VCE CHEMISTRY 2014

YEAR 12 TRIAL EXAM

Unit 3 & Unit 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	8	8	112
			Total 142

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STUDENT NUMBER

									Letter
Figures									
Words									

Student Name....…….....

VCE Chemistry 2014 Year 12 Trial Exam Unit 3/4

Student Answer Sheet

Instructions for completing test. 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

VCE Chemistry 2014 Year 12 Trial Exam Unit 3/4

SECTION A – Multiple Choice Questions

Section A consists of 30 multiple-choice questions.
Section A is worth approximately 22 per cent of the marks available.
*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 systematic name 2-amino-3-methyl butanoic acid applies to
A. glycine.
B. alanine.
C. leucine.
D. valine.

Question 2
One method of extracting copper from copper(II) oxide is heating the CuO in the presence of carbon monoxide. The reaction occurring is described by the equation.

$$CuO(s) + CO(g) \rightarrow Cu(s) + CO_2(g)$$

Use the thermochemical equations below to determine ΔH for this reaction between CuO and CO.

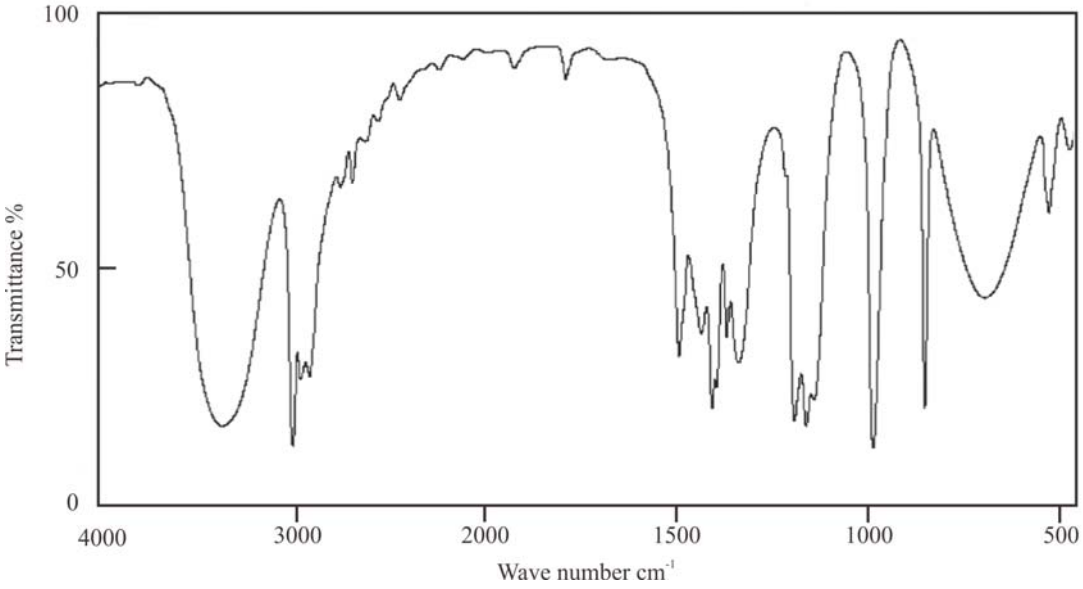
$$2CO(g) + O_2(g) \rightarrow 2CO_2(g); \ \Delta H = -566 \text{ kJ mol}^{-1}$$
$$2Cu(s) + O_2(g) \rightarrow 2CuO(s); \ \Delta H = -311 \text{ kJ mol}^{-1}$$

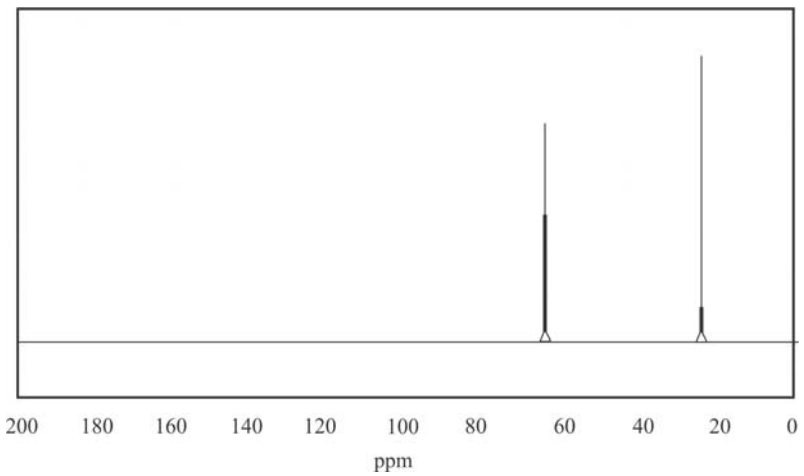
A. $\Delta H = -128 \text{ kJ mol}^{-1}$
B. $\Delta H = -255 \text{ kJ mol}^{-1}$
C. $\Delta H = +255 \text{ kJ mol}^{-1}$
D. $\Delta H = -877 \text{ kJ mol}^{-1}$

Question 3
It is possible to produce an ester starting with an alkene as the only organic compound. Which one of the following types of chemical reaction does not **need** to be part of the simplest reaction pathway?
A. Reduction.
B. Substitution.
C. Condensation.
D. Addition.

Question 4
Which of the following biomolecules has the highest percentage, by mass, of carbon?
A. Glucose.
B. Glycerol.
C. Sucrose.
D. Glycine.

Question 5
The spectra below are of a compound of carbon, hydrogen and oxygen that contains 60.0 percent by mass carbon.





The compound is most likely to be
A. ethanol.
B. ethanoic acid.
C. methyl methanoate.
D. 2-propanol.

Question 6
In a determination of the SO_2 content of wine, a treated wine sample was titrated with 0.00525 M $I_2(aq)$.
The reaction occurring during the titration was
$I_2(aq) + SO_2(g) + 2H_2O(l) \rightarrow 2I^-(aq) + HSO_4^-(aq) + 3H^+(aq)$.
The following titration data were recorded.

Titration	Initial Reading (mL)	Final Reading (mL)
1.	2.50	19.25
2.	19.25	30.40
3.	1.45	12.65
4.	12.65	23.75

The mass of SO_2 present in the treated wine sample was
A. 3.75 mg.
B. 4.22 mg.
C. 3.75 g.
D. 4.22 g.

Question 7
When a 0.62 g sample of element X is allowed to react completely with oxygen, 1.10 g of an oxide of formula X_2O_3 is produced.
Element X is
A. aluminium.
B. chromium.
C. phosphorus.
D. iron.

Question 8
Molybdenum-air batteries are efficient with both acidic and alkaline electrolytes.
The relative reduction half-equations and electrode potentials at 25°C for 1 M solutions are

$H_2MoO_4(aq) + 6H^+(aq) + 6e^- \rightleftharpoons Mo(s) + 4H_2O(l)$ $\quad E° = -0.11$ V

$MoO_4^{2-}(aq) + 4H_2O(l) + 6e^- \rightleftharpoons Mo(s) + 8OH^-(aq)$ $\quad E° = -0.91$ V

The expected operating voltage of a molybdenum-air using an alkaline electrolyte at standard conditions would be
A. 0.80 V.
B. 1.31 V.
C. 1.02 V.
D. 0.51 V.

