Student Number _____

| A-MC | B-FAU | B-ENG | B-NOY | B-HAY | C-CAR | TOTAL |
|---|---|---|---|---|---|---|
| /20 | /19 | /10 | /20 | /16 | /15 | /100 |
| | | | | | | |

**Student Name**

**Teacher** _____

**Sydney Technical High School**

# 2012

**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 35 minutes for this part

Part B – 65 marks
- Attempt Questions 21-34
- Allow about 1 hour and 40 minutes for this part

**Section II** Pages 29 -30

**15 marks**
- Attempt Questions 35
- Allow about 45 minutes for this section

## Section I
## 85 marks

## Part A – 20 marks
## Attempt Questions 1-20
## Allow about 35 minutes for this part

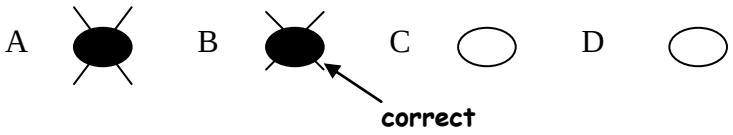
Use the multiple-choice answer sheet.

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 _____

# 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 ◯ | D ◯ |

Student Number _____

**1.** Which of the following pairs of reactants could undergo an addition reaction to produce 2-bromobutane?

(A) bromine and 2-butene

(B) bromine and butane

(C) hydrogen bromide and 2-butene

(D) hydrogen bromide and butane

**2.** What is the molecular formula of the *monomer* used in the production of polystyrene?

(A) $C_2H_4$

(B) $C_2H_3Cl$

(C) $C_6H_{12}O_6$

(D) $C_8H_8$

**3.** Four chemical reactions are shown below:

I $MgO + 2HCl \rightarrow MgCl_2 + H_2O$

II $Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$

III $CuCO_3 \rightarrow CuO + CO_2$

IV $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Which of the reactions are redox reactions?

(A) II only

(B) II and IV

(C) I and II

(D) III and IV

**4.** What is the maximum mass of ethanol that can be produced by the fermentation of 0.75 kg of glucose?

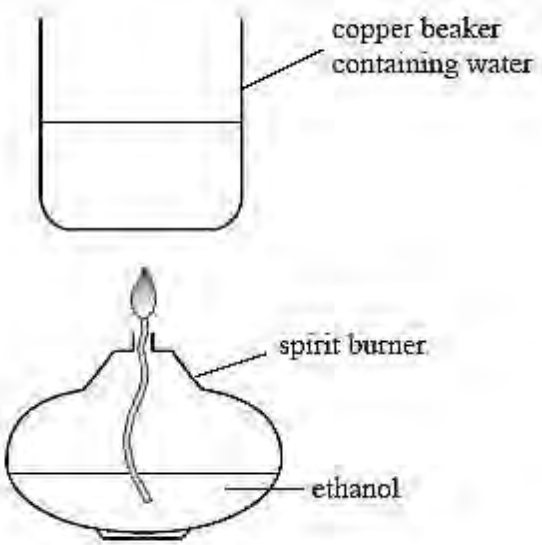
(A) 192 g

(B) 384 g

(C) 575 g

(D) 750 g

**5.** A student set up the following apparatus to compare the heat of combustion of methanol, ethanol and 1-propanol.




Which one of the following variables, if not controlled carefully, would have the greatest effect on the validity of the procedure?

(A) The distance between the flame and the can.

(B) The temperature to which the water is heated.

(C) The volume of water heated.

(D) The initial temperature of the water.

**6.** Which of the following lists contains only devices that can be used to detect *radiation*?

(A) Smoke detector, photographic film, Geiger counter, particle accelerator

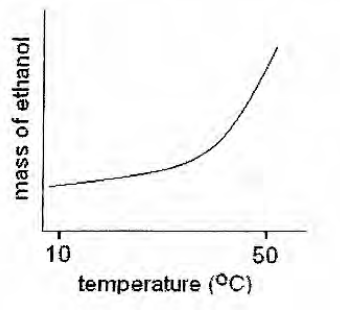
(B) Thickness gauge, cloud chamber, photographic film, smoke detector

(C) Thickness gauge, scintillation counter, Geiger counter, particle accelerator

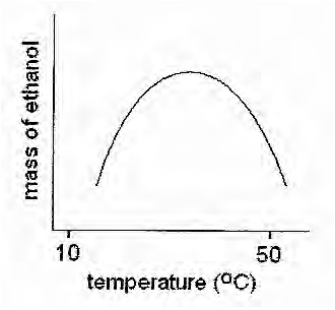
(D) Cloud chamber, scintillation counter, photographic film, Geiger counter

**7.** Which of the following graphs represents the mass of ethanol produced when a constant mass of glucose is fermented, for a fixed time interval at different temperatures?

