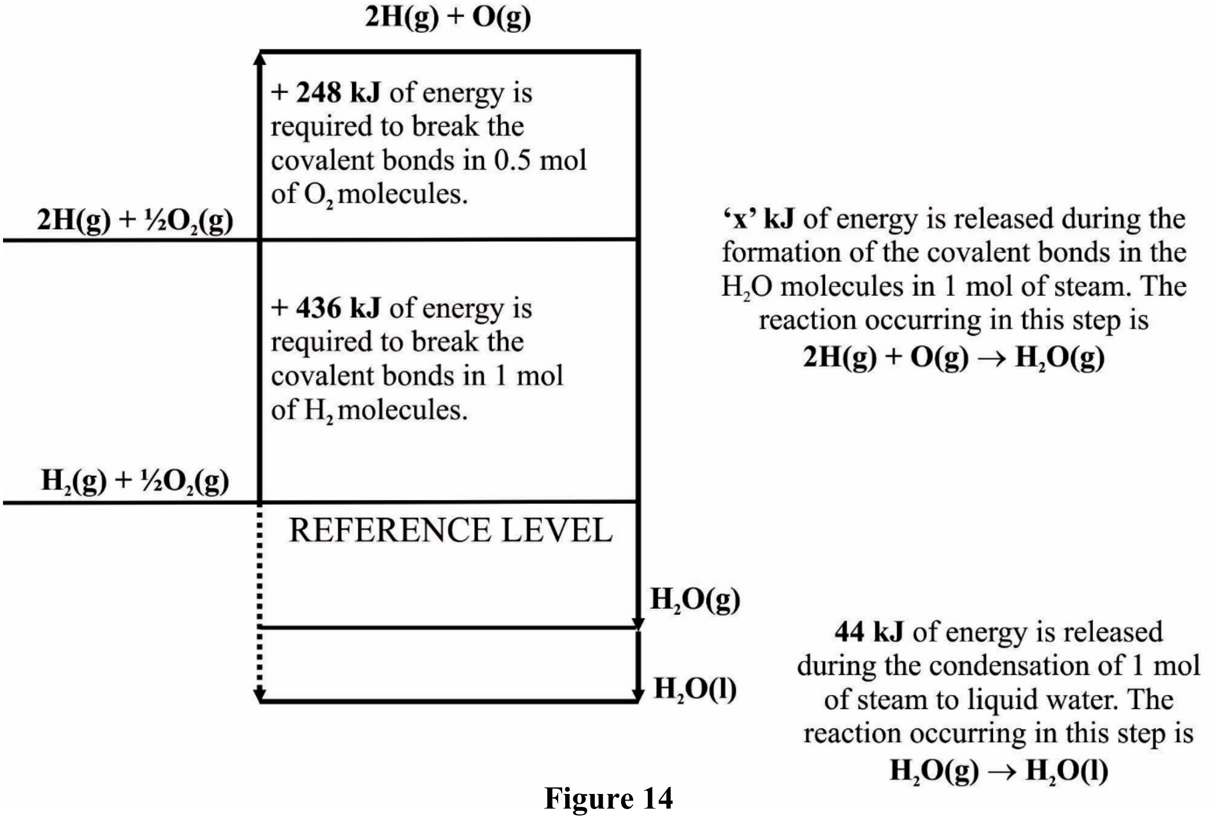


Figure 14

The value of '**x**' is

A. 684
B. 728
C. 922
D. 956

Question 30
Agricultural production of red meat is a significant biogenic source of greenhouse gases and it has been suggested that in the long-term interest of the environment, red meat consumption should be significantly reduced, if not eliminated. However, research has shown that mixing some forms of marine algae from seaweed with cattle feed reduces the total amount of a greenhouse gases emitted by cows. Bromoform, a compound in seaweed, disrupts the activity of enzymes used by microbes to produce one of the greenhouse gases released by cows. It is estimated that over an extended period, 1 kg of the greenhouse gas has 28 times as much global warming effect as 1 kg of carbon dioxide.
The chemical formula of this greenhouse gas produced by cows is

A. CH_4
B. H_2O
C. O_3
D. N_2O

End of Section A

VCE Chemistry 2019 Year 12 Trial Exam Units 3/4

SECTION B – Short Answer Questions

(95 marks)

Section B consists of 7 short answer questions. *You should answer all of these questions in the spaces provided.* *The allotted **marks** are shown at the end of each part of each question.*

Question 1 (15 marks)
Figures 15-18 shown below are representations of four different types of biomolecules.