Question 9

In an investigation to explore the effect of rinsing procedures in volumetric analysis, the concentration of an approximately 0.1 M solution of hydrochloric acid was determined by titrating an aliquot of a standard solution of sodium carbonate with the hydrochloric acid to the methyl orange endpoint.

The reaction occurring was:

$$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

Four groups completed the investigation using the same procedure and same solutions but with each group following specific rinsing instructions. Each group then calculated the *c*(HCl) based on their collected data.

The rinsing instructions are shown in the table below.

	Burette	Pipette	Titration flask
Group I	HCl(aq)	Na_2CO_3(aq)	Water
Group II	Water	Na_2CO_3(aq)	Water
Group III	Na_2CO_3(aq)	Na_2CO_3(aq)	Water
Group IV	HCl(aq)	Water	Water

The hydrochloric acid concentrations calculated by the four groups were 0.094 M, 0.095 M, 0.098 M, and 0.103 M.

The concentration of the acid according to Group I was most likely

A. 0.103 M.
B. 0.098 M.
C. 0.095 M.
D. 0.094 M.

Question 10

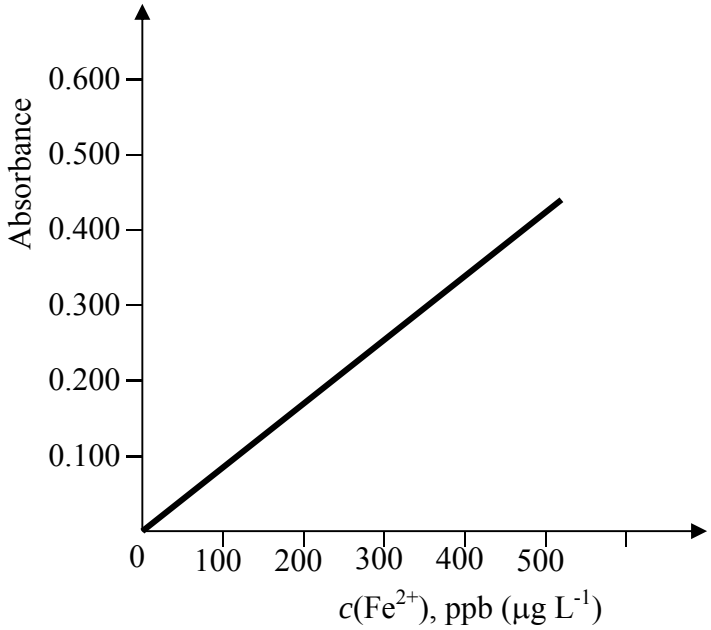
GC/MS (Gas Chromatography / Mass Spectrometry) was used to identify different alcohols present in an unidentified beverage. The most abundant alcohol present was ethanol with traces of butan-1-ol, methanol, and methylpropan-2-ol present.

The alcohol that would be expected to exit the gas chromatograph and enter the mass spectrometer first would be

A. ethanol.
B. methanol.
C. methylpropan-2-ol.
D. butan-1-ol.

Question 11
Levels of iron in solution can be determined by UV-Visible spectroscopy. In such an analysis all the iron present is converted to $Fe^{2+}(aq)$ and the spectrophotometric agent ferrozine is added. Ferrozine combines with $Fe^{2+}(aq)$ to produce an intense red solution. The complex species formed between $Fe^{2+}(aq)$ and ferrozine absorbs strongly at around 510 nm.

A series of $Fe^{2+}(aq)$ standards were prepared, treated with ferrozine, and their absorbances measured to produce the calibration graph below.



To calculate the mass of iron present in a 250 mL sample of a test solution, 5.0 mL of the solution was added to 145 mL water. This diluted solution was then treated with ferrozine and its absorbance measured at the wavelength used in establishing the calibration graph. The absorbance was 0.250.
The mass, in mg of iron, present in the test solution was closest to
A. 0.300 mg.
B. 2.25 mg.
C. 9.00 mg.
D. 225 mg.

Question 12

Copper reacts with dilute nitric acid to produce nitrogen(II) oxide according to the equation

$$3Cu(s) + 8HNO_3(aq) \rightarrow 3Cu(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$$

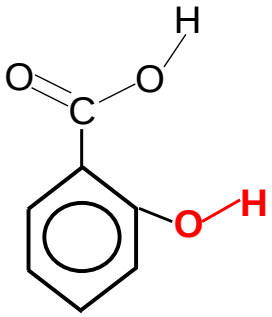
When 6.75 g of Cu is added to excess nitric acid and the reaction allowed to proceed to completion, 630 mL of NO is collected at STP.

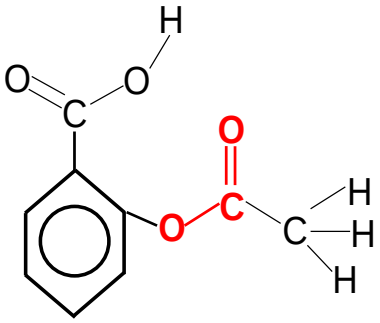
Which of the following is closest to the percentage of the NO produced in the reaction that was actually collected?

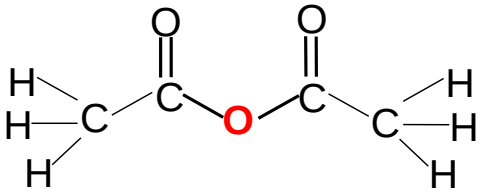
A. 27
B. 40
C. 60
D. 100

Question 13

The structures of some of the compounds associated with the production of aspirin are shown below.







The substance with the fewest peaks on its low resolution ^1H NMR spectrum is

A. ethanoic anhydride.
B. aspirin.
C. salicyl alcohol.
D. salicylic acid.

Question 14

A sample of bath salts contains a mixture of sodium carbonate, Na_2CO_3 and sodium hydrogen carbonate, $NaHCO_3$.

In a volumetric analysis to determine the amounts of both Na_2CO_3 and $NaHCO_3$ present in a sample of bath salts, a 50.00 mL aliquot of an aqueous solution of the bath salts was titrated with 0.1020 M hydrochloric acid solution using phenolphthalein to indicate the endpoint. Methyl orange indicator was then added to the resulting solution and this was titrated with the same acid to a second end point.