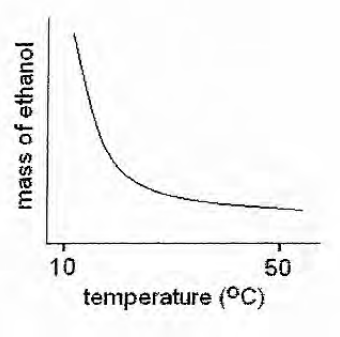
(A)



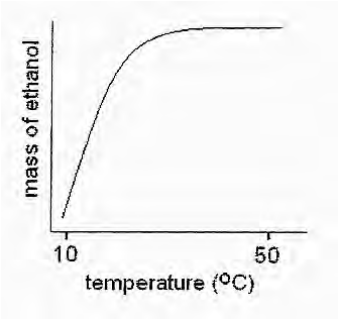

(B)




(C)




(D)




**8.** This question refers to the following substances:

i. $H_2CO_3$
ii. $NH_4Cl$
iii. $NaCH_3COO$
iv. $CH_3COOH$

Solutions of which of the substances listed would turn blue litmus red?

(A) (i) only

(B) (i) and (iv)

(C) (i), (ii) and (iv)

(D) (i), (iii) and (iv)

**9.** The following acid-base indicators change colour depending on pH as shown in the following table.

| pH / Indicator | 2 | 4 | 6 | 8 | 10 | 12 | 14 |
|---|---|---|---|---|---|---|---|
| **Methyl orange** | red | Yellow | | | | | |
| **Bromothymol blue** | Yellow | | | Blue | | | |

What colour will the following indicators be if a few drops are added to 0.1 M hydrochloric acid, and to 0.1 M acetic (ethanoic) acid ($CH_3COOH$)?

| | **Methyl orange** | | **Bromothymol blue** | |
|---|---|---|---|---|
| | **HCl** | **$CH_3COOH$** | **HCl** | **$CH_3COOH$** |
| (A) | Red | Red | Yellow | Yellow |
| (B) | Red | Yellow | Yellow | Yellow |
| (C) | Yellow | Yellow | Blue | Blue |
| (D) | Red | Yellow | Blue | Blue |

**10.** A solution of a strong acid has a pH of 3.2. A student dilutes 10 mL of the solution to 1000 mL. What is the final pH?

(A) 3.2

(B) 4.2

(C) 5.2

(D) 6.2

**11.** Solution *X* contains a monoprotic acid and its pH is 1.50. Solution *Y* contains a monoprotic acid and its pH is 4.5. Equal volumes of Solution *X* and Solution *Y* each neutralise 25.00 mL of 0.100 M HCl.

It can be correctly concluded that

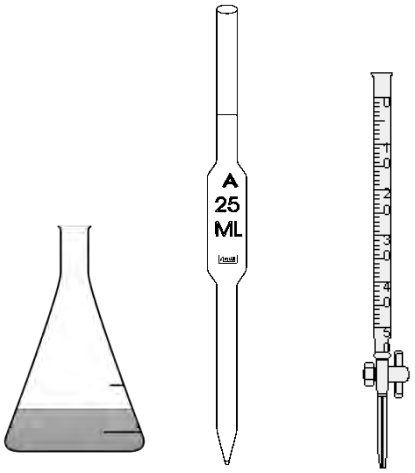
(A) Solution *Y* contains a weak acid.4.2

(B) Solution *X* contains a strong acid.

(C) Solution *Y* is three times as acidic as Solution *X*.

(D) Solution *X* is less concentrated than Solution *Y*.

**12.** Which of the following pieces of equipment may have water left in it before it is used?




X Y Z

(A) Y only

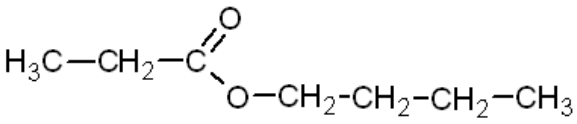
(B) X and Y

(C) X only

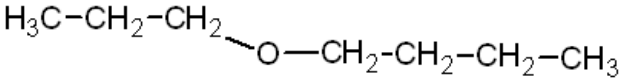
(D) Y and Z

**13.** A student mixes 1-butanol with propanoic acid in an esterification reaction.

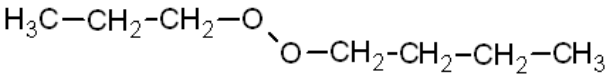
Which of the following shows the structure of the organic product?