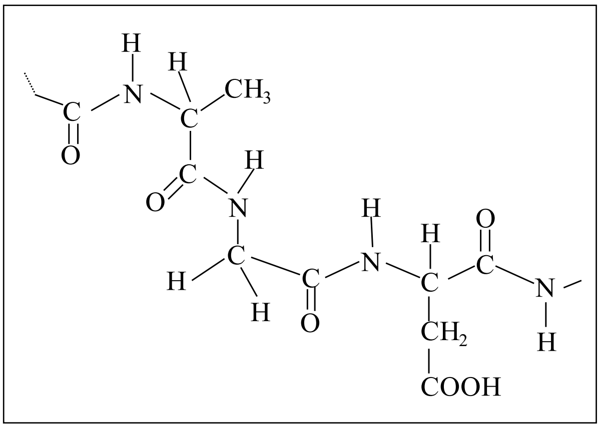


Figure 15

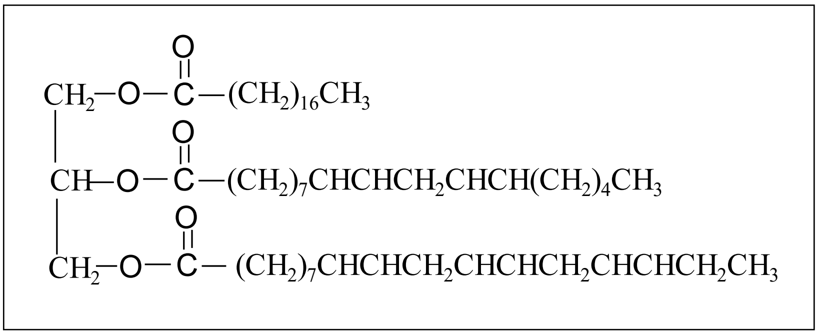


Figure 16

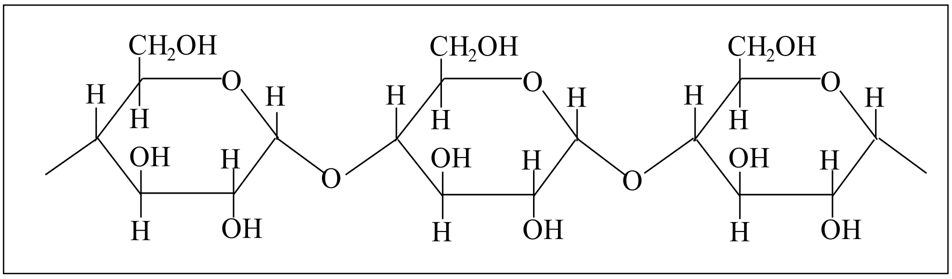


Figure 17

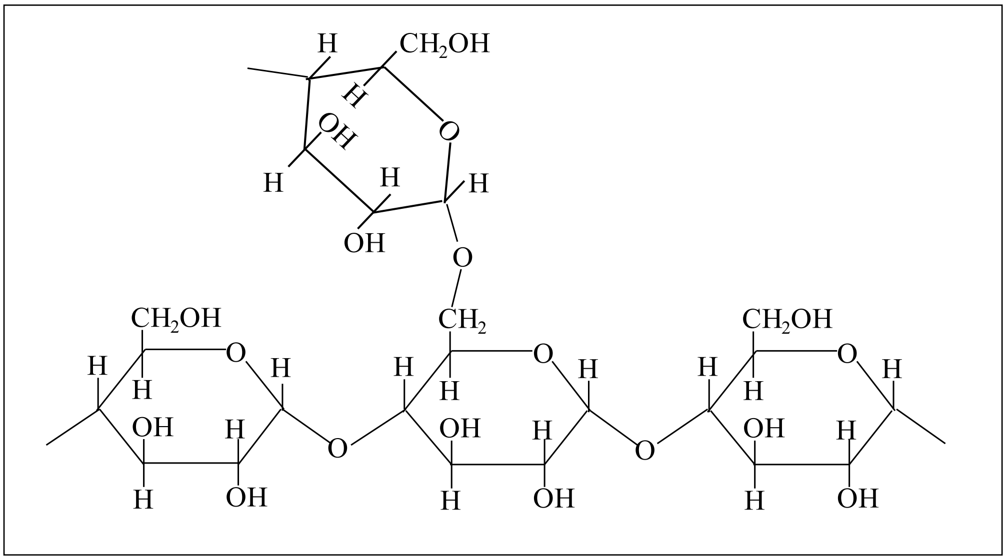


Figure 18

a. Identify **one** chiral carbon on each of the four structures shown. Circle the appropriate spot on **Figures 15-18**. **2 marks**

b. Using one of the structures as a reference point, describe the relationship between chiral carbons and biological catalytic action. **3 marks**

c. Hydrolysis of one of these structures produced four different compounds.

i. Give the names of the four compounds. **2 marks**

ii. Three of these compounds have the same functional group and are part of the same chemical family. Name the chemical family. **1 mark**

iii Describe the differences in the molecular structures of the three compounds with the same functional group. **3 marks**

iv. Explain how differences in molecular structure affect the melting points of the three compounds which have the same functional group. **2 marks**

d. Describe the links between two of the structures shown and glycemic index. **2 marks**

Question 2 (9 marks)
Aspartame ***(represented in Table 10 of the VCE Chemistry Data Book)*** is a white, odourless, crystalline powder which is about 200 times sweeter than sugar and very soluble. Taken to two significant figures, aspartame has the same energy content per gram as proteins. Aspartame can enhance the effect of other sweeteners so reducing the amount that needs to be added to food. Therefore, aspartame is used to reduce calorie intake and enhance natural fruit flavours.

a. Hydrolysis of aspartame produces three products, two of which are amino acids. Give the name of the third product. **1 mark**

Shown below are the IR Spectrum of one of the products of the hydrolysis of aspartame and the IR Spectrum of a compound that can be produced from that product.