The reactions occurring during the titration are:

$HCl(aq) + Na_2CO_3(aq) \rightarrow NaHCO_3(aq) + NaCl(aq)$ – phenolphthalein end point and then

$HCl(aq) + NaHCO_3(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$ – methyl orange end point

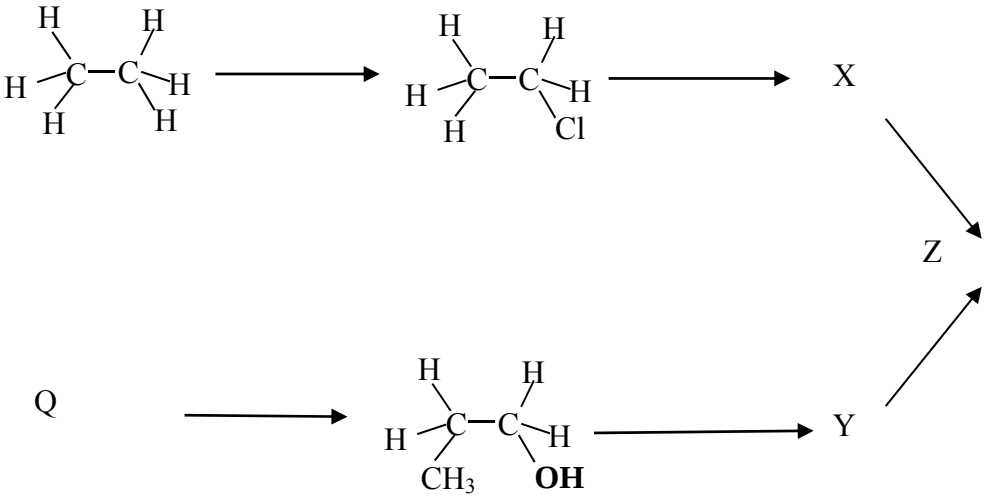
10.25 mL of the HCl(aq) was used to reach the phenolphthalein endpoint and a further 25.35 mL was used to reach the methyl orange endpoint.

What was the amount, in mol, of sodium hydrogen carbonate in the 50.00 mL aliquot of bath salts solution?

A. 1.046×10^{-3}
B. 1.540×10^{-3}
C. 2.586×10^{-3}
D. 3.632×10^{-3}

Question 15

The diagram below shows a reaction pathway consistent with the designated content of Unit 3.

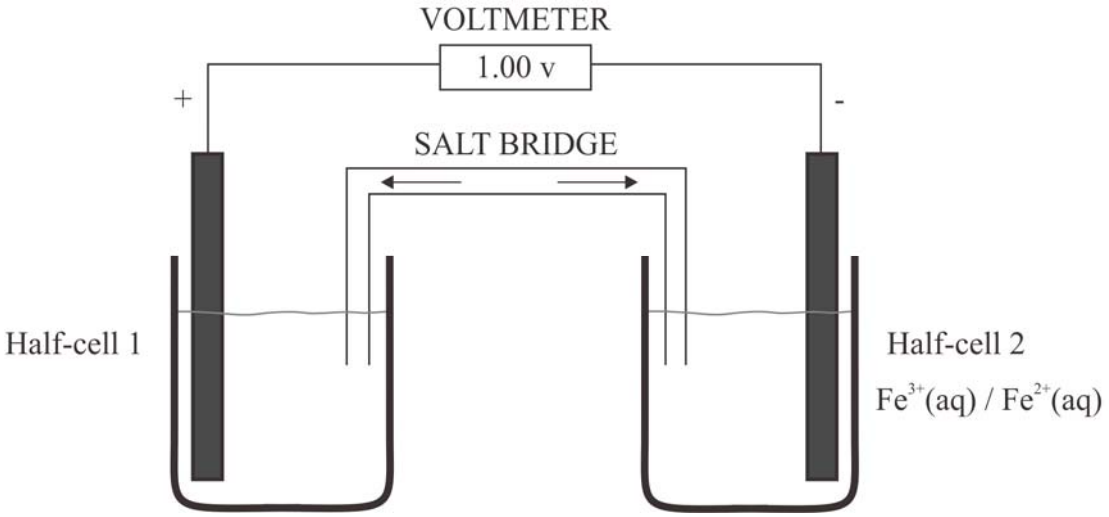


Which of the following correctly identifies compounds Q and Z?

A. Ethene, ethyl ethanoate.
B. Propane, propanoic acid.
C. Ethane, propyl ethanoate.
D. Propene, ethyl propanoate.

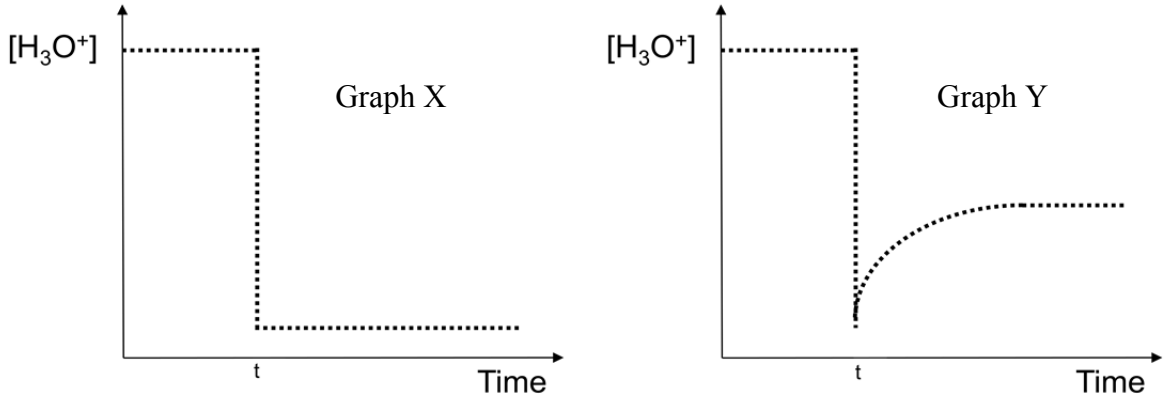
Question 16
The following statement describes an aspect of the operation of a type of modern analytical instrument:
……. e.g. the electron in the third shell of a sodium atom will absorb energy at 589.0 nm wavelength. Only ground state atoms can absorb energy at this wavelength, and a hollow cathode lamp supplies the energy …….
Which of the following analyses could be performed using this instrument?
A. Determining the amount of potassium in a sports drink.
B. Identifying the functional groups present in a compound.
C. Determining the number of 'different' carbon atoms in a molecule.
D. Determining the alcohol content of wine.

Question 17
Consider the galvanic cell, represented below, operating at 25°C, 101.3 kPa and using 1 M solutions.



The product(s) of the half-reaction occurring in half-cell 1 is (are)
A. Ni(s).
B. $Ni^{2+}(aq)$.
C. $H_2O_2(aq)/H^+(aq)$.
D. $H_2O(l)$.

Question 18
The graphs below show the impact on the $c(H_3O^+)$ of diluting 10 mL solutions of two acids X and Y, both with initial pH 3.00, to 100 mL at time 't', at 25 °C.



Which of the following statements is consistent with this information?
A. X is hydrochloric acid and has the higher initial concentration.
B. Y is methanoic acid and has the higher initial concentration.
C. X is methanoic acid and has the lower initial concentration.
D. Y is hydrochloric acid and has the lower initial concentration.