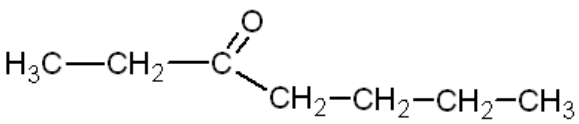
(A)



(B)



(C)



(D)

**14.** Which combination of solutes forms a buffer solution in water?

(A) Nitric acid and potassium nitrate

(B) Citric acid and potassium citrate

(C) Hydrochloric acid and sodium hydroxide

(D) Ammonia and potassium nitrate

**15.** Which of the following is ***not*** a use of ammonia?

(A) manufacture of explosives

(B) manufacture of detergents

(C) manufacture of fertilisers

(D) manufacture of paper

**16.** A student wants to determine the sulfate content of a fertilizer.

Following a typical procedure, they obtain the results shown below.

| | |
|---|---|
| Mass of fertilizer used (g) | 2.34 |
| Mass of fertilizer that did not dissolve (g) | 0.18 |
| Volume of saturated $BaCl_2$(aq) added (mL) | 50 |
| Mass of glass filter (g) | 19.5 |
| Mass of glass filter with dry $BaSO_4$ (g) | 21.6 |

What is the sulfate content of the fertilizer?

(A) 40%

(B) 50%

(C) 75%

(D) 90%

**17.** The molecules $O_2$ and $O_3$ are:

(A) diatomic

(B) compounds

(C) isotopes

(D) allotropes

**18.** Identify the main source of the pollutant *carbon monoxide*, in the lower atmosphere.

(A) Burning of fossils fuels

(B) Anaerobic decomposition of organic matter

(C) Smelting of metal ores

(D) Deforestation

**19.** A solid sample was known to contain two calcium salts. In order to determine the anions present, some tests were done on the solid, producing the following results.

| Test done | Results obtained |
|---|---|
| Observation of colour | White |
| Addition of water to solid | Solid partially dissolved |
| Addition of barium chloride to solution | No precipitate |
| Addition of silver nitrate to solution | White precipitate |
| Addition of HCl(aq) to solid | Gas bubbles observed |

Which two ions were present in the sample?

(A) $PO_4^{3-}$ and $SO_4^{2-}$

(B) $Cl^-$ and $SO_4^{2-}$

(C) $CO_3^{2-}$ and $Cl^-$

(D) $CO_3^{2-}$ and $PO_4^{2-}$

**20.** In which layer of the earth's atmosphere do oxides of sulfur occur naturally?

(A) troposphere

(B) stratosphere

(C) mesophere

(D) ionosphere

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Student Number _____

| FAULDER | /19 |
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## Section I (continued)

## Part B – 65 marks
## Attempt Questions 21 - 29
## Allow about 1 hour and 40 minutes for this part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

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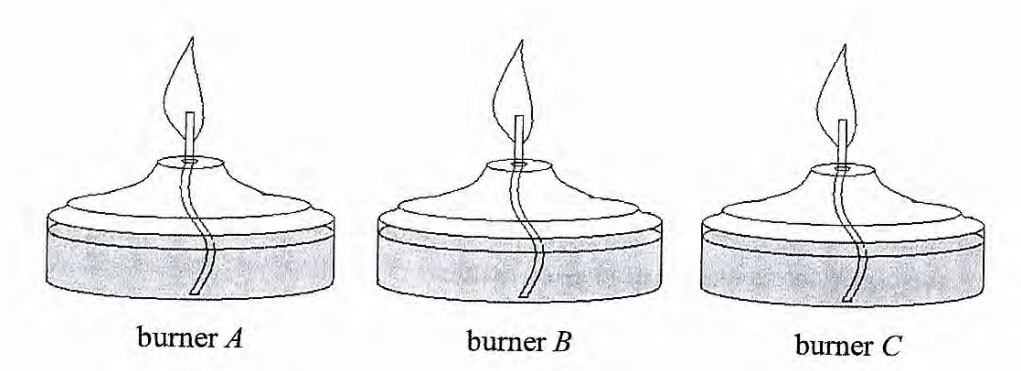
**Question 21** (6 marks) **Marks**

Three different fuels, butan-1-ol, ethanol and octan-1-ol , were burned in three separate identical spirit burners.




The fuel burned in burner B produced a bright yellow, very smoky flame, while the fuels in burners A and C produced pale blue flames with little smoke.

(a) Identify the fuel burned in burner B and account for the smoky appearance of the flame, in terms of the combustion products. **3**

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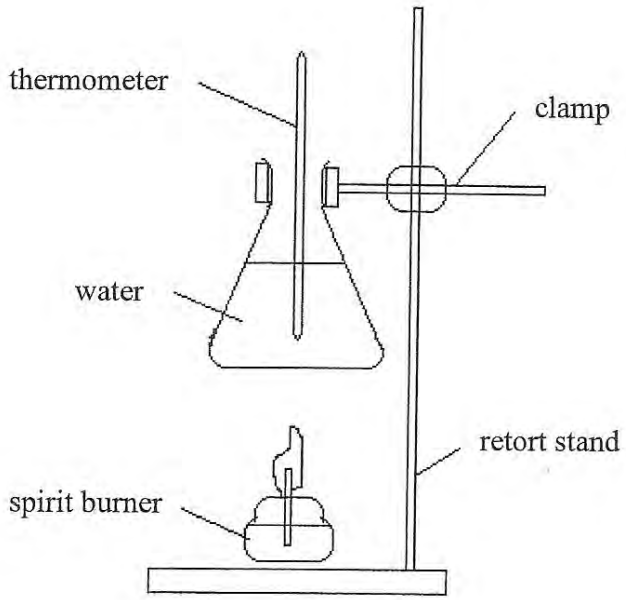
**Question 21 continues on page 14.**

Question 21 (continued) **Marks**

(b) Burners A and C were each used to heat water in identical experimental apparatus, as shown below.




