Student Number ________________

MC /20	Molino /23	Noyes /27	Faulder /15	Option /15	Total /100

NAME ______________________________________

Sydney Technical High School

2013

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Approved calculators may be used
- Write your student number in the space provided

Total marks – 100

Section I Pages 2 - 28

85 marks
This section has two parts, Part A and Part B

Part A – 20 marks
- Attempt Questions 1-20
- Allow about 30 minutes for this part

Part B –65 marks
- Attempt Questions 21-32
- Allow about 2 hours for this part

Section II Pages 28 - 29

15 marks
- Attempt Question 33
- Allow about 30 minutes for this section

Student Number ________________

Section I
85 marks

Part A – 20 marks
Attempt Questions 1-20
Allow about 30 minutes for this part

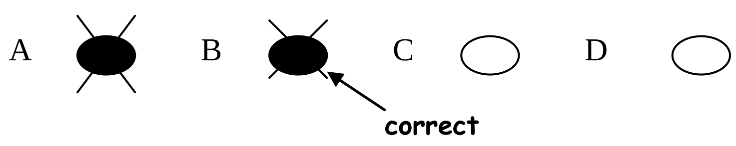
Use the multiple-choice answer sheet.

Select the alternative A,B,C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



Student Number ________________

2013

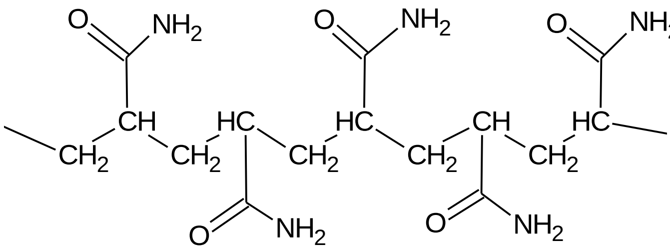
TRIAL HSC EXAMINATION

Chemistry

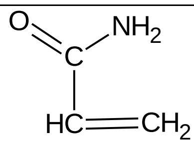
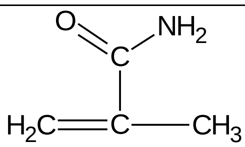
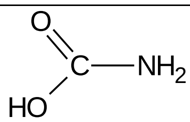
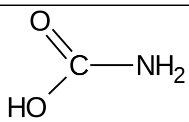
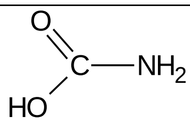
Multiple Choice Answer Sheet

1.	A ◯	B ◯	C ◯	D ◯
2.	A ◯	B ◯	C ◯	D ◯
3.	A ◯	B ◯	C ◯	D ◯
4.	A ◯	B ◯	C ◯	D ◯
5.	A ◯	B ◯	C ◯	D ◯
6.	A ◯	B ◯	C ◯	D ◯
7.	A ◯	B ◯	C ◯	D ◯
8.	A ◯	B ◯	C ◯	D ◯
9.	A ◯	B ◯	C ◯	D ◯
10.	A ◯	B ◯	C ◯	D ◯
11.	A ◯	B ◯	C ◯	D ◯
12.	A ◯	B ◯	C ◯	D ◯
13.	A ◯	B ◯	C ◯	D ◯
14.	A ◯	B ◯	C ◯	D ◯
15	A ◯	B ◯	C ◯	D ◯
16.	A ◯	B ◯	C ◯	D ◯
17.	A ◯	B ◯	C ◯	D ◯
18.	A ◯	B ◯	C ◯	D ◯
19.	A ◯	B ◯	C ◯	D ◯
20.	A ◯	B ◯	C ◯	◯

1. The diagram below shows a polymer.



Identify the type of polymerisation reaction used to produce it and the monomer or monomer units used to make it.

	Type of polymerisation	Monomer 1	Monomer 2
(A)	addition		-
(B)	addition		-
(C)	condensation	$H_2C=CH_2$	
(D)	condensation		

2. Identify the two components required to prepare a buffer solution.

(A) A weak acid and a weak base.

(B) A weak acid and its conjugate base.

(C) A strong acid and a strong base.

(D) A strong acid and its conjugate base.

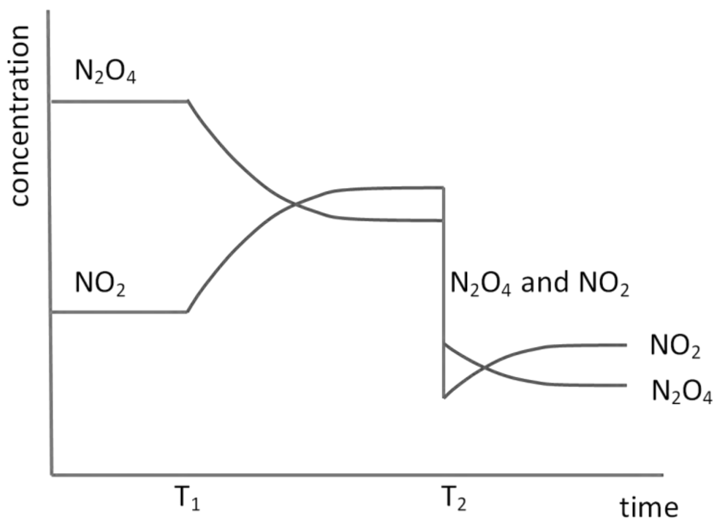
3. An analytical chemist thinks that a sample of drinking water contains high levels of copper(II).

Which of the following sets of results would be consistent with this?

	Flame colour	Effect of adding Cl^-	Effect of adding OH^-
(A)	Blue-green	No precipitate forms	Precipitate forms
(B)	Red	No precipitate forms	No precipitate forms
(C)	Red	Precipitate forms	No precipitate forms
(D)	Blue-green	Precipitate forms	Precipitate forms

4. The graph shows the concentrations over time for the equilibrium system:

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)} \quad \Delta H = -58 \text{ kJ mol}^{-1}$$



What has happened to the temperature at T_1 and to the volume at T_2?

	Temperature change at T_1	Volume change at T_2
(A)	Decrease	Increase
(B)	Increase	Decrease
(C)	Decrease	Decrease
(D)	Increase	Increase

5. HDPE and LDPE are two of the most commercially important polymers in use today.

Which one of the following options correctly describes aspects of their chemistry?

(A) HDPE contains multiple chain branches and is formed using an organic peroxide catalyst. LDPE has a higher melting point than HDPE, and is produced using Zeigler-Natta catalysts.

(B) HDPE contains no chain branches, and is formed using an organic peroxide catalyst. LDPE is also formed using an organic peroxide catalyst and has multiple chain branches.

(C) LDPE has multiple chain branches, and is formed in a high temperature and pressure reaction using an organic peroxide catalyst. HDPE has no chain branches and is formed using Zeigler-Natta catalysts.

(D) LDPE is formed using Zeigler-Natta catalysts and has no chain branches. Its melting point is higher than that of HDPE. HDPE is formed using an organic peroxide catalyst and also has no chain branches.

6. It is important that the reaction of methane with oxygen be monitored to prevent the formation of which substance?

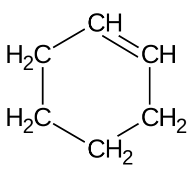
(A) CO_2

(B) CO

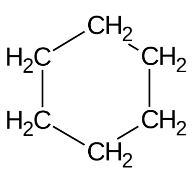
(C) H_2O

(D) H_2

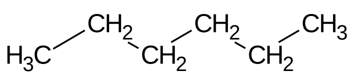
7. Consider the following carbon compounds, which are all clear, colourless liquids.