SDBSWeb: http://sdbs.db.aist.go.jp (National Institute of Advanced Industrial Science and Technology, June 2019).

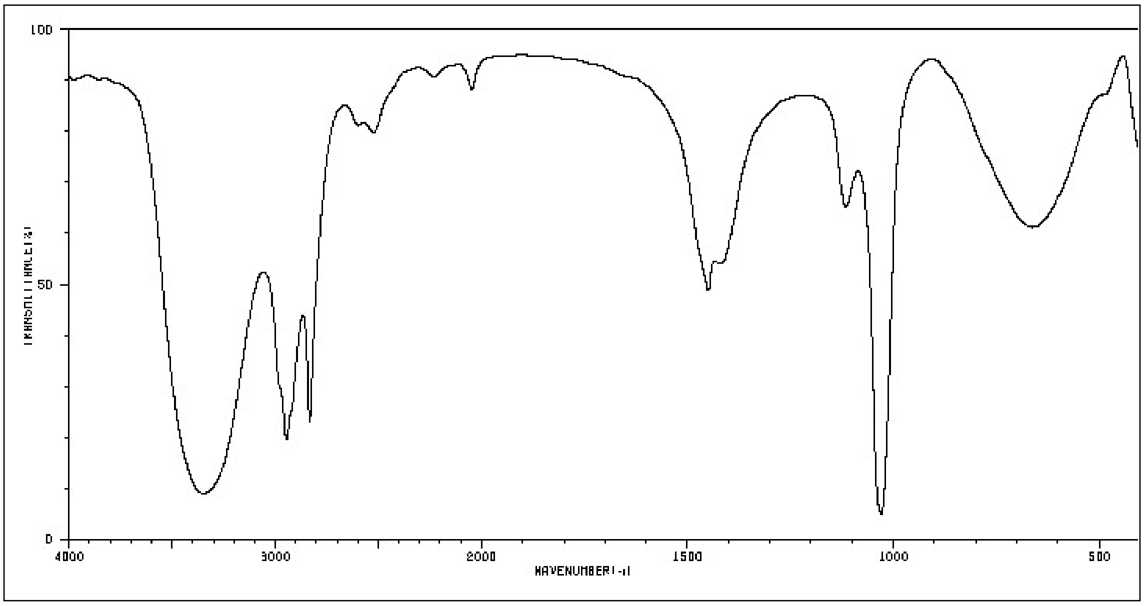


Figure 19: Spectrum 1 – product of hydrolysis

SDBSWeb: http://sdbs.db.aist.go.jp (National Institute of Advanced Industrial Science and Technology, June 2019).

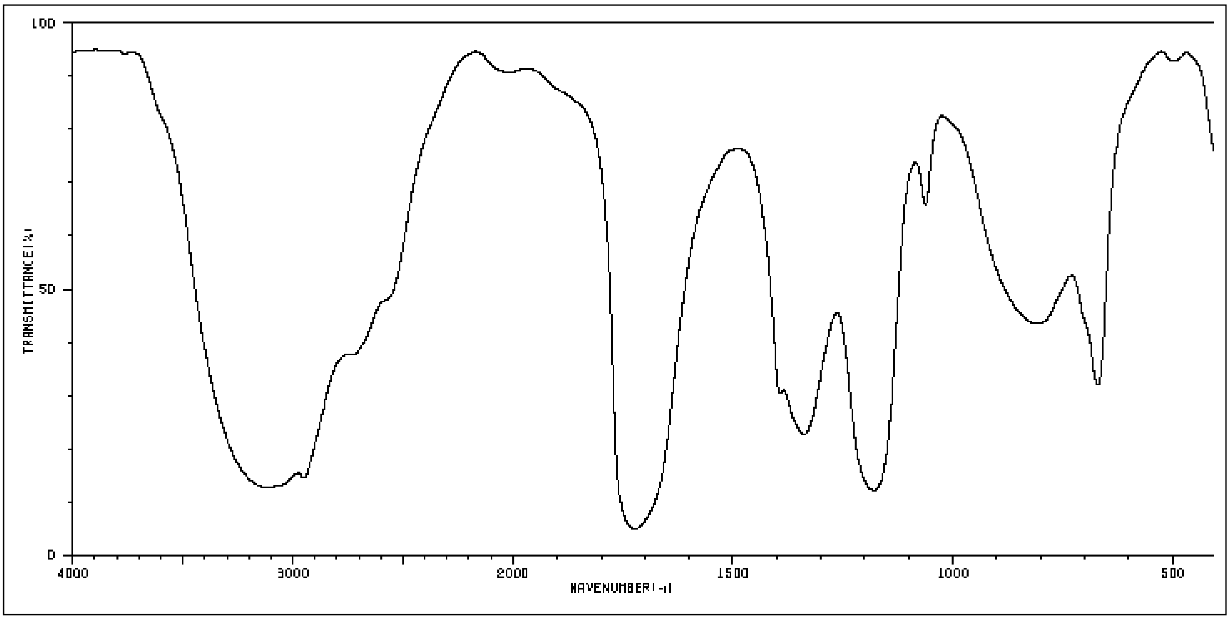


Figure 20: Spectrum 2

b. **i.** Give the chemical formula of the compound associated with each spectrum. **2 marks**

Spectrum 1: ____

Spectrum 2. ____

ii. Reaction of the product of hydrolysis of aspartame with acidified dichromate may produce a different organic product to the one associated with Spectrum 2. Write balanced half-equations describing the production of this different product. **2 marks**

iii. How many peaks would you expect to see on the ^{13}C NMR spectrum of the compound associated with Spectrum 2? Explain. **1 mark**

c. Shown below is the mass spectrum of the compound produced when one of the two compounds identified in **Question 2bi**. reacts with ammonia.