The following information applies to Questions 19 and 20.
The first nickel-cadmium storage battery, or NiCad battery, was created in 1899 in Sweden by Waldemar Jungner. NiCad batteries can be produced in a variety of sizes and are extremely durable, enabling a wide range of uses, including toys, power tools and industrial applications. Each rechargeable cell produces about 1.3-1.4 V on discharge. Prior to discharge, a NiCad cell contains NiO(OH)(s) and Cd(s) with an alkaline electrolyte.
The overall reaction occurring in a NiCad cell during **recharging** is

$$Cd(OH)_2(s) + 2Ni(OH)_2(s) \rightarrow 2NiO(OH)(s) + 2H_2O(l) + Cd(s)$$

Question 19
The half-reaction occurring at the anode when a NiCad battery is discharging will be
A. $Cd(OH)_2(s) + 2e^- \rightarrow Cd(s) + 2OH^-(aq)$
B. $2Ni(OH)_2(s) + 2OH^-(aq) \rightarrow 2NiO(OH)(s) + 2H_2O(l) + 2e^-$
C. $Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2(s) + 2e^-$
D. $2NiO(OH)(s) + 2H_2O(l) + 2e^- \rightarrow 2Ni(OH)_2(s) + 2OH^-(aq)$

Question 20
When a NiCad battery is being recharged, the negative terminal of the external power supply
A. should be connected to the electrode containing $Ni(OH)_2$ and a voltage of 1.35 V applied.
B. should be connected to the electrode containing $Ni(OH)_2$ and a voltage greater than 1.4 V applied.
C. should be connected to the electrode containing $Cd(OH)_2$ and a voltage of 1.35 V applied.
D. should be connected to the electrode containing $Cd(OH)_2$ and a voltage greater than 1.4 V applied.

Question 21

Nitrogen dioxide, NO_2, and dinitrogen tetroxide, N_2O_4, are compounds in which nitrogen has the same oxidation number.

Both compounds can be formed from reactions between nitrogen and oxygen according to the thermochemical equations

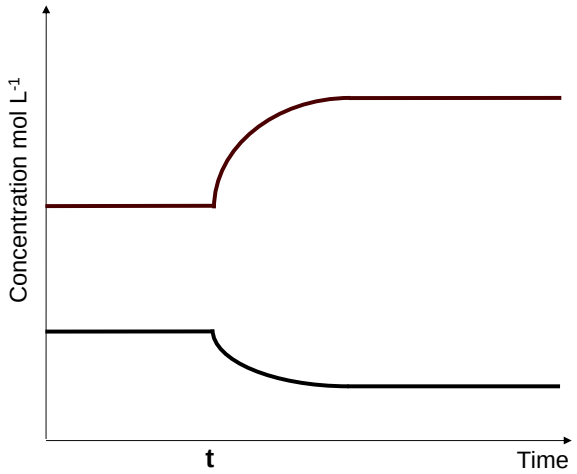
$$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g) \quad \Delta H = +90.4 \text{ kJ mol}^{-1}$$

$$N_2(g) + 2O_2(g) \rightarrow N_2O_4(g) \quad \Delta H = +9.7 \text{ kJ mol}^{-1}$$

A sample of pure $NO_2(g)$ collected in a sealed container quickly establishes an equilibrium with $N_2O_4(g)$, according to

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

The concentration-time graph below shows the effect of a change imposed at time 't' on this equilibrium.



The change imposed was most likely to have been a

A. temperature increase.
B. volume increase.
C. temperature decrease.
D. volume decrease.

Question 22

The value of the equilibrium constant, K_c, for the equilibrium $2NO_2(g) \rightleftharpoons N_2O_4(g)$ at 100 °C is 2.04 M.

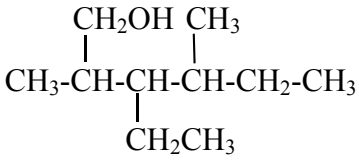
Some pure NO_2 is added to a 500 mL vessel and allowed to come to equilibrium at 100 °C. The $[NO_2]$ at equilibrium was 0.310 M.

What mass, in g, of NO_2 was added to the 500 mL vessel?

A. 7.13 g.
B. 11.6 g.
C. 14.3 g.
D. 16.1 g.

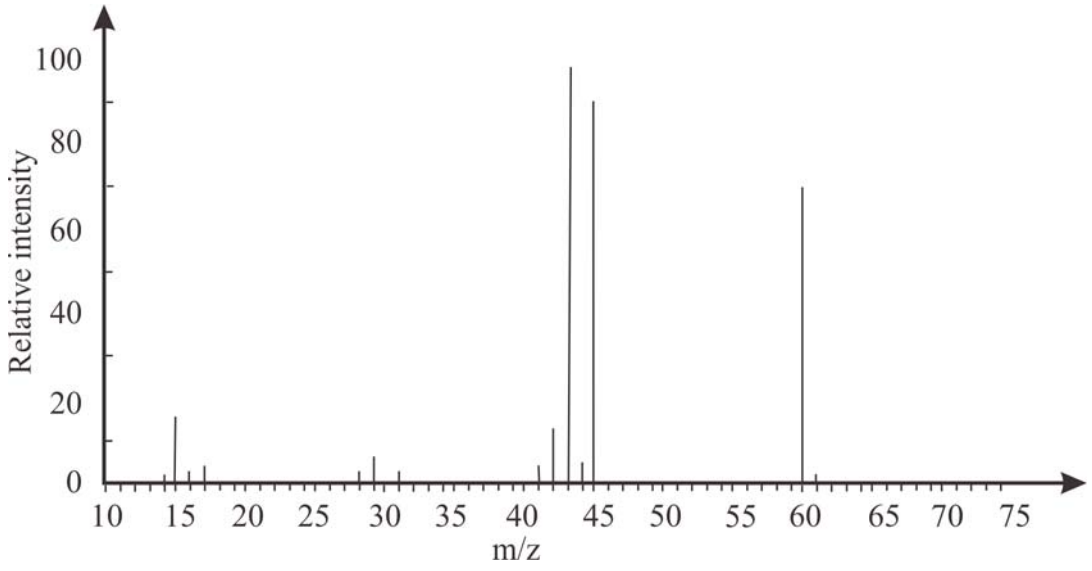
Question 23
Disproportionation reactions are chemical reactions in which the same species acts as both the oxidant and the reductant.
Which of the species below is **least** likely to be involved in a disproportionation reaction?
A. H_2O
B. Cu^{2+}
C. Sn^{2+}
D. H_2O_2

Question 24
What is the systematic name of the compound which has the semi-structural formula shown below?



A. 2-methyl-3,5-diethylhexan-1-ol.
B. 3,5-dimethyl-2ethylheptan-1-ol.
C. 3,5-dimethyl-4-ethylhexan-6-ol.
D. 2,4-dimethyl-3-ethylhexan-1-ol.

Question 25
A measured sample of a pure monoprotic acid is dissolved in water and made up to 200 mL of solution. When 25.00 mL aliquots of this solution are then titrated with 1.000 M sodium hydroxide solution, the average titre required to reach the endpoint is 27.48 mL.
The mass spectrum for the acid is shown below:



What was the mass of the pure acid sample?
A. 1.65 g.
B. 13.2 g.
C. 9.46 g.
D. 8.03 g.

Question 26
An analysis of a sample of vinegar for ethanoic acid content involved a sequence of three titrations. The equations and data associated with these titrations are given below.