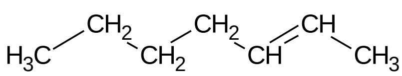
(i)



(ii)



(iii)



(iv)

Which of these compounds would decolourise $Br_2(aq)$ under ordinary laboratory light?

(A) i and ii

(B) ii and iii

(C) i and iv

(D) ii and iv

8. Phenolphthalein can be used to determine the equivalence point in the titration of acetic acid with sodium hydroxide, but methyl orange is no use in this case.

The most appropriate explanation for the above statement is:

(A) at equivalence, the salt produced is basic and its pH corresponds to that of the phenolphthalein colour change.

(B) at equivalence, the salt produced is acidic and its pH overlaps with that of phenolphthalein's colour change.

(C) methyl orange has a pH range which is too high and does not correspond to the basic salt produced.

(D) methyl orange has a pH range which is too low and does not correspond to the acidic salt produced.

9. Which one of the following species could be analysed using AAS?

(A) Sr^{2+}

(B) S^{2-}

(C) SO_2

(D) SO_4^{2-}

10. Which one of the following substances can be classified as an Arrhenius acid?

(A) NaCl

(B) CH_3COOH

(C) CH_4

(D) $NaCH_3COO$

11. Which of the following describes a correct procedure to test for barium ions in 2 mL of a dilute acid solution?

(A) Add a few drops of dilute sulfuric acid

(B) Add a few drops of dilute sodium hydroxide

(C) Add a few drops of dilute hydrochloric acid, filter and heat the residue

(D) Add a few drops of dilute sodium nitrate and observe any changes.

12. Consider the table below:

Half-reaction	**E°_{red} / V**
$A^+ + e^- \rightarrow A$	1.8
$B^{3+} + e^- \rightarrow B^{2+}$	0.9
$C^{2+} + 2e^- \rightarrow C$	-0.9
$D^{2+} + 2e^- \rightarrow D$	-1.7

Which one of the following is the best oxidising agent?

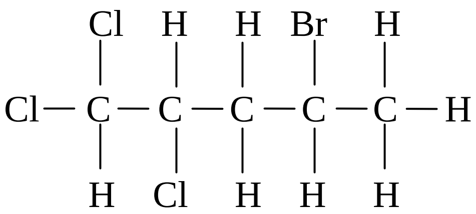
(A) A

(B) A^+

(C) D^{2+}

(D) D

13. What is the correct systematic name for the compound having the structure shown below?



(A) 4-bromo-1,1,2-trichoropentane

(B) 4,5,5-trichloro-2-bromopentane

(C) 2-bromo-4,5,5-trichloropentane

(D) 1,1,2-trichloro-4-bromopentane

14. Which one of the following species contains a coordinate covalent bond?

(A) H_2

(B) OH^-

(C) H_2O

(D) H_3O^+

15. The table shows the recorded values for the enthalpy of combustion of natural gas, from different sources, under standard conditions.

Origin	**Heat of Combustion MJ/m^3**
Algeria	42.00
Canada	38.20
Indonesia	40.60
United Kingdom	39.71
United States	38.42

Which is the most probable explanation for the differences in these values?

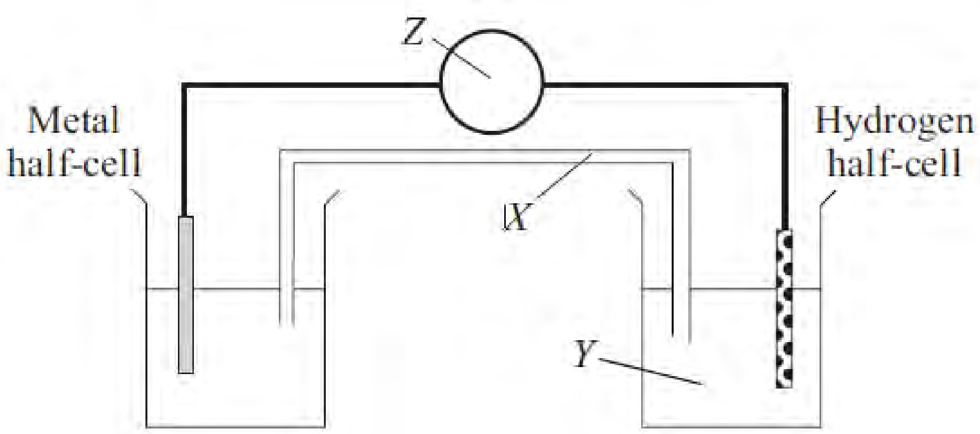
(A) Experimental uncertainty

(B) The pressure and temperature of natural gas varies

(C) Some countries over-state their results

(D) Natural gas is a mixture, which varies in composition

16. The diagram shows a galvanic cell used to measure electrode potentials.



Which response correctly identifies the components of the cell?

	X	*Y*	*Z*
(A)	salt bridge	electrolyte	ammeter
(B)	salt bridge	electrolyte	voltmeter
(C)	water	electrode	voltmeter
(D)	electrolyte	water	ammeter

17. Cellulose is an example of a condensation polymer, and it is the major component of biomass.

Why is cellulose known as a condensation polymer?

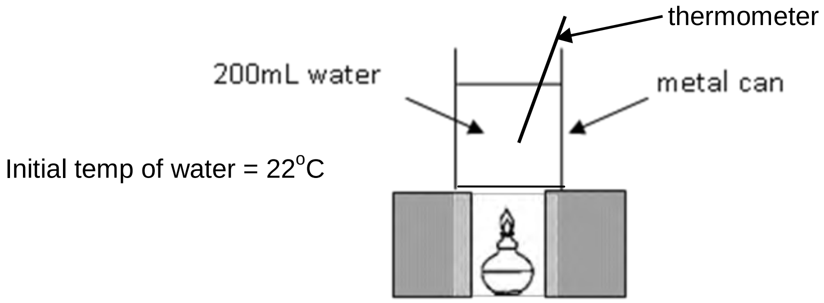
(A) It is made of β-glucose monomers.

(B) Water is a by-product of this polymerisation process.

(C) Water is required for this polymerisation process.

(D) It is made of α-glucose monomers.

18. A student carried out an experiment, using the apparatus shown, to find the heat of combustion of ethanol.



When 1.635g of ethanol was burnt, the temperature of the water increased to 47°C.

Calculate the energy released, in kJ, when 1.50g of ethanol was burnt.