SDBSWeb: http://sdbs.db.aist.go.jp (National Institute of Advanced Industrial Science and Technology, June 2019).

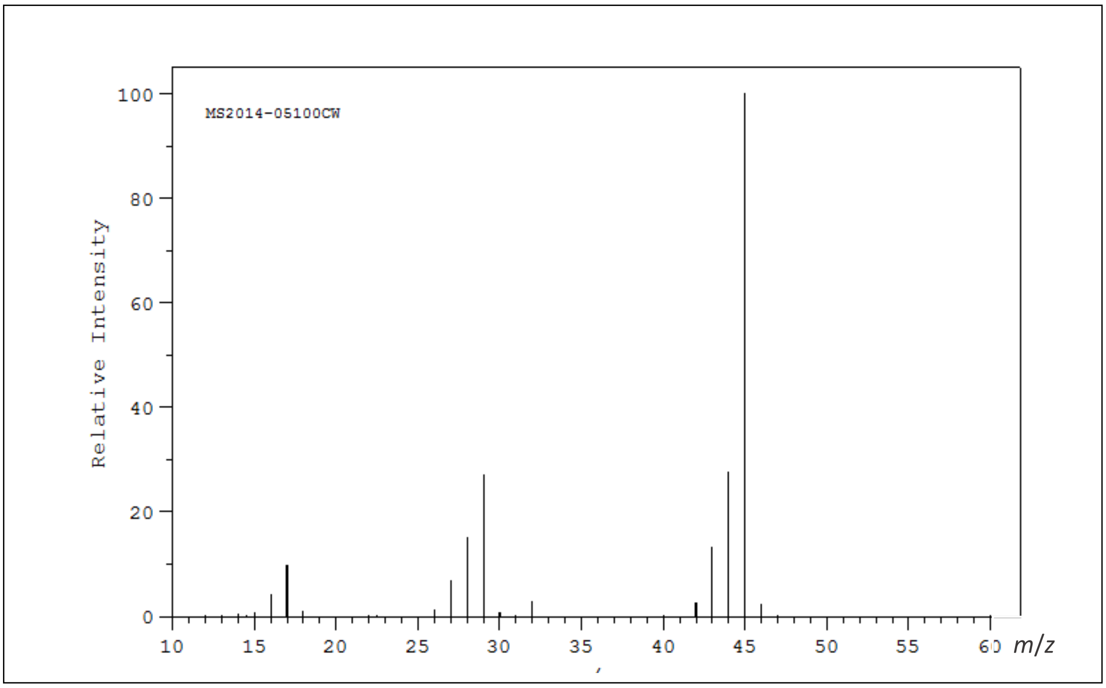


Figure 21

Give semi-structural formulae for the species causing the peaks at *m*/*z* = **3 marks**

45 – ______________________________

43 – ______________________________

29 – ______________________________

Question 3 (15 marks)
Lactic acid, $C_3H_6O_3$, also known as 2-hydroxypropanoic acid, is formed from the anaerobic respiration of glucose. When the oxygen level is low, carbohydrate breaks down for energy and makes lactic acid. Lactic acid levels get higher when strenuous exercise or other conditions, such as heart failure, a severe infection (sepsis), or shock, lower the flow of blood and oxygen throughout the body.
Higher-than-normal *lactic acid* levels can lead to a condition called *lactic acidosis* which may, if severe enough, upset the body's pH balance.
Whilst lactic acid has the same empirical formula as the monosaccharides, glucose and galactose, it is technically not a carbohydrate.
The heat of combustion, at SLC, of lactic acid is 15.0 kJ g^{-1}.

a. Draw the structure, showing all bonds, of lactic acid molecules and indicate any sites where optical isomerism may occur. **2 marks**

b. Write a balanced equation for the production of lactic acid from glucose by anaerobic respiration. **1 mark**

c. Describe, using an appropriate equation, how lactic acidosis affects blood pH. **1 mark**

d. Blood pH balance is controlled by way of the interrelated equilibria

$CO_2(g) \rightleftharpoons CO_2(aq)$ 1.

$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$ 2.

$H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$ 3.

Describe how these equilibria respond to lactic acidosis. **2 marks**

e. In the series of chemical reactions by which glucose is converted to CO_2 in the body, pyruvic acid (**Figure 22)** is produced. Acetyl-CoenzymeA (acetyl-CoA) is synthesised from pyruvic acid. The structure of acetylCoA is represented in **Figure 23**.