Measurements recorded during the experiment are shown in the following table.

| Burner | Mass of water heated (g) | Initial temperature of water (°C) | Final temperature of water (°C) | Initial mass of burner (g) | Final mass of burner (g) |
|---|---|---|---|---|---|
| A | 200 | 20.0 | 30.0 | 275.48 | 274.83 |
| B | 200 | 20.0 | 30.0 | 287.61 | 286.51 |

Compare the heat of combustion (per gram) for these two fuels and use this information to identify the fuel in burner A **3**

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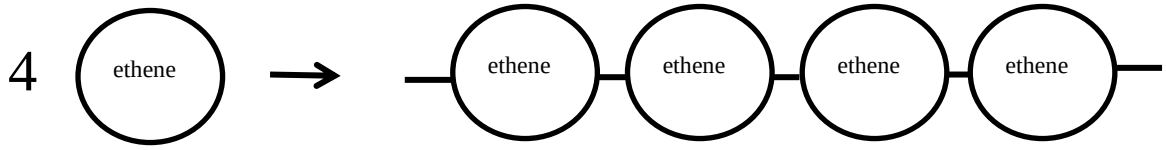
Student Number _____

**Question 22** (3 marks) **Marks**

The following model was used by a chemistry student to demonstrate their understanding of the reaction to form a short segment of polyethene, and the composition of polyethene.




With reference to the model only, assess the student's understanding of polyethene and the reaction that forms it. **3**

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**Question 23** (2 marks)

Radioisotopes are used in medicine. **2**

Describe the way a named radioisotope is used in medicine.

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Student Number _____

**Marks**

**4**

**Question 24** (4 marks)

Discuss the production and use of a named biopolymer (other than cellulose) and the need for the further development of biopolymers.

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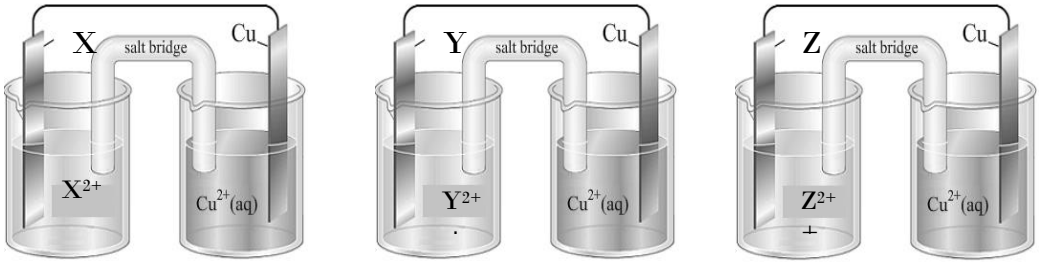
Student Number _____

**Question 25** (4 marks)

**Marks**

Half-cells made from three metals (X, Y and Z) and their solutions were coupled with a copper half-cell under standard conditions, as shown in the diagram below.




The voltage produced and the polarity of the copper electrode, were recorded in a table below.

| **Metal** | **Cell voltage produced by coupling metal half- cell with Cu half-cell** | **Polarity of Copper** |
|---|---|---|
| X | 0.31 | +ve |
| Y | 1.14 | -ve |
| Z | 0.42 | -ve |

(a) Outline the function of the salt bridge in the cells above. **1**

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(b) Using the data provided, rank the metals (X, Y, Z and Cu), in increasing order of reactivity.
Explain how you arrived at your answer. **3**

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Student Number _____

| ENGEL | /10 |
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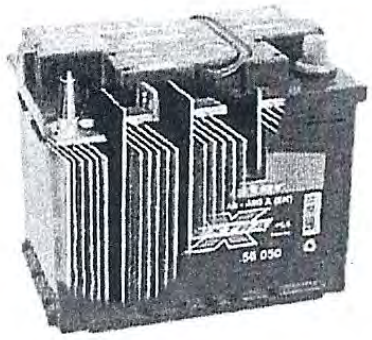
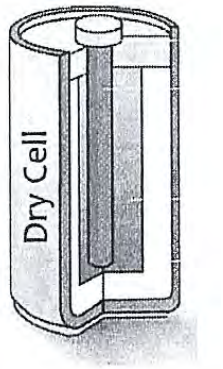
**Question 26** (4 marks)

**Marks**

The images below show two types of common battery cells. **4**






Describe the structure and chemistry of *either* cell.