(A) 19.2 kJ

(B) 5.89 kJ

(C) 5.44 kJ

(D) 18.8 kJ

19. The naturally occurring acid 2-hydroxypropane-1,2,3-tricarboxylic acid is also known as

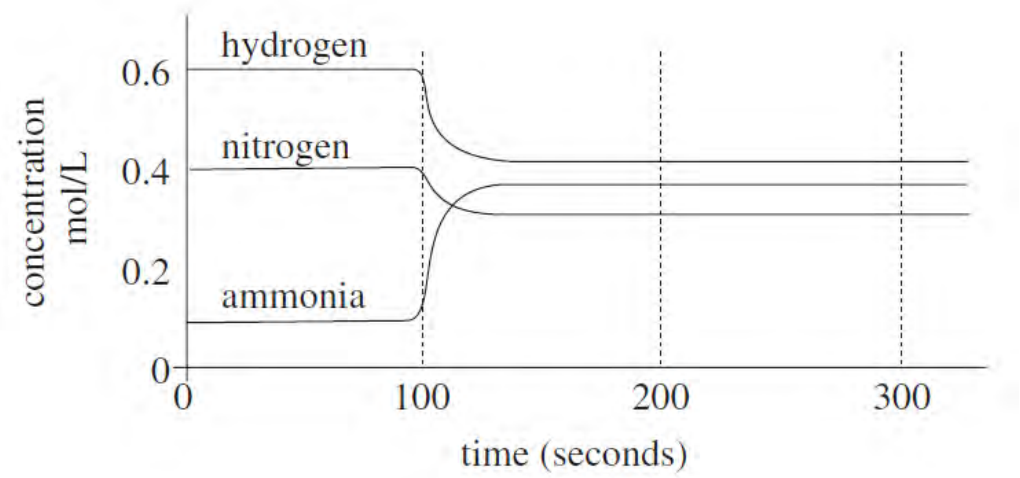
(A) acetic acid

(B) benzoic acid

(C) ascorbic acid

(D) citric acid

20. Consider the following graph which relates to the Haber process:



Which of the following caused the changes in concentration observed after 100 seconds had passed?

(A) The pressure was decreased.

(B) The temperature was decreased.

(C) A catalyst was added to the reaction vessel.

(D) The volume of the reaction vessel was increased.

Student Number ________________

Section I (continued)

MOLINO /23

Part B – 55 marks
Attempt Questions 21 - 32
Allow about 2 hours for this part

Answer the questions in the spaces provided.

Marks

Question 21 (4 marks)

E10 engine fuel is a blend of 10% ethanol and 90% petrol. One of the issues with its use is the absorption of water vapour from the atmosphere.

(a) Explain how ethanol is able to blend with petrol and also cause water retention in the fuel blend. Include a diagram in your answer. **3**

....

....

....

....

....

....

(b) Write an equation for the incomplete combustion of ethanol **1**

....

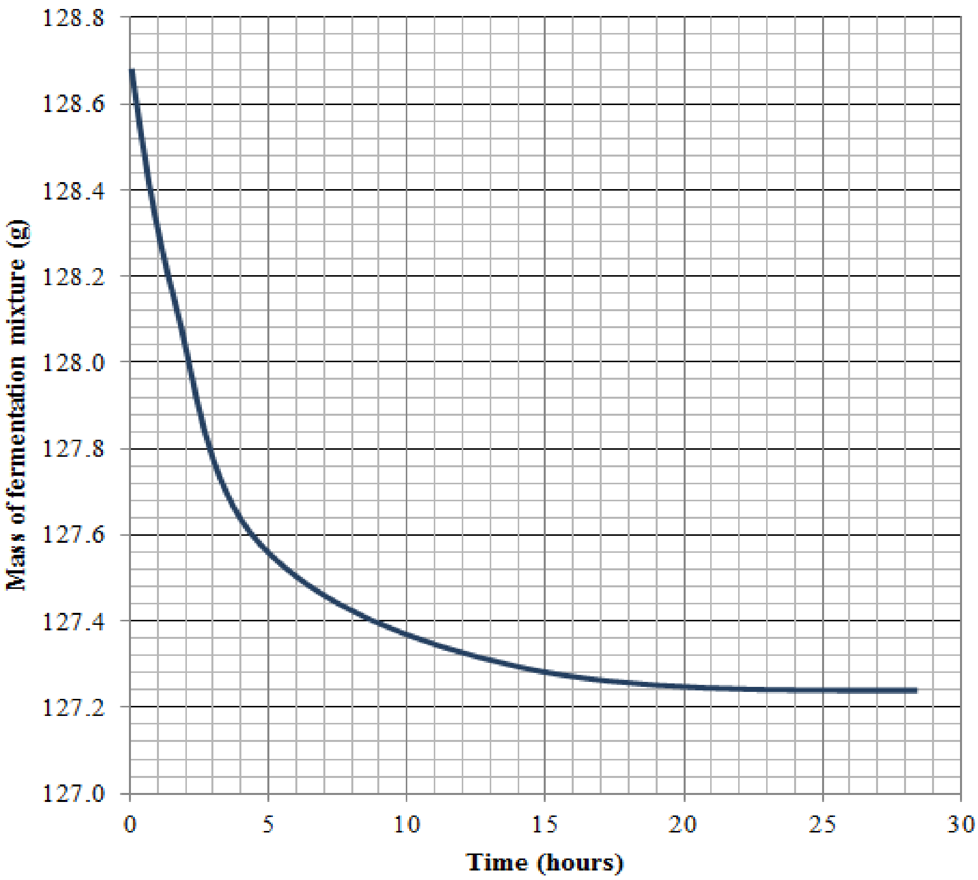
....

Question 22 (9 marks) **Marks**

Fermentation converts glucose into ethanol.

A student added 12g of glucose to a conical flask along with 1g of yeast and 50 mL of water.
The conical flask was attached to a computer to monitor mass changes in the reaction vessel.

The graph below shows how the mass of the reaction mixture changes over a 24 hour period.



(a) Write an equation for the fermentation of glucose. **1**

....

(b) Use the graph to calculate the mass change in the conical flask. **1**

....

....

Question 22 continues on page 14.

Question 22 (continued)

(c) Use the mass change to calculate the mass of ethanol produced by the reaction, and compare this to the theoretical mass of ethanol.

Show all working. **4**

....

....

....

....

....

....

....

....

(d) Describe how you could test for the gas that was produced.

....

.... **2**

....

(e) Identify the conditions that are necessary for fermentation. **1**

....

....

Question 23 (5 marks)

"The development of the Haber process to synthesise ammonia was an important scientific contribution during the early 1900's not only to Germany's war efforts but also to our understanding of equilibrium processes"

Assess the accuracy of the statement above.

.... **5**

....

....

....

....

....

....

....

……………………………………………………………………………………...

……………………………………………………………………………………...

Student Number _______________

Marks

Question 24 (5 marks)

Iodine-125 is a radioisotope used in cancer therapy and to diagnose deep vein thrombosis in the leg. It is also widely used in radioimmuno-assays to show the presence of hormones in tiny quantities. ^{125}I emits Beta particles when it decays.

(a) Write a nuclear equation for the radioactive decay of $^{125}_{53}I$.

.... **1**

....

(b) Describe how transuranic elements are produced commercially.

.... **3**

....

....

....

....

....

....

(c) Identify an instrument used to detect radiation.

.... **1**

THIS PAGE IS INTENTIONALLY LEFT BLANK

Student Number _______________

NOYES	/27

Question 25 (5 marks) **Marks**

A chemistry student determined the percentage of sulfate in a lawn fertiliser using the following procedure.
He ground the fertiliser into a powder, weighed out 1.03 g of the powder, added it to 250 mL of dilute hydrochloric acid and stirred to dissolve as much as possible of the fertiliser. The insoluble material was then removed by filtration. The filtrate was warmed and a solution of barium chloride was slowly added until no more precipitate formed. The precipitate was allowed to settle. After 30 minutes, the precipitate was filtered through a weighed sintered glass filter, washed, dried and the mass of the precipitate determined.
The precipitate was found to have a mass of 1.80 g.