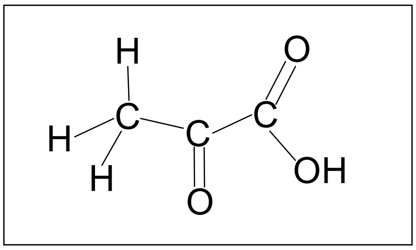


Figure 22

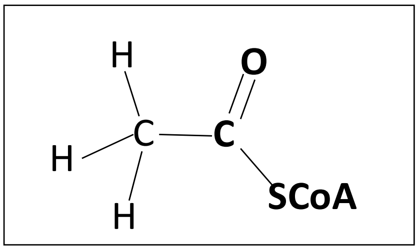


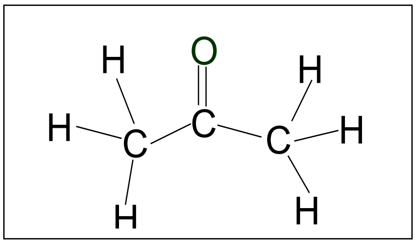
Figure 23

i. Lactic acid has been described as a reduction product of pyruvic acid. Explain why this is a valid description. **2 marks**

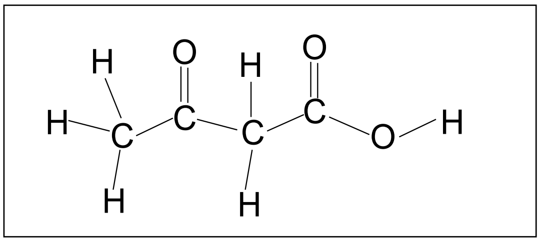
ii. Acetyl-coenzymeA (acetylCoA) is a thiol ester formed when ethanoic acid reacts with the thiol group on coenzymeA. Show the structure of the zwitterion of an amino acid which contains the thiol, –SH, functional group. **1 mark**

iii. One role of coenzymes is to act as carriers of electrons, atoms or functional groups. AcetylCoA carries acetyl groups for conversion to CO_2 during energy production. Give the formula of an acetyl radical. **1 mark**

f. When carbohydrate intake is low or when untreated diabetes mellitus means insulin levels are insufficient to convert glucose to glycogen for storage, the body will start to break down fats for energy release in the process of ketosis. During excessive breakdown of fatty acids by the liver, 'ketone bodies' are formed in the process of ketogenesis. The three ketone bodies formed have the structures shown below. The common names of two of these ketone bodies are shown.



Acetone



Acetoacetic acid

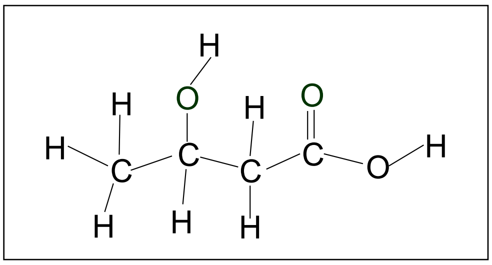


Figure 24

All these ketone bodies can be linked back to acetyl coenzymeA.

i. Give the systematic name of acetone**.** **1 mark**

ii. Give the systematic name of the third ketone body in **Figure 24**. **1 mark**

g. The heats of combustion, at SLC, of lactic acid, pyruvic acid, and glucose are 1165 kJ mol^{-1}, 1362 kJ mol^{-1}, and 2802 kJ mol^{-1} respectively.

i. Relate these data to the chemical change that occurs to glucose when it is converted to lactic acid or pyruvic acid. **1 mark**

ii. Use the data given to discuss the relative extent of that change in the production of lactic acid and pyruvic acid and relate this to the molecular structures of both compounds. **2 marks**

Question 4 (14 marks)
In a typical combustion engine, an ignition source, e.g. a spark, is needed to initiate the combustion reaction. Rocket propellants, used to generate thrust, generally consist of a fuel and oxidant, but this may be a hypergolic fuel system in which the combination of the fuel and the oxidant self-ignites at room temperature.

One such hypergolic fuel system uses hydrazine, N_2H_4, (boiling point 114°C) and dinitrogen tetroxide, N_2O_4, (boiling point 21.7°C). When mixed at 20°C, these compounds react to produce nitrogen gas and water vapour releasing 5.85 kJ per gram of N_2O_4 reacting.

a. Write a balanced thermochemical equation for the reaction between hydrazine and dinitrogen tetroxide. **2 marks**

b. Explain how the reaction between hydrazine and dinitrogen tetroxide contributes to thrust generation in a rocket. **2 marks**

c. Why does hydrazine have a much higher boiling temperature than dinitrogen tetroxide? **1 mark**

d. Why is it easier to store the hydrazine and dinitrogen tetroxide, at 20°C, than it is to store hydrogen? **1 mark**

Hydrazine and hydrogen peroxide may, if the compounds come in contact, also be a hypergolic fuel system. However, the discovery that nanoporous gold leaf shows electrocatalytic properties toward both hydrazine (N_2H_4) oxidation and hydrogen peroxide (H_2O_2) reduction, allowed for the implementation of a direct hydrazine-hydrogen peroxide fuel cell (DHHPFC) as a unique power source for air-independent applications under extreme conditions such as outer space and underwater environments. The DHHPFC is represented in **Figure 25**.