$Na_2CO_3(aq)$ + $2HCl(aq)$ → $2NaCl(aq) + CO_2(g) + H_2O(l)$
20.00 mL from 250.0 mL containing 1.330 g Na_2CO_3 | *20.30 mL of **'x'** M*

$HCl(aq)$ + $NaOH(aq)$ → $NaCl(aq) + H_2O(l)$
*20.00 mL of '**x**' M* | *29.85 mL of '**y**' M*

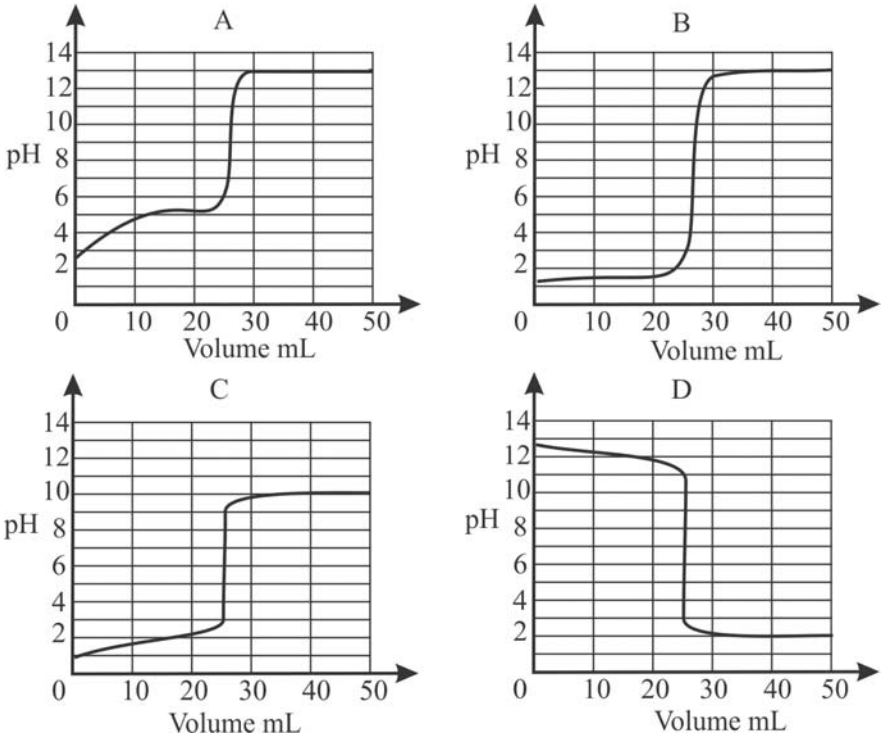
$CH_3COOH(aq)$ + $NaOH(aq)$ → $CH_3COONa(aq) + H_2O(l)$
in 20.00 mL from 250.0 mL containing 20.00 mL (19.95 g) of vinegar | *19.00 mL of '**y**' M*

The most likely reason for using the sequence of three titrations would have been
A. sodium carbonate is a primary standard.
B. ethanoic acid is a weak acid.
C. sodium hydroxide is not a primary standard.
D. the analysis is more accurate if back titration is used.

Question 27
Consider the equilibrium system $N_2O_4(g) \rightleftharpoons 2NO_2(g)$.
If the volume of a sample of this equilibrium mixture was halved and the temperature restored to its original value, it would be expected that, when equilibrium was established in the smaller volume, the
A. $[NO_2]$ would have increased and the $m(NO_2)$ would have increased.
B. $[NO_2]$ would have increased even though the $m(NO_2)$ would have decreased.
C. $[NO_2]$ would have decreased and the $m(NO_2)$ would have decreased.
D. $[NO_2]$ would have decreased even though the $m(NO_2)$ would have increased.

Question 28
The number of carbon atoms present in a 365 μg sample of methyl-2-propanamine is
A. 2.00×10^5
B. 9.00×10^{18}
C. 1.20×10^{19}
D. 4.80×10^{19}

Question 29
Shown below is a set of titration curves for reactions between approximately 0.10 M solutions of acids and bases.



Which of the following reactions is **not** associated with one of these titration curves.

A. $NH_3(aq) + HCl(aq) \rightarrow NH_4^+(aq) + Cl^-(aq)$
B. $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$
C. $CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$
D. $NH_3(aq) + CH_3COOH(aq) \rightarrow NH_4^+(aq) + CH_3COO^-(aq)$

Question 30
In an experiment to determine the percentage by mass of sulfur in a fertiliser, all the sulfur in a known mass of fertiliser was converted to sulfate ions which were precipitated as barium sulfate. When calculating the percentage by mass of sulfur in the fertiliser sample from data collected in the experiment, the final answer was found to be over 100 per cent.
Which of the following errors would **not** have led to the calculated percentage being over 100 %?

A. Not rinsing the precipitate with water during collection.
B. Not drying the precipitate fully prior to weighing.
C. Incorrectly recording the weight of the fertiliser as 1.798 g rather than the correct 1.978.
D. Not converting all the sulfur in the sample to sulfate prior to precipitation.

End of Section A

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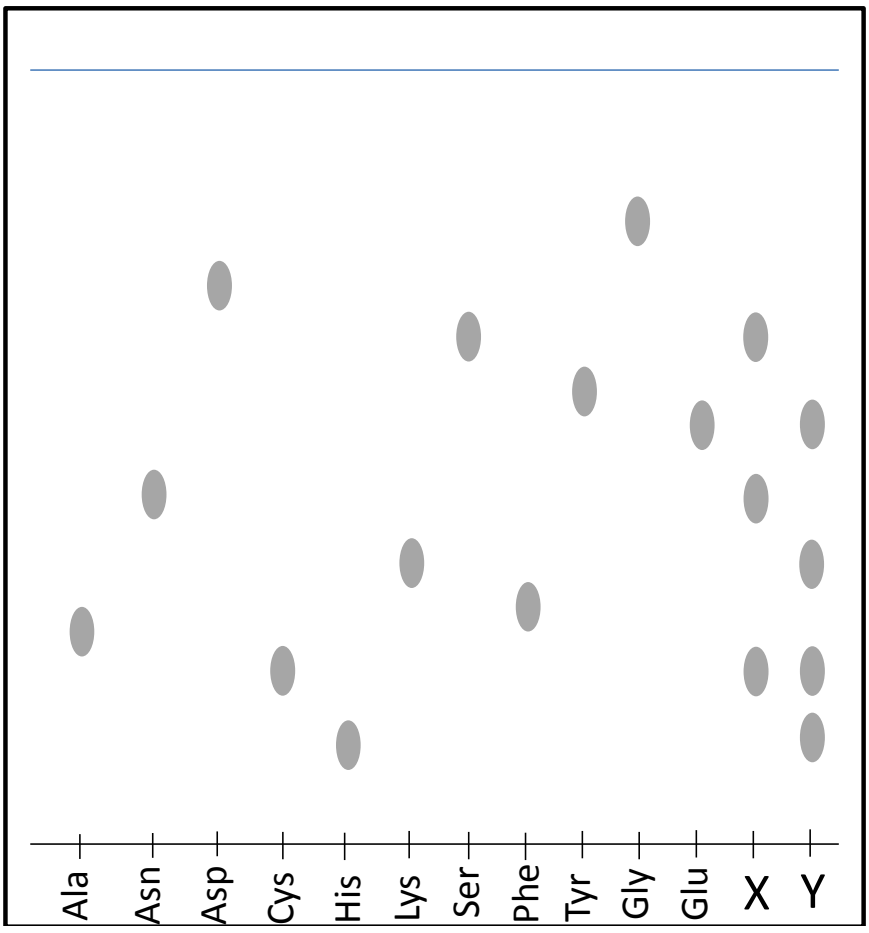
SECTION B – Short Answer Section

Section B consists of 8 short answer questions.
You should answer all of these questions in the spaces provided.
This section is worth approximately 78 per cent of the total marks available.
The marks allotted are shown at the end of each part of each question.