(a) Write the net ionic equation for the reaction that occurred when the $BaCl_2$ was added to the beaker. **1**

....

(b) Use the above data to calculate the percentage of sulfate in the lawn fertiliser. **2**

....

....

....

....

(c) Explain how incorrect techniques during the washing and drying stages could impact on the accuracy of the result. **2**

....

....

....

....

Marks

Question 26 (6 marks)

A chemist needed to determine whether a 0.01M solution was only a weak acid rather than a strong acid.

(a) Using the indicators listed below, describe how she could do this.

indicator	colour (low pH – high pH)	pH range
bromothymol blue	yellow-blue	6.0 – 7.6
litmus	red - blue	5.0 – 8.0
methyl orange	red - yellow	3.1 – 4.4
phenolphthalein	colourless - red	8.3 – 10.5

Justify your choice and give the range of pH values that the substance could have, based on your method. **3**

....

....

....

....

....

....

(b) 50.00 mL of 0.250 M hydrochloric acid was added to 25.00 mL of 0.300 M potassium hydroxide. **3**

Calculate the pH of the resulting solution.

....

....

....

....

Marks

Student Number _______________

Question 27 (5 marks)

Explain why acidic oxides in the atmosphere are of such concern to society and the environment. Include a relevant chemical equation in your answer. **5**

....

....

....

....

....

....

....

....

....

....

....

....

Student Number ________________

Marks

Question 28 (6 marks)

A chemist wanted to determine the percentage of calcium carbonate in a sea shell.

He collected a number of sea shells which he crushed into a fine powder.

To 2.65 g of sea shell powder he added 25.0 mL of 5.00 M $HCl_{(aq)}$.

When all the fizzing ceased, he filtered the remaining mixture into a conical flask and carefully washed the residue.

Finally he titrated the filtrate with 2.20 M $NaOH_{(aq)}$ and 46.3 mL of base was required.

(a) Write a chemical equation for the reaction that took place when the acid was added to the crushed sea shell. **1**

....

(b) Calculate the number of moles of NaOH that were used in the titration. **1**

....

....

(c) Determine the number of moles of acid that reacted with the sea shell. **1**

....

....

(d) Calculate the percentage of calcium carbonate in the sea shells. **3**

....

....

....

....

....

....

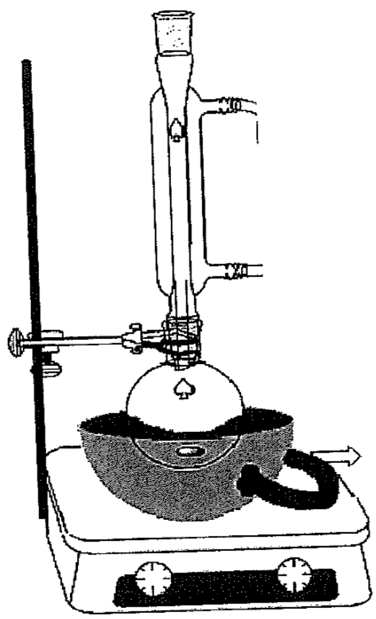
Student Number ________________

Question 29 (5 marks)

Pentyl butanoate was prepared in the school laboratory.

(a)Draw a structural equation for the formation of this substance and name each species **3**

(b) The image below shows the equipment used for this reaction. **2**



Explain reasons for using this apparatus for this technique.

....

....

....

....

....

THIS PAGE IS INTENTIONALLY LEFT BLANK

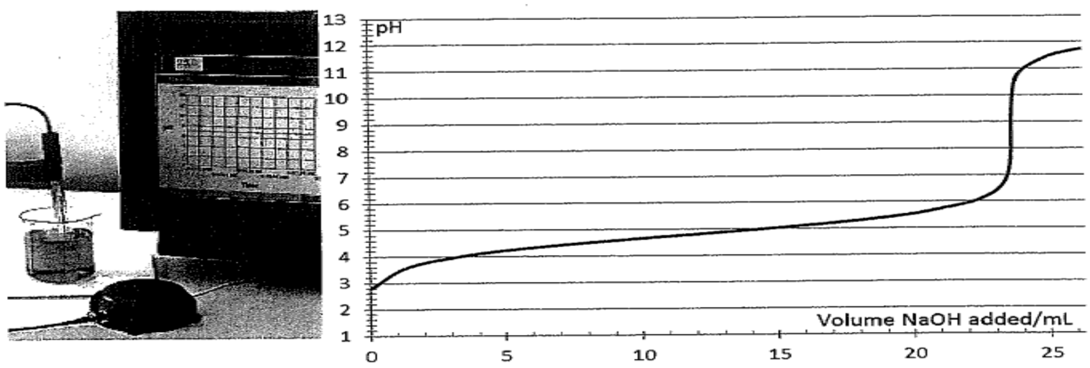
Student Number _______________

FAULDER /15

Question 30 (6 marks)

A chemist titrated 25.0 mL of diluted (1:10) household vinegar against a standard solution of 0.112 mol L^{-1} sodium hydroxide solution.

The chemist used a pH meter, attached to a graphical data recorder. The right-hand diagram shows the output of the data recorder.



The chemist also recorded the following observations:

Volume diluted vinegar for titration = 25.00 ml (by pipette)

Concentration of standard NaOH solution = 0.112 mol L^{-1}

Equivalence point = 23.6 mL ; pH = 9.1

(a) Outline the procedure used to make the NaOH standard solution. **4**

....

....

....

....

....

....

....

....

....

....

(b) Determine the concentration of the acid in the diluted vinegar. **2**

....

....

....

....

....

Question 31 (4 marks)

The table below lists the *heat of combustion* for some carbon compounds and the proportion of oxygen in each substance.

Compound	*Proportion of oxygen (%)*	*Heat of combustion (MJ kg^{-1})*
Ethane	0	52
Ethanol	35	30
1-propanol	27	31
1-butanol	22	33
1-pentanol	18	34
Acetic acid	53	15

(a) Construct a graph of these data. **2**

(b) Using your graph, predict the heat of combustion of ethyl acetate. **2**

....

....

....

Question 32 (5 marks)

Vinyl chloride and styrene are described as commercially significant monomers – the annual production of vinyl chloride is currently estimated at 350 million tonnes and that of styrene is 6.8 million metric tonnes. Both are obtained from the petrochemical industry.

(a) Describe a use of a polymer made from each of these monomers in terms of its properties. **2**

....

....

....

....

....

(b) Discuss the need for alternative sources of monomers rather than those obtained from the petrochemical industry. **3**

....

....

....

....

....

....

....

Student Number _______________

Section II

15 marks
Attempt ONE question from Questions 33
Allow about 30 minutes for this section

Answer in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations.

Pages

Student Number ________________

Marks

Question 33 - Industrial Chemistry (15 marks)

(a) Describe the issues associated with struggling world resources of ONE identified natural product that is not a fossil fuel and a replacement material that is used. **3**

(b) Consider the following mixture of gases in a closed 5.0L vessel at 730 °C.

Gas	*Quantity (mol)*
CH_4	2.00
H_2O	1.25
CO	0.75
H_2	0.75

The following reaction occurs:

$$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3H_{2(g)} \qquad \Delta H = +206kJ$$

The equilibrium constant, K, is 0.26 at 730 °C.