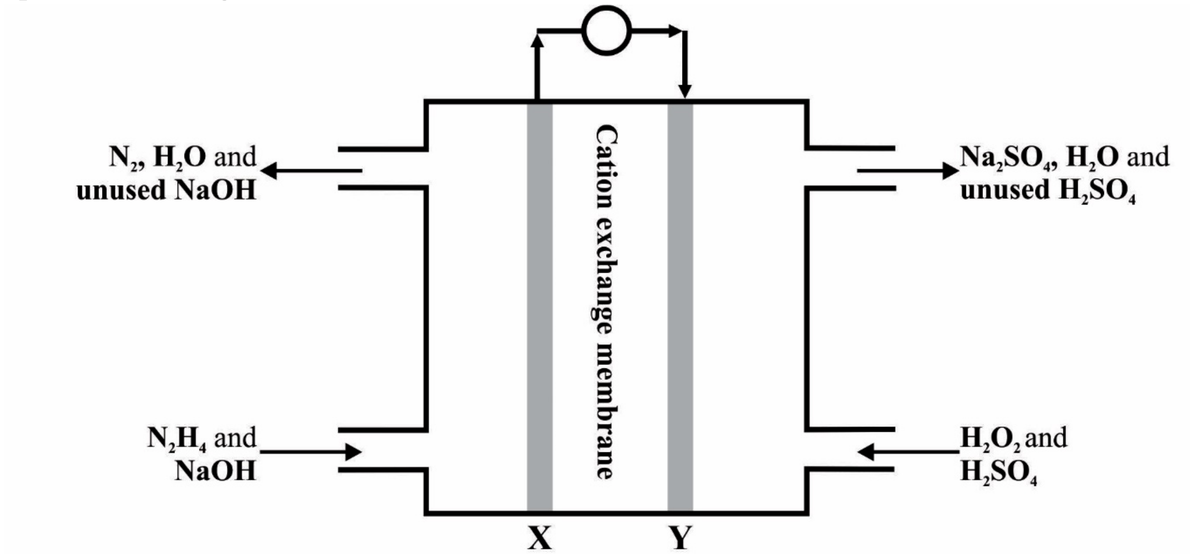


Figure 25

e. Indicate which electrode acts as the anode in the DHHPFC. Explain your choice. **1 mark**

f. Give the sign of the left hand electrode in the DHHPFC. **1 mark**

g. Complete and balance the half-equation for the reaction at the left hand electrode in the DHHPFC. **1 mark**

___$N_2H_4(l)$ + ___$OH^-(aq)$ →

h. Write a balanced half-equation for the reaction at the right-hand electrode in the DHHPFC. **1 mark**

i. Describe what happens in the cation exchange membrane as the cell is delivering energy. **1 mark**

j. Identify a change that would be noticeable in the fuel cell if NaOH and H_2SO_4 come into contact. **1 mark**

k. Hydrazine, N_2H_4, may react with oxygen to form nitrogen gas and water.

$N_2H_4(g) + O_2(g) \rightarrow N_2(g) + 2H_2O(l)$

If 6.47 g of N_2H_4 reacts and produces 4.50 L of N_2, at 28°C and 110 kPa, what is the percent yield of nitrogen? **2 marks**

Question 5 (14 marks)

On the international space station water use efficiency is maximised by extracting water from urine, sweat and breathing condensate and purifying it.

Oxygen is generated by electrolysis of water in a proton exchange membrane (PEM) electrolysis cell, which only allows water and positive ions to cross between compartments. The PEM system essentially consists of water, an anode and a cathode, a central polymer membrane between the two electrodes. The membrane also serves as the electrolyte in the cell, eliminating the need for hazardous liquid electrolytes such as concentrated potassium hydroxide.

a. Identify the most likely energy source for the electrolysis of water on the international space station. **1 mark**

b. The PEM electrolysis cell is represented in **Figure 26**.

On **Figure 26**, indicate the: **2 marks**

i. positive electrode.
ii. cathode.
iii. side of the cell to which water is supplied.
iv. site where O_2 exits the cell.

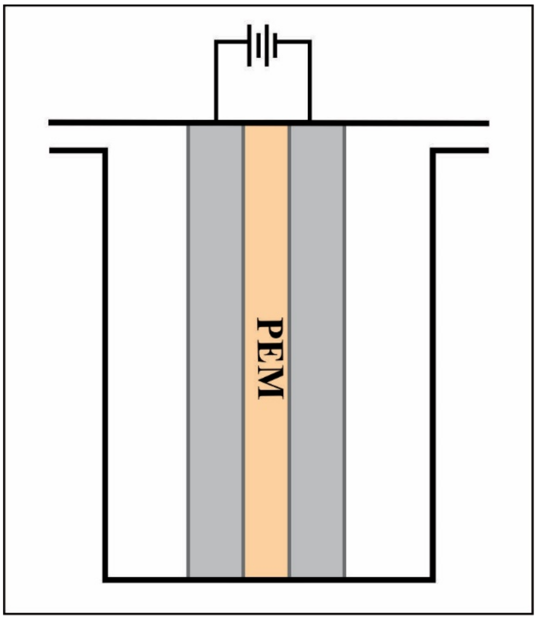


Figure 26

c. Give a balanced half-equation for the reaction at the electrodes in the electrolysis of water in the PEM cell and explain the link between these reactions and the proton exchange membrane. **3 marks**

d. Write the half-equation for the production of O_2 in an earlier generation electrolytic cell using KOH(aq) as an electrolyte. **1 mark**