Include chemical equations in your answer.

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Student Number _____

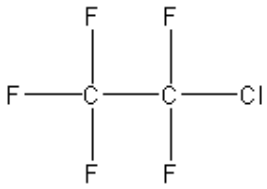
**Marks**

**Question 27** (6 marks)

Relatively recent human activity has reduced the concentration of ozone in the upper atmosphere, with serious consequences.

(a) The molecules responsible for ozone depletion are CFCs.

(i) Give the systematic name of the compound below. **1**

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(ii) Describe how a compound such as that shown in part (i) can destroy ozone. Support your answer with chemical equations. **3**

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(b) Outline the consequences of ozone depletion in the upper atmosphere. **2**

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Student Number _____

NOYES / 20

**Question 28** (4 marks)

*A can of soda water contains carbon dioxide dissolved under pressure, forming carbonic acid.* **Marks**

(a) With the aid of a chemical equation, explain why carbonic acid is described as a weak acid. **2**

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(b) Using Le Chatelier's Principle, justify the change in pH of the contents, after a can of soda water is opened.

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**Question 29** (10 marks)

A student used temperature change during neutralization to calculate the concentration of hydrochloric acid. The method they used was: **Marks**

1. 1L of 0.145 M NaOH and 1L of HCl were allowed to sit at room temperature for 60 minutes.
2. 25.0 mL of 0.145 M NaOH was added to a polystyrene cup using a volumetric pipette.
3. The temperature of the NaOH(aq) was measured using a thermometer.
4. 10.0 mL of HCl was added to the cup using a volumetric pipette.
5. The highest temperature reached was measured.
6. Steps 1 – 4 were repeated with 20, 30, 40, 50 and 60 mL of HCl.

The results they obtained are shown in the table below.

**V (HCl) added vs temp. when neutralizing 0.145 M NaOH.**

| Volume of HCl added (mL) | Max. temperature reached ($^{o}$C) |
|---|---|
| 0 | 21.0 |
| 10 | 28.0 |
| 20 | 35.0 |
| 30 | 35.0 |
| 40 | 32.5 |
| 50 | 30.0 |
| 60 | 27.5 |

**2**

(a) Use the grid below to graph the data above.


**3**

(b) Draw two straight lines through the points and extend them until they cross. **1**

**Question 29 continues on page 23.**

Question 29 (continued)

(c) What volume of HCl was required to completely neutralize the NaOH? On your graph, show how you obtained this value. **Marks**

..... **1**

(d) Calculate the concentration of the HCl.

..... **2**

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(e) The NaOH was standardised using a 0.1 M oxalic acid primary standard.

Outline how the 0.1 M oxalic acid ($H_2C_2O_4$) standard solution was prepared. **3**

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Student Number _____

**Question 30** (6 marks)

An ester can be prepared by using 1-propanol and penatanoic acid. **Marks**

(a) Identify a use for esters. **1**

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(b) Write a structural equation for the formation of this ester. **2**

(c) Outline with the aid of a diagram how this ester could be prepared in the school laboratory. **3**

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Student Number _____

HAYES /16

**Question 31** (4 marks)

Hydrogen sulfide gas is extremely flammable, has an unpleasant smell similar to rotten eggs and is toxic. **Mark**

Hydrogen sulfide gas is formed when hydrochloric acid reacts with sodium sulfide. In anexperiment, 0.15 g of sodium sulfide was added to 25.0 mL of 0.10 M HCl.

Calculate the maximum volume of hydrogen sulfide gas that could be produced by this reaction at 25° C and 100 kPa?

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**4**

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**Question 32** (1 mark)

Identify the bonding within ozone, using a Lewis electron-dot diagram.

**1**

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**Question 33** (6 marks)