(i) Deduce whether the system is shifting to the left or right to reach Equilibrium. **3**

(ii) Explain how conditions in this reaction could be adjusted to increase the quantity of products **3**

(c) "Sulfuric acid is one of most important industrial chemicals in use today despite the need to monitor the conditions of its production and the hazards associated with its transport". **6**

Assess this statement.

End of paper.

2013 Chemistry Trial HSC examination.   Marking Guidelines and model Answers.

MOLINO

Section I A   Multiple Choice

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	A	A	D	C	B	C	A	A	B	A	B	D	D	D	B	B	A	D	B

Section I B

21.a.

Marking Guidelines	Marks
• Explains the structure of ethanol and its ability to act as a solvent for both polar and non-polar substances AND • Draws a structural diagram of the ethanol molecule labelling the polar and non-polar sides of the molecule.	3
• Describes the structure of ethanol and its ability to act as a solvent for either polar or non-polar substances AND • Draws a structural diagram of the ethanol molecule labelling the polar and non-polar sides of the molecule	2
• Identifies the polar and non-polar nature of ethanol OR • Draws a structural diagram of the ethanol molecule	1

The ethanol molecule has both a polar –OH group and a non-polar CH_3CH_2- group.

The non-polar end can form weaker dispersion forces with other non-polar molecules such as hydrocarbons and can therefore dissolve petrol. The polar end attracts other polar molecules such as water, hence, ethanol in E10 absorbs water from the air. Therefore ethanol is a solvent for both water and petrol.

21.b.

Marking Guidelines	Marks
• Correctly writes a balanced equation for the incomplete combustion of ethanol showing states	1

$C_2H_5OH_{(l)} + 2O_{2(g)} \rightarrow 2CO_{(g)} + 3H_2O_{(l)}$

OR

$2C_2H_5OH_{(l)} + 2O_{2(g)} \rightarrow 4C_{(s)} + 6H_2O_{(l)}$

OR

$C_2H_5OH_{(l)} + 2O_{2(g)} \rightarrow CO_{2(g)} + C_{(s)} + 3H_2O_{(l)}$

22.a.

Marking Guidelines	Marks
• Correctly writes equation.	**1**

$C_6H_{12}O_{6(aq)} \xrightarrow{\text{yeast}} 2C_2H_5OH_{(aq)} + 2CO_{2(g)}$

22.b

Marking Guidelines	Marks
• Correctly calculates the mass change in conical flask.	**1**

128.68 – 127.24 = 1.44g

22.c.

Marking Guidelines	Marks
• Correctly uses the mass change to calculate the mass of ethanol produced by the reaction, and compares this to the theoretical mass of ethanol, showing all working.	**4**
• As above with one error.	**3**
• Calculates correct mass of ethanol produced or correctly calculates the theoretical mass of ethanol.	**2**
• Correctly calculates moles of carbon dioxide using mass lost.	**1**

$C_6H_{12}O_{6(aq)} \rightarrow 2CH_3CH_2OH_{(aq)} + 2CO_{2(g)}$

Actual mass of ethanol produced:

$n(CO_2) = 1.44 / 44.01 = 0.0327\ldots$

$n(CH_3CH_2OH) = 0.0327\ldots$

$m(CH_3CH_2OH) = 0.0327\ldots \times 46.068 = 1.5g$

Theoretical mass of ethanol produced:

$n(C_6H_{12}O_6) = 12 / 180.156 = 0.0666\ldots$

$n(CH_3CH_2OH) = 0.0666\ldots \times 2 = 0.1332\ldots$

$m(CH_3CH_2OH) = 0.1332\ldots \times 46.068 = 6.1g$

The actual mass of ethanol produced is lower than the theoretical mass of ethanol.

22.d

Marking Guidelines	Marks
• Describes how the lime water turns milky white in the presence of CO_2	**2**
• Identifies the presence of limewater OR • Identifies a milky result	**1**

To test for the presence of carbon dioxide gas, bubble the sample of the gas in a test tube containing lime water.
If the lime water solution turns a milky white, the gas is carbon dioxide.

22.e

Marking Guidelines	Marks
• Identifies conditions needed for fermentation to occur	**1**

- 37ºC
- Anaerobic conditions
- Yeast

23.

Marking Guidelines	Marks
• States conditions and thoroughly explains the LCP AND • Explains the importance of the Haber Process to WWI in Germany AND • Makes a judgement AND • Demonstrates coherence and logical progression and includes correct use of scientific principles and ideas AND • Writes the correct chemical equation for the production of ammonia from nitrogen and hydrogen.	**5**
• Writes the correct chemical equation for the production of ammonia from nitrogen and hydrogen. AND • States conditions and an explanation of LCP OR • Explains the importance of the Haber Process to WWI for Germany.	**4**
• Outlines the historical context of the Haber process, and identifies the synthesis of ammonia from its elements. AND • Writes the correct chemical equation for the production of ammonia from nitrogen and hydrogen. OR • Outlines that the reaction is an equilibrium reaction	**2-3**
• Response contains one correct statement about the Haber process, or a correct chemical equation for the production of ammonia from nitrogen and hydrogen.	**1**

During WWI there was an Allied naval blockade of Germany's shipping routes, which prevented supplies of nitrogen-rich guano and saltpetre traveling from Chile to Germany (required for munitions and fertilizer production). As a result, Fritz Haber began work on developing a process for converting gaseous nitrogen and hydrogen into ammonia:

$3H_2(g) + N_2(g) \leftrightarrow 2NH_3(g)$ -92 kJ/mol.

This allowed continued expansion of crop production and continued production of munitions and explosives which allowed Germany to prolong the war.

The reaction is an example of an exothermic equilibrium. At standard conditions of temperature and pressure this equilibrium lies
well to the left, and very little ammonia is present in the equilibrium mixture.

The conditions used in the Haber process, made the process viable as a means of manufacturing ammonia on a commercial scale. The development of ammonia on an industrial scale involved balancing the conditions of the reaction so that the products are produced at a fast rate and the quantity of product (the **yield**) is maximised.

The conditions used are as followed:
• *Reactants:* N2 and H2 (mole ratio 1 : 3). Although Le Chatelier's principle predicts that the equilibrium can be shifted to the product side by increasing reactant concentration, it is important that the 1 : 3 mole stoichiometry is maintained.

• *Pressure:* 15–35 MPa (typically ~20–25 MPa). Although equilibrium and kinetic considerations suggest that the pressure should be as high as possible, economic and safety considerations require a lower pressure so that the reaction vessel has as long a lifetime as possible.

• *Temperature:* 400ºC–550ºC. Equilibrium and kinetic factors are in conflict here. This compromise temperature allows the reactants to have sufficient kinetic energy to overcome the activation energy barrier as well as achieve a reasonable yield per cycle through the reaction vessel.

• *Catalyst:* magnetite (Fe3O4) fused with K2O, Al2O3 and CaO (the magnetite is then reduced to porous iron). It is essential that the iron
catalyst be ground to a fine powder to expose a high surface area for the gases to adsorb onto its surface.

Judgement:

Development of this process to an industrial scale had a huge impact on world history, since it undoubtedly enabled Germany to maintain its war effort for longer than it otherwise would have. It also contributed to understanding of equilibrium reactions and the industrial monitoring needed to produce the greatest amount of yield.