Prior to the uptake of the Sabatier system, hydrogen and carbon dioxide produced on the space station were discarded into space and large quantities of water had to be regularly transported to the space station for oxygen generation and human consumption and use.
The Sabatier system uses a hydrogenation catalyst to enable the production of water from the previously discarded carbon dioxide and hydrogen as indicated in the equilibrium reaction

$$CO_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2O(g) \quad \Delta H = -182 \text{ kJ mol}^{-1} \text{ at } 400°C$$

e. The optimum temperature for the Sabatier equilibrium reaction is 400°C. Suggest reasons why this temperature is used. **2 marks**

f. Discuss the relation between pressure and the Sabatier equilibrium. **2 marks**

g. It is currently estimated that to carry 1 kg of fuel to Mars, 225 kg of fuel would need to be burnt in transit. There are clear benefits to be gained from the onsite production of fuel.
It's believed that there are significant water deposits below the Martian surface and its atmosphere is 96 % CO_2.
Long term storage of hydrogen could prove too risky for the environment. Explain how Martian resources could be used to generate an alternative fuel and oxygen. Assume all necessary equipment has been transported from Earth to the surface of Mars. **3 marks**

Question 6 (11 marks)
The thermal efficiency of an engine or device shows the percentage of the available thermal energy that is converted to useful work. Some approximate thermal efficiencies are petrol engine – 25 %, coal-fired power station – 35 %, diesel engine – 40 %.
Fuel cells, such as a methanol-oxygen, generally have significantly higher thermal efficiencies.

a. Write a balanced thermochemical equation for the complete combustion of methanol. **2 marks**

b. Write balanced half-equations for the reactions occurring at each electrode in a methanol-oxygen fuel cell with acid electrolyte. **2 marks**

c. The thermal efficiency per mol of fuel for a fuel cell can be calculated from the relationship.

Efficiency = $-n(e) \text{ x } F \text{ x } E_{cell} / \Delta H$

Calculate the thermal efficiency of a methanol-oxygen fuel cell operating at 0.657 V. **2 marks**

d. Explain why the thermal efficiency of the methanol-oxygen fuel cell is higher than that of a coal-fired power station. **1 mark**

e. A resource gives the electrode potential for a $CO_2(g),H^+(aq)/CH_3OH(l),H_2O(l)$ half-cell as -0.38 V.
Show that this is not consistent with the fuel cell voltage used in **Question 6d.** and suggest one possible reason. **2 marks**

f. Determine the mass of methanol which has the same energy content as a 50.0 L tank of octane. [$d(C_8H_{18}) = 0.703\ g\ mL^{-1}$]. **2 marks**

Question 7 (17 marks)

The Oxford dictionary defines vinegar as 'sour-tasting liquid containing acetic [ethanoic] acid, obtained by fermenting dilute alcoholic liquids, typically wine, cider, or beer, and used as a condiment or for pickling'. Acetic acid bacteria promote the oxidative fermentation which produces ethanoic acid.

To be classified as a vinegar, a liquid must contain at least 4 % (m/V) ethanoic acid.

Laboratory investigation of whether commercial vinegars satisfy this minimum requirement requires each student to titrate aliquots of a vinegar randomly selected from several commercially available vinegars with the same standardised 0.982 M NaOH(aq) solution to the phenolphthalein endpoint following the appropriate experimental procedure.

The data recorded by three students during the investigation are given in **Tables 4, 5 and 6**.

Student A

Volume of vinegar aliquot	Initial burette reading	Endpoint burette reading
10.0 mL	1.55 mL	9.51 mL
10.0 mL	9.51 mL	17.38 mL
10.0 mL	17.38 mL	25.40 mL

Table 4

Student B

Volume of vinegar aliquot	Initial burette reading	Endpoint burette reading
20.0 mL	2.50 mL	26.80 mL
20.0 mL	26.80 mL	46.73 mL
20.0 mL	0.65 mL	20.61 mL
20.0 mL	20.61 mL	40.64 mL

Table 5

Student C

Volume of vinegar aliquot	Initial burette reading	Endpoint burette reading
10.0 mL	6.64 mL	16.61 mL
10.0 mL	16.61 mL	26.59 mL
10.0 mL	26.59 mL	36.61 mL

Table 6

a. Write a balanced chemical equation for the titration reaction. **1 mark**

b. Suggest a reason why Student B included on extra set of data compared to Students A and C. **1 mark**

c. Determine the average V(NaOH) used by Student B to reach the endpoint. **1 mark**

d. Discuss the possibility that two students analysed the same vinegar. **2 marks**

e. Determine the concentration of ethanoic acid, as % (m/V), in the vinegar used by Student B. **2 marks**

f. Based on the data supplied, discuss whether or not vinegar A meets the requirements to be classified as a vinegar solution? **2 marks**

g. Identify **one** of each of the types of variable associated with **this analysis**. **3 marks**

Independent variable: ______________________________

Dependent variable: ______________________________

Controlled variable: ______________________________

h. Explain if it is possible to classify the recorded data as (i) accurate and (ii) reliable. **2 marks**

i. Shown in **Figure 27** is a titration curve for the titration of a 20.0 mL vinegar aliquot with the same NaOH(aq) solution. The data for the curve were obtained using an electronic pH meter during the titration.