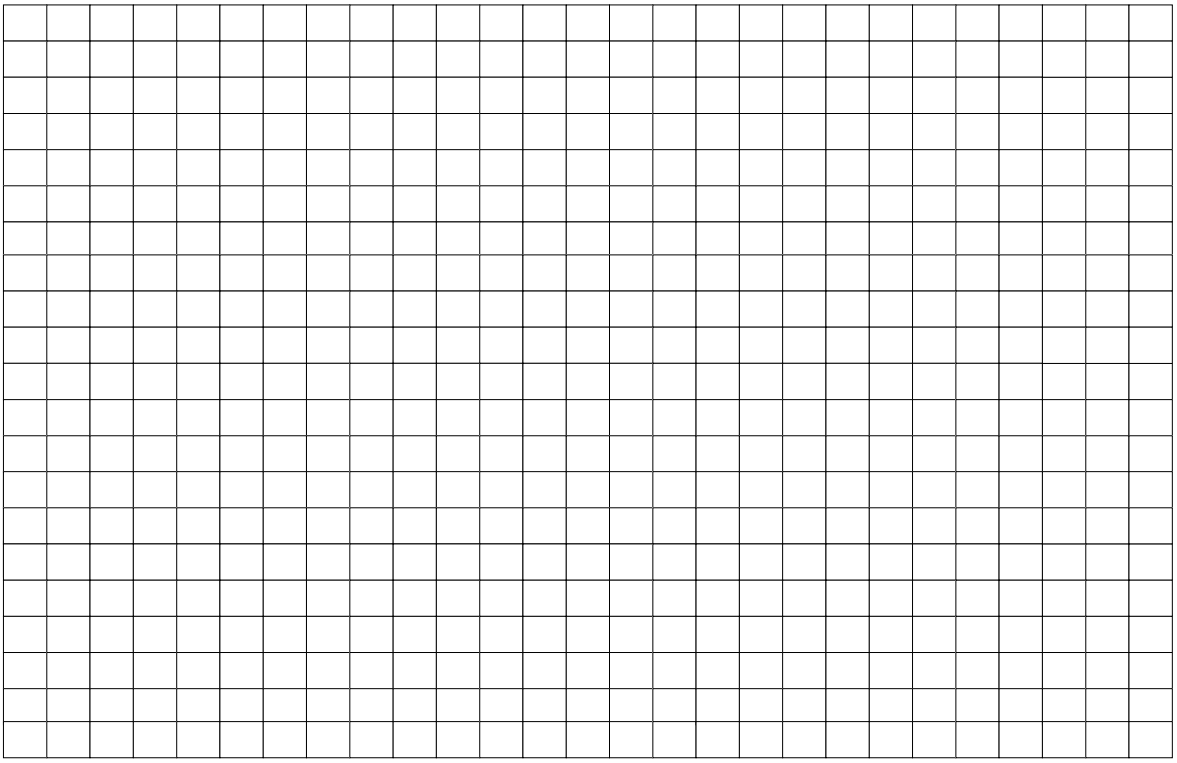
**Mark**

A student gathered the following data about the Haber process, from secondary sources.

| **Pressure (MPa)** | 0 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|
| **% Yield of ammonia at 400°C** | 0 | 17 | 34 | 48 | 64 | 79 |
| **% Yield of ammonia at 550°C** | 0 | 4 | 10 | 14 | 19 | 24 |

(a) Graph *the yield* (vs. pressure) for each temperature.

**3**



(b) By referring to the graphs, and including a reaction equation, explain the effects of temperature and pressure on the yield of ammonia. **3**

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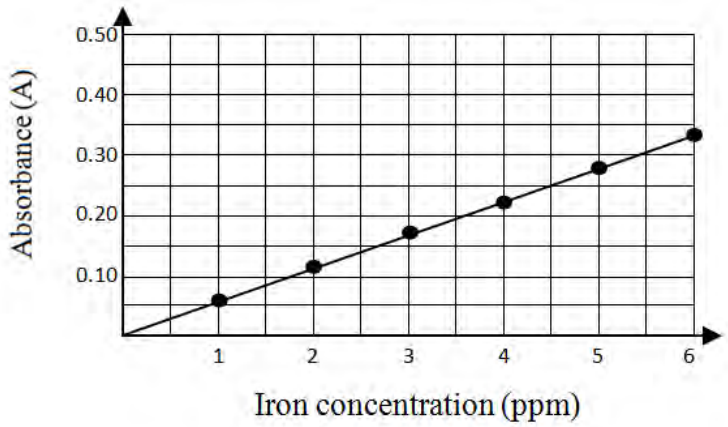
Student Number _____

**Question 34**. (5 marks)

Atomic absorption spectroscopy (AAS) is widely used by analytical chemists to detect and measure the concentration of metal ions in solution. The level of iron in a sample of mineral water was analysed using AAS. The calibration graph shown below was used to determine the concentration of iron in the sample. **Mark**




(i) The absorbance (A) of the mineral water sample was 0.25
Use the graph determine the concentration of iron in the mineral water.

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. **1**

(ii) Calculate the mass of iron that would be present in 600mL of the mineral water.

..... **2**

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(iii) Outline how the chemist would have obtained the calibration graph before testing the sample of mineral water.

**2**

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Student Number _____

**Section II**
**Total marks: 15**
**Attempt \Questions 35**
**Allow about 45 minutes for this Section.**

**Answer the OPTION question on the writing paper supplied.** Extra writing paper is available.

Show all relevant working in questions involving calculations.

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Student Number _____

**Question 35 - Industrial Chemistry** (15 marks) **Marks**

(a) Many industrial processes involve equilibrium reactions.

Manipulating equilibrium conditions is an important part of industrial chemistry.

**1**

(i) Identify the experimental variable that changes the value of the equilibrium constant.

(ii) The water-gas shift reaction is a useful industrial method for the production of hydrogen gas, some of which is used to provide hydrogen for the Haber process. The equation for the process is:

$$CO(g) + H_2O(g) \leftarrow \rightarrow CO_2(g) + H_2(g)$$

A flask initially containing only 1.3 moles/litre of CO and 2.4 moles/litre of $H_2O$ was found to contain 0.6 moles/litre of $CO_2$ at equilibrium.