Question 1 (16 marks)
The diagram below is a simulated TLC chromatogram for the separation of the amino acids produced from the hydrolysis of the compounds X and Y, together with some known amino acids.



a. Describe the reaction in which the individual amino acids were released from the compounds X and Y in terms of functional group changes. **2 marks**

b. Does the presence of three spots on the chromatogram of X mean that this was a tripeptide? Explain. **1 mark**

c. Draw the structure, showing all bonds on the side chains, of a dipeptide formed from valine and the sulfur containing amino acid present in both X and Y. On this structure circle the group of atoms associated with the peptide group. **2 marks**

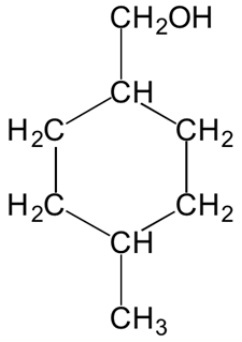
d. One of the amino acids present in Y has a charge +2 in solution at pH 3. Give the name of this amino acid and explain why it has a charge of +2 under these conditions. **2 marks**

e. Chromatography involves separation of the compounds in a mixture. Referring to two amino acids on the TLC chromatogram image, describe the general principles of chromatography. **3 marks**

f. Proteins and nucleic acids both have distinct primary and secondary structures.
Complete the following table covering associated types of bonding. **6 marks**

	Proteins	Nucleic acids
Type of bond associated with primary structure.		
Atoms between which primary structure bonds occur.		
Types of bonds associated with secondary structure.		
Atoms between which secondary structure bonds occur.		

Question 2 (16 marks)
On January 9, 2014, at least 28 000 L of a chemical known as MCHM leaked into the Elk River near Charleston, West Virginia (U.S.), near the intake for the local domestic water system. This prompted the declaration of a state of emergency with one quarter of West Virginia's population instructed not to drink or use tap water.
The systematic name of MCHM is 4-methylcyclohexylmethanol.
Its structure is shown below.



MCHM is used as a cleaning agent for coal, to reduce coal dust. The declared safe limit of MHCM for human ingestion was one ppm (m/V).

a. i. If the density of MHCM is 0.95 g mL^{-1}, into what volume of solution, in GL, would 28 000 L of MHCM need to be uniformly dispersed for the concentration to be reduced to one ppm (m/V). **2 marks**

ii. Determine the molar concentration of a 1.00 ppm (m/V) solution of MHCM. **1 mark**

b. Residents affected by this spill were advised that their water supply was usable after three days. However it was emphasised that they should thoroughly flush their pipes before using the water for cooking, washing or drinking. Why would this flushing have been necessary? **2 marks**

c. Consider the low resolution ^{1}H NMR spectrum of 4-methylcyclohexanemethanol. How many peaks would be present? **1 mark**

d. When 4-methylcyclohexanemethanol reacts with an acidified aqueous solution of dichromate ions, one organic compound is formed. $Cr^{3+}(aq)$ is another product.

i. Draw the structure showing all bonds of the organic compound formed. **1 mark**

ii. Write a balanced half-equation for the reduction part of the reaction. **1 mark**

e. Coal is a fossil fuel which, in Australia, is mined in both black and brown forms. Brown coal has higher moisture content than black coal.

i. A 1.00 kg sample of brown coal contains 40 per cent combustible material with the rest of the sample water.
Assuming that the combustible material is carbon and that the molar enthalpy of vaporisation for water is 41.0 kJ mol^{-1}, calculate the heat of combustion of the brown coal in kJ g^{-1}. **5 marks**

ii. A coal fired power station is currently '30 per cent efficient'. Explain the term '30 per cent efficient' and state **two** advantages – one economic and one environmental – which should be the result of improved efficiency. **2 marks**

iii. Coal fired power stations also emit SO_2. What is the link between that SO_2 and proteins? **1 mark**

Question 3 (9 marks)

In an investigation of electrolysis, an electric current was passed through a colourless one molar aqueous solution of a divalent metal nitrate at 25°C, using carbon electrodes.
It was observed that a gas was produced at one electrode and the metal was deposited on the other electrode.
The pH of the solution, near the electrode at which the gas was collected, was monitored during the process. Initially the pH was slightly below 7 and decreased as the electrolysis progressed.

The electrolysis was allowed to run for 5.30 minutes at a consistent current of 3.20 A.
At the conclusion of the electrolysis, the carbon electrode on which the metal had deposited was carefully washed, dried and weighed. Its mass had increased by 1.09 g.

a. **i.** State the name and give the sign of the electrode at which the metal was deposited. **1 mark**

ii. Why was the metal, rather than a gas, produced at this electrode? **2 marks**

b. **i.** Assuming the electrolysis process was 100 per cent efficient, calculate the molar mass of the metal deposited. **3 marks**

ii. Identify the metal deposited. **1 mark**

c. Another group carrying out the same investigation left the current running through the cell and noticed that after some time, bubbles of gas appeared at the electrode on which the metal had deposited. Explain this observation. **2 marks**

Question 4 (10 marks)

Consider the following statements relating to exothermic and endothermic reactions.