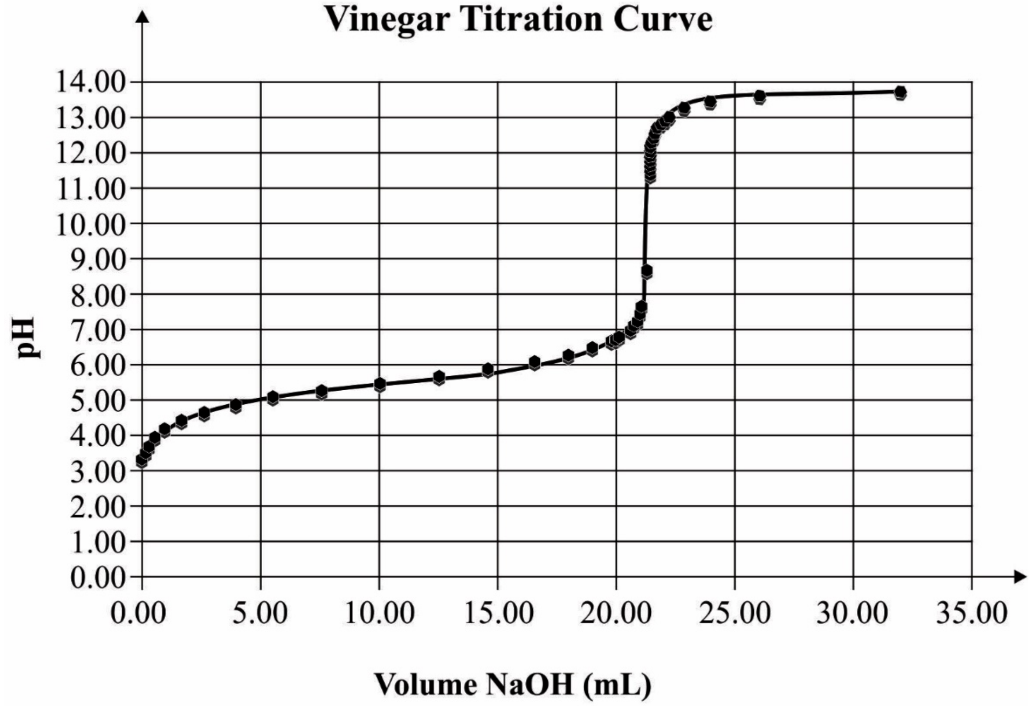


Figure 27

i. Explain how this titration curve supports the use of phenolphthalein as the indicator in this analysis using a 20 mL aliquot of a vinegar. **1 mark**

ii. Explain how you can use the curve to decide whether the concentration of ethanoic acid in the vinegar used to obtain this curve was higher or lower than the concentration of the vinegar used by Student B. **1 mark**

iii. If bromothymol blue had been used as the indicator rather than phenolphthalein, identify which measurement recorded during the exercise would have been affected. **1 mark**

End of Section B

End of Trial Examination

STUDENT NUMBER Letter

Figures									
Words									

Student Name...……………………...

VCE Chemistry 2019 Year 12 Trial Exam Units 3/4

Student Answer Sheet

Instructions for completing exam. Use only a 2B pencil. If you make a mistake, erase it and enter the correct answer. Marks will not be deducted for incorrect answers.

Write your answers to the Short Answer Section in the space provided directly below the question. There are **30 Multiple Choice** questions to be answered by circling the correct letter in the table below.

Question 1	A	B	C	D	*Question 2*	A	B	C	D
Question 3	A	B	C	D	*Question 4*	A	B	C	D
Question 5	A	B	C	D	*Question 6*	A	B	C	D
Question 7	A	B	C	D	*Question 8*	A	B	C	D
Question 9	A	B	C	D	*Question 10*	A	B	C	D
Question 11	A	B	C	D	*Question 12*	A	B	C	D
Question 13	A	B	C	D	*Question 14*	A	B	C	D
Question 15	A	B	C	D	*Question 16*	A	B	C	D
Question 17	A	B	C	D	*Question 18*	A	B	C	D
Question 19	A	B	C	D	*Question 20*	A	B	C	D
Question 21	A	B	C	D	*Question 22*	A	B	C	D
Question 23	A	B	C	D	*Question 24*	A	B	C	D
Question 25	A	B	C	D	*Question 26*	A	B	C	D
Question 27	A	B	C	D	*Question 28*	A	B	C	D
Question 29	A	B	C	D	*Question 30*	A	B	C	D