24.a.

Marking Guidelines	Marks
• Correctly writes nuclear equation for the decay	**1**

$$^{125}_{53}I \rightarrow \, ^{125}_{54}Xe + \, ^{0}_{-1}e$$

24.b.

Marking Guidelines	Marks
• Describes both processes to produce a transuranic element AND • Correctly writes nuclear equations	**3**
• Describes both processes to produce a transuranic OR • Describes a process to produce a transuranic element AND Correctly writes nuclear equations	**2**
• Identifies one correct statement about the production of transuranic elements. OR • Names a transuranic element produced commercially	**1**

Elements heavier than uranium (92) are called transuranic elements. They can be synthesised in either a nuclear reactor or an accelerator.

An accelerator allows particles to be accelerated at high speed and fired at nuclei of atoms with controlled energies. A nuclear reactor is a device that allows a uranium chain reaction to occur safely, releasing neutrons at a slow and controlled rate. A target is bombarded with neutrons to produce a radioactive speciecs

.

For example, the equations for the production of technetium-99 are given below. Molybdenum-98 undergoes neutron bombardment to form molybdenum-99, which then undergoes beta decay to form technetium-99.

$$^{98}_{42}\text{Mo} + ^{1}_{0}\text{n} \rightarrow ^{99}_{42}\text{Mo}$$

$$^{99}_{42}\text{Mo} \rightarrow ^{99}_{43}\text{Tc} + ^{0}_{-1}\text{e}$$

24.c.

Marking Guidelines	Marks
• Identifies an instrument used to detect radiation	**1**

Photographic film, Thermoluminescent dosimeters (TLDs), Geiger-Muller (GM) probe and counter and Cloud Chamber are all accepted.

NOYES

25.a.

Marking Guidelines	Marks
• Writes the correct net ionic equation for barium ions + sulfate ions.	**1**

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

25.b.

Marking Guidelines	Marks
• Correctly calculates the percentage of sulfate in the lawnfood.	**2**
• Calculation of percentage sulfate contains one error.	**1**
• Calculates moles of precipitate (based on their identification of the precipitate in 25a).	**0.5**

Mass lawn food = 1.03 g.
Mass of precipitate ($BaSO_4$) = 1.80 g.
Moles of $BaSO_4$ = 1.80/233.37 = 7.71 x10^{-3}
Moles of sulfate = 7.71 x10^{-3}
Mass of sulfate = 7.71 x10^{-3} x 96.07 = 0.74099
Percentage sulfate = 0.74099/1.03 x 100 = 71.9 %.

25.c.

Marking Guidelines	Marks
• Explains both washing and drying.	**2**
• Explains either washing or drying OR • Brief description of both	**1**

This is a gravimetric analysis and requires accuracy. If you weigh the filter paper while it is still wet the result will be inaccurate because the mass of the precipitate will be inflated. Therefor it is essential to make sure that all the filter paper and precipitate are 100% dry. You must also wash the solution thoroughly to ensure that all the precipitate goes through to be collected, otherwise the recorded mass will not have all the precipitate recorded.

26.a.

Marking Guidelines	Marks
• Correctly describes tests to determine whether a solution was a strong or weak acid using the indicators listed • Justifies the choice • Identifies the pH range of the substance.	**3**
• As above with one omission or error.	**2**
• Identifies one correct choice of indicator. OR • Describes a test	**1**

The student could use bromothymol blue and methyl orange to determine whether substance was a weak acid. Bromothymol blue turns yellow if pH < 6. Methyl orange turns yellow if pH > 4.4. Hence the substance will be in the weak acid range (6>pH>4.4).
They could use methyl orange to test for a strong acid. If colour is red then the pH < 3.1.

26.b.

Marking Guidelines	Marks
• Correctly calculates the pH of the resulting solution with working.	**3**
• Correct calculation with working but not 2 dp.	**2.5**
• As above with one error or omission.	**2**
• Correctly calculates moles of H^+ and OH^-.	**1**

$n(H^+) = 0.25 \times 0.05 = 0.0125$
$n(OH^-) = 0.3 \times 0.025 = 0.0075$

H^+ is in excess by $0.0125 - 0.0075 = 0.005$mol
$C(H^+) = 0.005/0.075 = 0.0667$ $molL^{-1}$

$pH = -\log(0.0667) = 1.17$

27.

Marking Guidelines	Marks
• Thoroughly explains why acidic oxides in the atmosphere are of concern to society and the environment • correct, relevant chemical equations • Identifies sulphur and nitrogen oxides as acidic gases. • Identifies the major reasons for concern i.e. acid rain AND photochemical smog formation. • Explains why acid rain and photochemical smog are of concern to society AND the environment.	**5**
• As above with one error or omission.	**4**
• Identifies sulphur and nitrogen oxides as acidic gases. • Identifies a major reason for concern i.e. acid rain OR photochemical smog formation. • Explains why acid rain OR photochemical smog are of concern to society AND the environment. OR • Identifies sulphur and nitrogen oxides as acidic gases. • Identifies the major reasons for concern i.e. acid rain AND photochemical smog formation. • Briefly explains why acid rain AND photochemical smog are of concern to society OR the environment.	**3**
• Identifies sulphur and nitrogen oxides as acidic gases. • Identifies the major reasons for concern i.e. acid rain OR photochemical smog formation. • Outlines why acid rain OR photochemical smog are of concern to society OR the environment.	**2**
• Identifies one correct statement regarding the cause for concern to society and the environment of acidic gases in the atmosphere.	**1**

Acidic gases such as SO_2 and oxides of nitrogen in the atmosphere are a major cause for concern as they contribute to the formation of acid rain and photochemical smog.

The formation of acid rain by the reaction of sulphur dioxide and nitrogen dioxide with rain water - $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$ - causes damage to buildings and statues. As a consequence, there would be significant costs to society in maintaining these structures. In some cases, acid rain can cause the leaching of aluminium from soils into rivers and cause death to aquatic life and health problems for people living in the area. Acid rain can cause damage to forests, killing leaves and thereby interfering with photosynthesis.

Oxides of nitrogen can lead to the formation of photochemical smog due to their reaction with atmospheric oxygen in the presence of UV light. This causes a high social cost as it reduces a citizen's standard of living, not just because it looks aesthetically unappealing but also because it exacerbates many respiratory complaints such as asthma. Nitrogen oxides can also suppress plant growth.

28.a.

Marking Guidelines	Marks
• Writes a correct chemical equation for the reaction that took place when the acid was added to the crushed sea shell.	1

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

28.b.

Marking Guidelines	Marks
• Correctly calculates the number of moles of NaOH that were used in the titration.	1

n(NaOH) = C x V = 2.2 x 0.0463 = 0.10186 = 0.102

28.c.