1. Exothermic reactions always start spontaneously whereas endothermic reactions require a source of energy to start.
2. In exothermic reactions, the release of heat energy causes the products to have a lower chemical energy content than the reactants.
3. On an energy profile for an endothermic reaction, the reactants are lower than products.
4. In the presence of catalyst the energy required to break reactant bonds is decreased but the energy released when product bonds form is not affected.
5. At higher temperature, both exothermic and endothermic reactions speed up.
6. At chemical equilibrium either an exothermic reaction **or** an endothermic reaction will be occurring.
7. The rate of an exothermic reaction increases as it proceeds but the rate of an endothermic reaction decreases as it proceeds.

a. Identify **two** of these statements which are **correct**. **1 mark**

b. Select **three** of the statements which are **incorrect** or partially correct and for each one explain why this is the case. **6 marks**

c. Two students investigated the reaction between zinc and 2.0 M hydrochloric acid. One used finely grained zinc powder, whilst the other one used lumps of zinc.

i. Write a balanced equation for the reaction. **1 mark**

ii. Explain, referring to collision theory, which reaction would be faster. **2 marks**

Question 5 (14 marks)

Because it inhibits the growth of mould and some bacteria, benzoic acid, C_6H_5COOH, along with its potassium, sodium and calcium salts, is used as a food preservative. It is a weak acid and is used to calibrate bomb calorimeters. Its molar enthalpy of combustion, (ΔH_c), is -3227 kJ mol^{-1}.

a. Write the chemical formula for the potassium salt of benzoic acid. **1 mark**

b. **i.** Write the equilibrium law expression for an aqueous solution of benzoic acid. **1 mark**

ii. Calculate the pH of a 0.100 M aqueous solution of benzoic acid. **3 marks**

c. A bomb calorimeter is calibrated by adding 1.56 g benzoic acid and excess oxygen to the reaction bomb and sparking the mixture. The temperature of the water surrounding the reaction bomb rises by 19.6 °C.

i. Determine the calibration factor of the calorimeter, in J $°C^{-1}$. **3 marks**

ii. If the calibration factor had been determined using the specific heat capacity of water **would** it differ from the value calculated in **i.**? Explain. **2 marks**

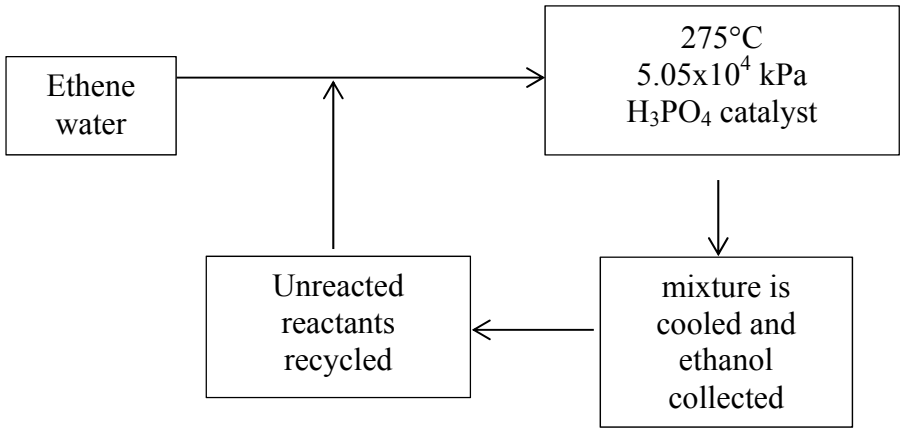
d. A different bomb calorimeter, with calibration factor 3.17 kJ $°C^{-1}$, is used to measure the heat of combustion of pentane. A weighed sample of the fuel was added to the reaction bomb along with oxygen and the mixture sparked. The temperature of the water surrounding the reaction bomb rose by 17.8°C.

i. Assuming the calorimeter is 100 per cent efficient, calculate the mass of pentane added to the calorimeter. **3 marks**

ii. What could cause the calculated mass of pentane to be significantly less than the mass **actually** added to the calorimeter? **1 mark**

Question 6 (28 marks)

The diagram below is a simplified representation of the industrial production of ethanol via an equilibrium reaction between ethene and steam.



a. Write a balanced equation for the ethanol producing reaction consistent with the information supplied. **1 mark**

b. The production of 1.02 g of ethanol by this method releases 1.04 kJ of energy. Determine ΔH for your equation. **2 marks**

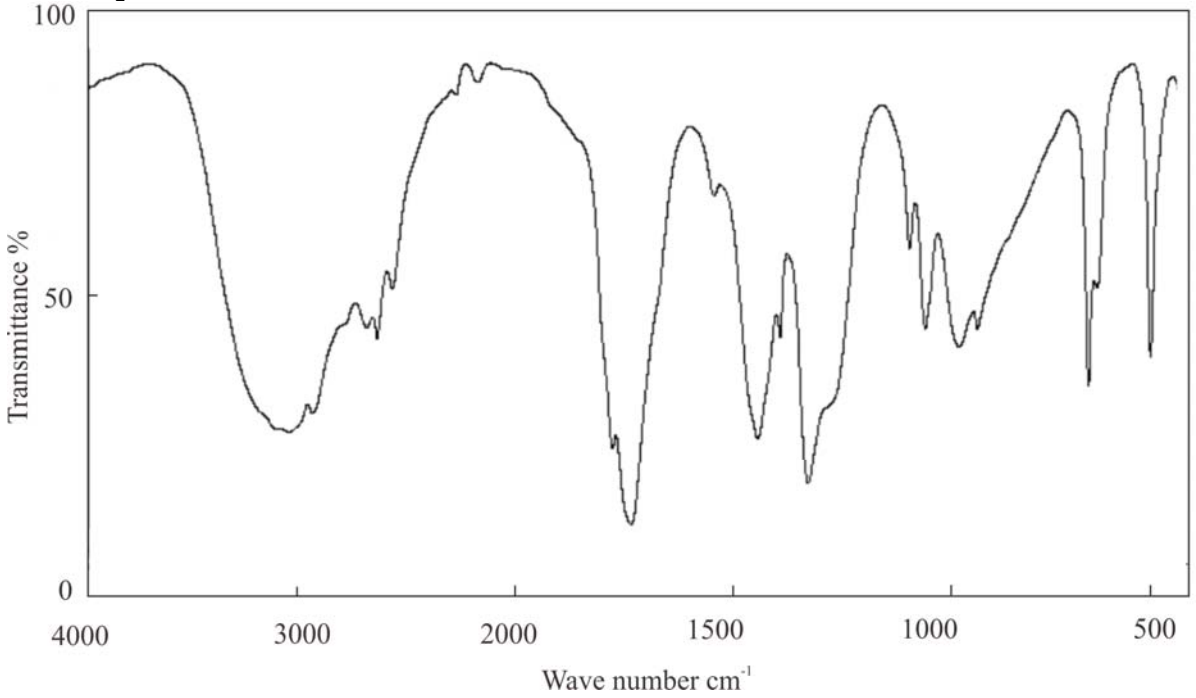
c. In an investigation of this production process, 44.6 g of ethene and 21.6 g of water were mixed in a 2.0 L container at 300°C and 4.75×10^4 kPa pressure. When equilibrium was established, 5.00 per cent of the ethene had been converted to ethanol. Calculate the value of the equilibrium constant under these conditions. **4 marks**

d. Explain why a slightly different yield of ethanol might be expected if the temperature and pressure conditions used in the investigation had been the same as those shown in the diagram for the industrial production. **3 marks**