**2**

Calculate the equilibrium constant K for the reaction.

.

(b) Environmental considerations have become increasingly important in chemical industry. The production of sulfuric acid has environmental impacts.

**1**

Outline an environmental issue associated with the extraction of sulfur.

(c)Describe and explain the exothermic nature of sulfuric acid ionization. **2**

(d)

(i) Models are often used to explain complex concepts. Outline a first- hand investigation that you undertook to model an equilibrium reaction. **2**

(ii) Assess the validity of the information that could be collected in this investigation. **2**

(e) Discuss the issues associated with shrinking world resources with regard to one identified natural product that is not a fossil fuel. **5**

Identify the replacement materials used and/or current research in place to find a replacement for the named material.

**PART A: Multiple Choice**

**1. C**

**2. D**

**3. B**

**4. B**

**5. A**

**6. D**

**7. B**

**8. C**

**9. B**

**10.**

**11. A**

**12. C**

**13. A**

**14. B**

**15. D**

**16.**

**17. D**

**18. A**

**19. C**

**20. A**

## PART B: FAULDER ( 19 marks)

### Question 21 (6 marks)

**(a)**

| Marking Criteria | Marks |
|---|---|
| • Identifies the fuel burned in burner B<br>• Accounts for smokey flame – incomplete combustion<br>- Carbon produced | **3** |
| • Identifies the fuel burned in burner B<br>• Names **either** carbon or incomplete combustion as cause of smokey flame | **2** |
| • Identifies either the fuel burned in burner B **OR** names carbon **OR** incomplete combustion as cause of smokey flame | **1** |

**Sample answer**

Burner B contained octan-1-ol
Incomplete combustion results in the production of solid carbon (soot) which causes a smokey flame.

**(b)**

| Marking Criteria | Marks |
|---|---|
| • Calculates the heats of combustion of the alkanols<br>• Identifies A as butan-1-ol | **3** |
| • Calculates the heats of combustion of the alkanols only OR<br>Calculates one heat of combustion and correctly identifies A | **2** |
| • Calculates the heat of combustion of one alkanol correctly OR<br>Correctly identifies A | **1** |

A 200 x 4.18 x 10/0.65 = 12.86kJ/g

C 200 x 4.18 x 10/1.1 = 7.6kJ/g

Therefore A contains butan-1-ol (the greater the chain length the greater the energy released)

**Question 22 (3 marks)**

| Marking Criteria | Marks |
|---|---|
| • Assesses (judgement) the student's understanding<br>• refers to the diagram to describe a feature of the model<br>• describes the correct features of addition polymerisation and the composition of polyethene. | **3** |
| • Describes the correct features of addition polymerisation and the composition of polyethene AND gives a judgement **OR**<br>• Describes a feature of polyethene shown by the model AND gives a judgement **OR**<br>• Describes the correct features of addition polymerization and the composition of polyethene AND a feature shown by the model | **2** |
| • Identifies a feature of polyethene the model shows **OR** a feature/s it doesn't show | **1** |

**Sample answer**

The model demonstrates the student's understanding which is that polyethene is a long-chained molecule formed from the joining of several smaller molecules of ethene.
However, the student's model does not show that the polymerisation is an addition reaction, where the monomers join as the double bonds in ethene break, allowing the carbon atoms to bond to each other. Thus, the repeating unit is not ethene.
Therefore, overall, the model shows a limited understanding of the composition and reaction to produce polyethene.

**Question 23 (2 marks)**

| Marking Criteria | Marks |
|---|---|
| • Describes the use of a named radioisotope in medicine | **2** |
| • Identifies a radioisotope used in medicine OR identifies a use of a radioisotope in medicine | **1** |

**Sample Answer**

Technetium -99m can be used as a liver-bile tracer to determine the functioning of the bile duct.

**Question 24 (4 marks)**

| Marking Criteria | Marks |
|---|---|
| • Names biopolymer<br>• Discusses production<br>• Discusses use<br>• Discusses need for further development | **4** |
| • Names biopolymer **AND**<br>• Discusses two of production, use and development | **3** |
| • Names biopolymer **AND**<br>• Discusses one only of either production, use or development | **2** |
| • Names biopolymer **Or** discusses one of either production, use or development | **1** |

**Sample Answer**

Polyhydroxybutyrate (PHB) is a biopolymer produced by micro-organisms (eg *Alcaligenes eutrophus*) during fermentation of renewable carbohydrate food stocks.

It has the potential to replace polypropylene for use in packaging such as bottles, bags and wrapping film.

As biopolymers are made from renewable resources and are biodegradable/ biocompatible, further development is needed to reduce production costs and improve properties. This would make the use of biopolymers more viable compared to conventional polymers which are made from non-renewable petroleum resources.