Marking Guidelines	Marks
• Correctly determines the number of moles of acid that reacted with the sea shell.	1

$n(HCl)_{unreacted}$ = 0.10186
$n(HCl)_{initial}$ = C x V = 5 x 0.025 = 0.125
$n(HCl)_{reacted}$ = 0.125 – 0.10186 = 0.0231

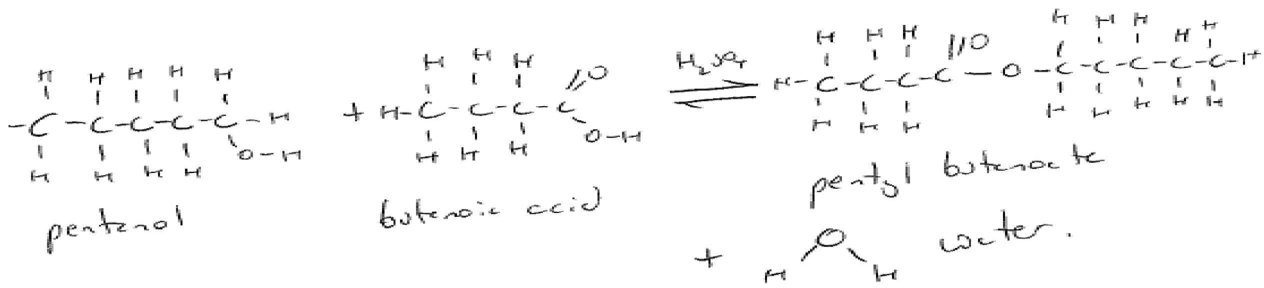
28.d.

Marking Guidelines	Marks
• Correctly calculates the percentage calcium carbonate in the shells.	3
• Correctly calculates the percentage calcium carbonate in the shell with one error or omission.	2
• Correctly calculates one step to determine the percentage of calcium carbonate in the sea shells.	1

$n(CaCO_3) = 0.02314/2 = 0.01157$
$m(CaCO_3) = 0.01157 \times 100.09 = 1.158\ldots g$
$\%CaCO_3 = 1.158\ldots/2.65 \times 100 = 43.7\%$

29.a.

Marking Guidelines	Marks
• Writes correct structural equation, • Names each species • Reaction is in equilibrium	**3**
• Writes a structural equation for the reaction with not all species correct AND • Names each species OR • Reaction is in equilibrium	**2**
• Writes a structural equation for the reaction with not all species correct OR • Names each species OR • Reaction is in equilibrium	**1**



29.b.

Marking Guidelines	Marks
• Explains refluxing.	**2**
• Identifies refluxing OR • Gives a reason for refluxing	**1**

The apparatus is called refluxing. Heating is necessary because the reactants and products are volatile. By cooling in a water cooled condenser it ensures that the reactants are returned to the reaction flask & enables the reaction to proceed. Refluxing also gives this reaction more time to proceed as it is a slow reaction.

FAULDER

30.a

Marking Guidelines	Marks
• Calculates grams which match volumetric flask (either NaOH or primary) • Describes the method (for either NaOH or Primary) • Correct rinsing (NaOH or primary) • Fills to calibration mark (NaOH or Primary)	**4**
• Calculates grams **AND** • Describes the method **OR** • Correct rinsing **OR** • Fills to calibration mark	**2-3**
• Identifies volumetric flask **OR** • Calculates moles **OR** • Identifies one part of method	**1**

1. A 250 mL volumetric flask was used which was rinsed with distilled water..

2.Calculate the number of grams of NaOH needed.

n NaOH = M x V(L) = 0.112 x 0.25 = 0.028

g = n x MM = 0.028 x (22.99 + 16 + 1.008) = 0.028 x 39.998 = 1.12 g

3. Weigh out 1.12g of NaOH into a clean beaker.
4. Dissolve in distilled water and decant in to the 250mL volumetric flask, rinsing thoroughly.
5. Fill to the calibration mark, stopper and invert.

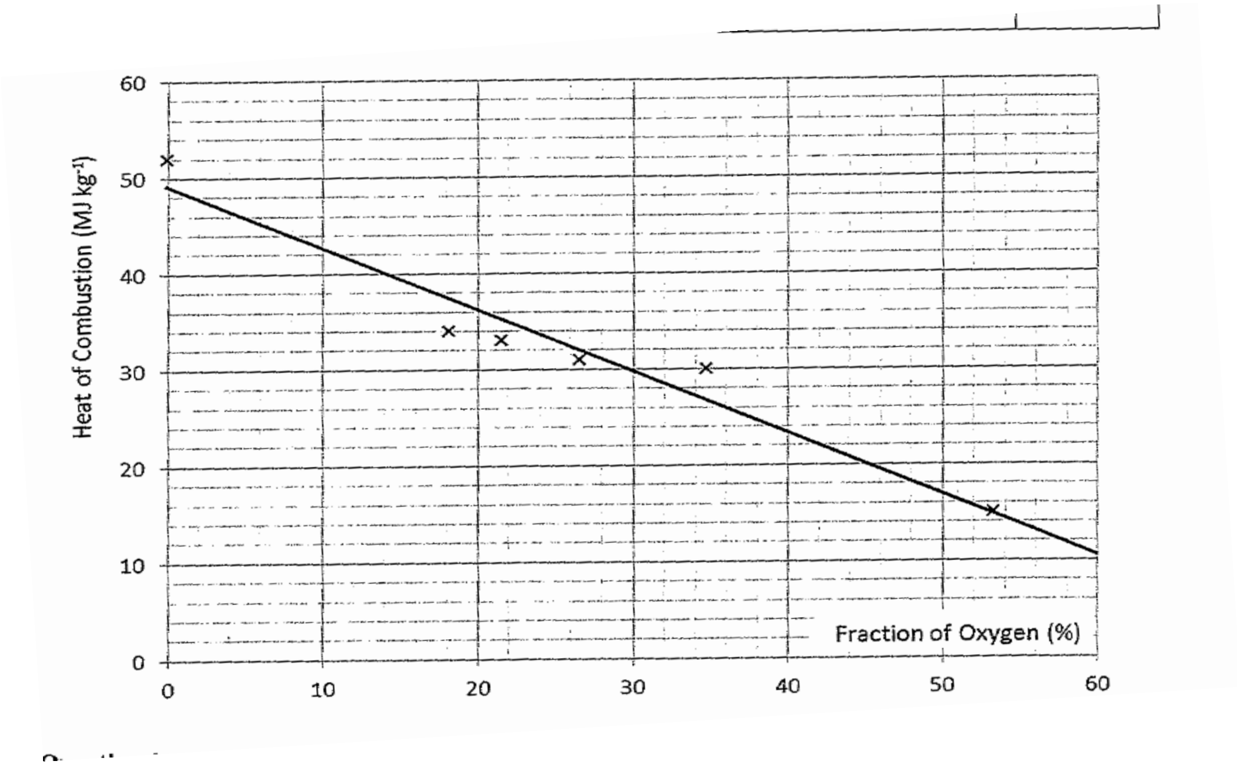
30.b

Marking Guidelines	Marks
• Calculates moles of NaOH/acetic acid AND • Calculates the correct concentration of the acetic acid	**2**
• Calculates a moles or NaOH/acetic acid OR • Calculates correct concentration by using C1V1 = C2V2	**1**

Acetic acid = CH_3COOH
Concentration of CH_3COOH = 23.6 x 0.112 / 25.0 = 0.106 M

31.a

Marking Guidelines	Marks
• Plots the data accurately, using suitable scales, visible data points AND line of best fit	**2**
• Plots the data accurately OR • using suitable scales OR • visible data points AND line of best fit	**1**



31.b

Marking Guidelines	Marks
• Calculates the % oxygen AND obtains heat of combustion from graph	**2**
• Calculates the % oxygen OR • obtains heat of combustion from graph	**1**

Ethyl acetate has the formula $C_4H_8O_2$

Oxygen fraction = 2 x 16 /(4 x 12 + 8 x 1.008 + 2 x 16) =32/88.08 = 36.3%

Estimated heat of combustion from graph = 26 MJ kg $^{-1}$

32.a

Marking Guidelines	Marks
• Identifies two relevant polymers and gives uses in terms of properties	**2**
• Identifies two relevant polymers **OR** • Identifies one relevant polymer and gives use or property	**1**

Styrene can be used to make polystyrene (PS). PS is a thermoplastic, which means it is stable to heat and can be melted and cast into a new shape. This process (called injection moulding) is very cheap and therefore PS is used to make many disposable objects, such as packaging materials.
Vinyl chloride is used to make polyvinyl chloride (PVC). The main use of PVC is in the production of pipes for water or sewage. PVC does not react with water, the pipes made of PVC are very light and easy to handle, and PVC pipes can be easily glued together to give water tight seals, making PVC an ideal material from which to make water or sewage pipes.