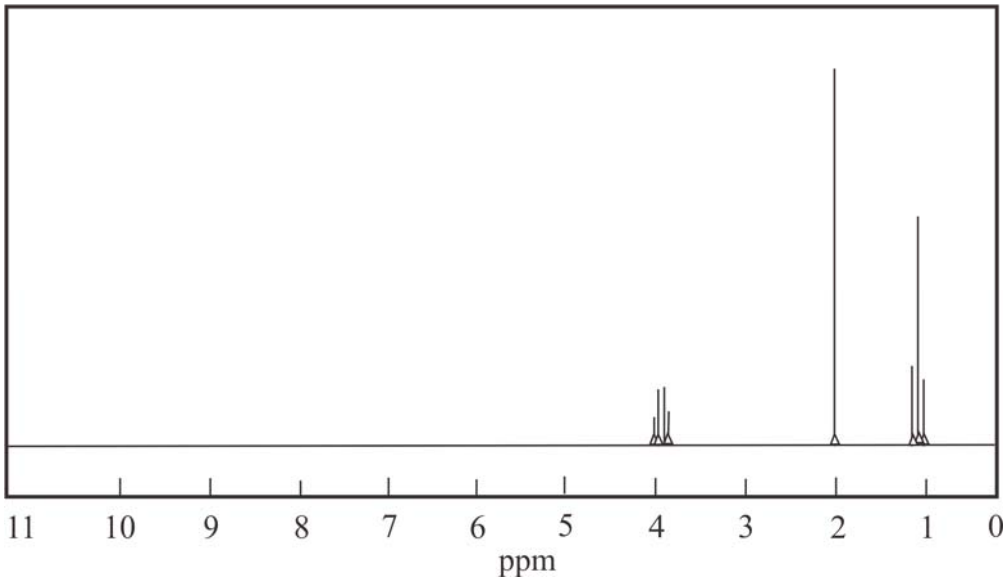
e. Explain, in terms of collision theory, how this system reaches equilibrium. **3 marks**

f. The spectra shown below are spectra of two organic compounds produced in a reaction pathway from ethanol where ethanol is the only starting organic compound.

Spectrum 1



Spectrum 2



i. Explain how these spectra can be used to identify the two compounds. Give the names and semistructural formulae of the two different compounds. **6 marks**

ii. What inorganic chemicals are commonly used in the production of the two different compounds from ethanol? **2 marks**

g. Ethanol is an important biofuel and is produced by fermentation.

i. Write a balanced equation for the fermentation reaction. **1 mark**

ii. Ethanol is added to petrol, mainly octane, to produce what is known as E10 blend. Ethanol is also the alcoholic component of alcoholic beverages which are aqueous solutions. Explain how ethanol dissolves in both water and octane. **3 marks**

iii. Write a balanced equation for the combustion of ethanol. **1 mark**

h. Ethanol is the fuel in ethanol-oxygen fuel cells.

i. State the name and sign of the electrode at which ethanol reacts. **1 mark**

ii. Write the half-equation for the reaction of ethanol in a fuel cell containing an acidic electrolyte. **1 mark**

Question 7 (8 marks)

An investigation to determine the reducing strength of four metals, represented by P, Q, R, and S, made use of the four metals, aqueous solutions of their cations and hydrochloric acid. All four metals existed as +2 ions in solution.

The following observations were recorded.

	P	**Q**	**R**	**S**
P^{2+}(aq)		reaction	no reaction	reaction
Q^{2+}(aq)	no reaction		no reaction	no reaction
R^{2+}(aq)	reaction	reaction		reaction
S^{2+}(aq)	no reaction	reaction	no reaction	
1 M HCl(aq)	no reaction			reaction

a. Explain how the recorded observations can be used to arrange the four metals in order of increasing reducing strength. **5 marks**

b. If all the solutions used were 1 M solutions at 25°C, identify which of the metals would have positive $E°$ values on the electrochemical series and explain the reasoning behind your choice(s). **2 marks**

c. A student uses the electrochemical series to predict that when $Cl_2(g)$ at 25°C and 101.3 kPa is bubbled through 1 M $Fe^{2+}(aq)$ solution, $Fe^{3+}(aq)$ ions should be produced in the solution. However on adding KSCN(aq) to the solution, the dark red colour characteristic of $Fe(NCS)^{2+}(aq)$ is not produced. Suggest a reason why the 'expected' reaction between $Fe^{2+}(aq)$ and $Cl_2(g)$ is not observed. **1 mark**

Question 8 (11 marks)

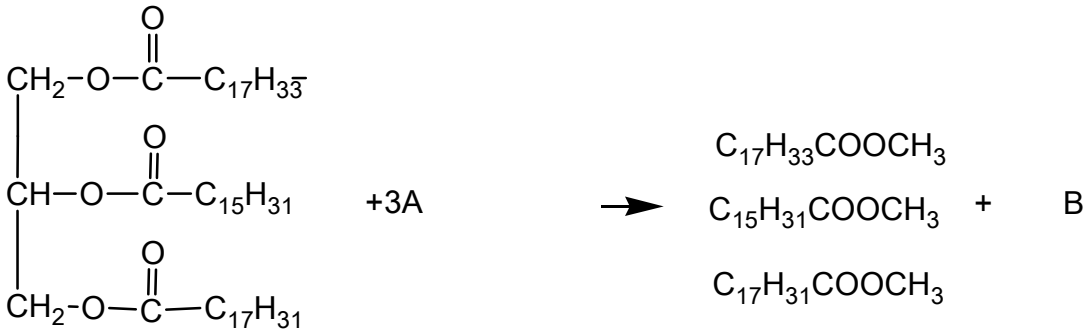
'The Conversation' (http://theconversation.com/ipcc-report-biofuels-alone-are-unsustainable-but-can-still-help-combat-climate-change-25046) on April 1, 2014 included an article entitled 'IPCC report: biofuels alone are unsustainable, but can still help combat climate change'. The article discusses a report from the meeting of Working Group II of the International Panel on Climate Change (IPCC) in March 2014 that raised some issues about the extent to which biofuels may assist in reducing carbon dioxide emissions as part of an overall strategy in reducing the impact of climate change.

a. The article includes a statement 'If all went according to plan, the carbon cycle would be "closed" and there would be no (or very little) net release of carbon dioxide into the atmosphere from (the use of) biofuels.'

i. Using bioethanol as an example, explain why there should be little, if any, net release of CO_2 into the atmosphere from the use of biofuels. **1 mark**

ii. Many areas of the planet are regularly under the impact of drought. Give two reasons **why** biofuels are unlikely to be a sustainable fuel source in such areas. **1 mark**

b. Biodiesel is produced by transesterification, a process in which triglycerides are converted to methyl esters in a reaction catalysed by either an acid or a base. Research has shown that chicken fat is very suitable for the production of biodiesel. The transesterification of a triglyceride in chicken fat is represented by the incomplete equation below.



i. Write the name and give the semistructural formula of compound A. **1 mark**

ii. Give the name and molecular formula of compound B. **1 mark**

iii. Give the semistructural formula of the biodiesel produced which is monounsaturated. **2 marks**

c. Analysis of the combustion of a 0.631 g sample of methyl palmitate indicated the release of 23.5 kJ of energy.
Write a balanced thermochemical equation for the combustion of methyl palmitate. **3 marks**

d. Nuclear energy is often put forward as the best fuel source for reducing CO_2 emissions in power stations.

i. What is the **main** advantage of nuclear fuel as an energy source? **1 mark**

ii. What is the **main** disadvantage in the use of nuclear energy as a fuel source? **1 mark**

End of Section B

End of Trial Exam