32.b

Marking Guidelines	Marks
• Gives a discussion containing at least three relevant points and has a judgement	**3**
• Gives a discussion containing three relevant points OR • Two points and judgement	**2**
• Mentions two relevant points OR • One point and judgement	**1**

Monomers such as ethylene, vinyl chloride and styrene are produced in the petrochemical industry from crude oil. Crude oil is a fossil fuel and this finite resource will eventually run out as it is non-renewable. The price of crude oil is increasing as crude oil becomes scarce and so the price of these polymers will also increase. Also plastics derived from these monomers currently produced by the petrochemical industry are not biodegradable and are polluting the environment. Therefore, renewable and biodegradable sources, such as cellulose, need to be developed to replace monomers that currently come from fossil fuel resources.

OPTION

Question 33 – Industrial Chemistry

32.a

Marking Guidelines	Marks
• Identifies a resource and describes the issues associated and suggests a suitable replacement material	**3**
• Identifies a resource and describes one issue OR suggests a suitable replacement	**2**
• Identifies a resource OR identifies an issue OR suggests a suitable replacement	**1**

One natural product is guano, a natural nitrogen/phosphate fertiliser derived from bird droppings. The natural deposits in Peru and Nauru have rapidly been depleted by the intensive farming techniques used around the world. Synthetic replacements therefore became essential to meet the growing demand for food supplies. One synthetic replacement is superphosphate produced from crushed phosphate rocks treated with sulphuric acid.

b.i.

Marking Guidelines	Marks
• Writes the correct expression for K, correctly calculates its value and correctly deduces direction of shift.	**3**
• Writes the correct expression for K and correctly calculates its value OR • Writes the incorrect expression for K but calculates the value and deduces direction of shift	**2**
• The response contains one correct step or substitution.	**1**

Volume of system is 5L but concentration is L therefore:
$[H_2] = 0.75/5 = 0.15$
$[CO] = 0.75/5 = 0.15$
$[CH_4] = 2.00/5 = 0.4$
$[H_2O] = 1.25/5 = 0.25$

$$Q = \frac{[CO][H_2]^3}{[CH_4][H_2O]}$$
$$= \frac{0.15 \times 0.15}{0.4 \times 0.25}$$
$$= \frac{0.00050625}{0.1}$$
$$= 5.06 \times 10\text{-}3$$

Q < K therefore the system is shifting to the right

b.ii

Marking Guidelines	Marks
• Explains thoroughly all the conditions	**3**
• Explains most or only describes the conditions	**2**
• Identifies one condition	**1**

Conditions in the reaction can be adjusted using Le Chatelier's Principle.
The forward reaction is endothermic so increasing the temperature will increase the products as it will shift to the right to decrease temperature.
Reducing pressure will also increase products. There are less moles of reactants than products so it will shift to increase pressure by creating more moles ie products.
Removing either the products (CO or H_2) will cause a shift to replace products or increasing concentration of reactants (CH_4 or H_2O) will also cause a shift to produce more products.

c.

Marking Guidelines	Marks
Thoroughly • Identifies and describes at least three uses AND • Identifies and explains monitoring of all reaction conditions used in the formation of sulfuric acid from SO_2 AND • Identifies and describes hazards associated with transport AND • Includes at least two equations AND • Gives a judgement	**6**
• Identifies and describes some uses AND • Identifies and explains monitoring of some of the reaction conditions used in the formation of sulfuric acid from SO_2 AND • Identifies and describes hazards associated with transport AND • Includes at least two equations AND • Gives a judgement	**5**
• Identifies and describes some uses AND • Identifies and explains monitoring of some of the reaction conditions used in the formation of sulfuric acid from SO_2 AND • Identifies and describes hazards associated with transport AND • Includes at least two equations OR • Includes one equation and gives a judgement	**4**
• Identifies and describes some uses AND • Identifies and explains monitoring of some of the reaction conditions used in the formation of sulfuric acid from SO_2 OR • Identifies and describes hazards associated with transport AND • Includes one equation OR • Gives a judgement	**3**
• Identifies a use AND • Identifies most reaction conditions used to produce sulfuric acid OR identifies hazards	**2**
• Identifies one use OR identifies one reaction condition used in the production of sulfuric acid OR identifies one hazard	**1**

Sulfuric acid has many important uses such as

- Manufacture of fertilisers – allows intensive farming techniques to be used to meet food supply demands
- The electrolyte in lead-acid batteries which are used extensively for transport
- Dehydrating agent in industrial processes such as producing ethene from ethanol
- Cleaning iron and steel before galvanising

The conditions for the production of sulfuric acid needs to be monitored. Converting SO_2 into SO_3 is an equilibrium reaction that is carried out in excess O_2.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

This is an exothermic reaction so temperature has to be controlled. According to LCP it favours low temperatures but the reaction rate would be too slow, so initial temperatures of around 550° C are used. The reactants are then passed over more catalyst beds each of successively lower temperatures to increase the yield. At each stage the temperature has to be monitored to prevent it rising from the heat liberated.
The amount of SO_2 liberated to the atmosphere also has to be monitored to ensure it remains within environmental guidelines.
The SO_3 is then bubbled into conc sulfuric acid to form oleum

$$SO_{3(g)} + H_2SO_{4(l)} \longrightarrow H_2S_2O_{7(l)}$$

which can then be diluted with H_2O

$$H_2S_2O_{7(l)} + H_2O_{(l)} \longrightarrow 2H_2SO_{4(l)}$$

This must be carefully monitored so that excess water is not added to ensure that only molecular H_2SO_4 is present
Once made there are hazards involved in the transport of conc sulfuric acid. As it is molecular it can be transported in steel containers but it cannot come in contact with water.
The ionisation of H_2SO_4 is exothermic, releasing lots of heat energy.

$$H_2SO_{4\,(l)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)} + HSO_4^-{}_{(aq)}$$

As an acid it is very corrosive and will then readily attack the steel container. Also conc H_2SO_4 is a dehydrating agent and will readily attack carbohydrates and other organic substances such as living tissue.

$$C_{12}H_{22}O_{11(s)} \longrightarrow 12C_{(s)} + 11H_2O_{(g)}$$

Even though the manufacture of H_2SO_4 must be monitored and care must be taken to address the hazards involved with its transport, sulfuric acid has many uses and therefore is one of the most important industrial chemicals in use today.