**Question 25 (4 marks)**

(a)

| Marking Criteria | Marks |
|---|---|
| • Outlines the function of the salt bridge in a galvanic cell. | 1 |

**Sample Answer**

The salt bridge allows ions to move between half-cells to complete the circuit

(b)

| Marking Guidelines | Marks |
|---|---|
| • Determines the correct order of reactivity of the metals and justifies the order fully. | **3** |
| • Determines the correct order of reactivity of the metals AND gives one correct relevant feature of the galvanic cells shown **OR**<br>• two correct relevant feature of the galvanic cells shown. | **2** |
| • Determines the correct order of reactivity of the metals **OR**<br>• a correct relevant feature of galvanic cells. | **1** |

**Sample Answer**

Galvanic cells are based on redox reactions. The more reactive metal is oxidised and this occurs at the anode which is the negative terminal. The voltage produced by different combinations is an indication of the reactivity, the greater the voltage the greater difference.

Metal X – Copper is the positive electrode so metal X is oxidised and hence more reactive than copper

Metal Y and Z – Copper is the negative electrode so it is more reactive than both Y and Z

The cell voltage of Cu and Y is larger than Cu and Z so the difference in reactivity is greater between Cu and Y than Cu and Z. Z must therefore be more reactive than Y.

Rank : Y, Z, Cu, X

## PART B: ENGEL ( 10 marks)

**Question 26 (4 marks)**

| Marking Criteria | Marks |
|---|---|
| • Describes the anode and the chemical reaction including the correct half-equation for the reaction.<br>• Describes the cathode and the chemical reaction including the correct half-equation for the reaction.<br>• Identifies the electrolyte<br>• States voltage produced<br>• Describes cell rechargeability | **4** |
| • Describes the anode/cathode and the chemical reaction **AND**<br>• Describes the other electrode and the chemical reaction **OR**<br>• Writes a correct half-equation **OR**<br>• Identifies the electrolyte **OR**<br>• States voltage produced **OR**<br>• Describes cell rechargeability **OR** | **2-3** |
| • Identifies the electrolyte **OR**<br>• Identifies the cathode or anode **OR**<br>• Writes a correct half-equation. **OR**<br>• States voltage produced **OR** rechargability | **1** |

**Sample answers**

A lead-acid cell is made of a lead anode plate and lead(IV) oxide coated lead cathode plate immersed in a sulphuric acid (35%) electrolyte solution.
Lead at the anode oxidises to form $Pb^{2+}$ ions in the form of solid $PbSO_4$.
$Pb(s) + SO_4^{2-} \rightarrow PbSO_4(s) + 2e^-$
$Pb^{4+}$ ions from the $PbO_2$ at the cathode are reduced to $Pb^{2+}$ ions and also form solid $PbSO_4$.
$PbO_2(s) + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$
The cell is rechargeable and produces approx. 2 volts.

**OR**

A dry cell has a central positive cathode consisting of an inert graphite rod surrounded by graphite and manganese dioxide powder. The zinc casing for the cell acts as the negative anode. Between the two electrodes is an aqueous electrolyte paste of ammonium chloride 26%(w/w) containing more powdered graphite and manganese dioxide.
Zinc is oxidised at the anode to zinc ions.
$Zn(s) \rightarrow Zn^{2+} + 2e^-$
$Mn^{4+}$ in manganese dioxide is reduced to $Mn^{3+}$ when $Mn_2O_3$ solid is produced at the cathode.
$2MnO_2(s) + 2NH_4^+ + 2e^- \rightarrow Mn_2O_3(s) + H_2O(l) + 2NH_3$
It is non-rechargeable and produces 1.5 volts

## Question 27 (6 marks)

**27(a)(i)**

| Marking Criteria | Marks |
|---|---|
| • Correctly names the compound. | 1 |

1-chloro-1,1,2,2,2-pentafluoroethane.

**27(a)(ii)**

| Marking Criteria | Marks |
|---|---|
| • Outlines how the compound can destroy ozone, including relevant chemical equations | 3 |
| • Outlines how the compound in a(i) can destroy ozone, **OR**<br>• Includes relevant chemical equations, **OR**<br>• Incomplete outline and one relevant equation | 2 |
| • One correct statement or relevant equation. | 1 |

**Sample answer**
The compound shown can destroy ozone because in the presence of UV light the C-Cl bond is broken, producing a chlorine free radical. This Cl radical attacks ozone, and in a sequence of reactions shown below, is regenerated. It is able to continue reacting with other ozone molecules, destroying thousands before it is removed from the atmosphere.
$CF_3CF_2Cl(g) + UV \rightarrow CF_3CF_2{\cdot}(g) + Cl{\cdot}(g)$
$Cl{\cdot}(g) + O_3(g) \rightarrow O_2(g) + ClO{\cdot}(g)$
$ClO{\cdot}(g) + O{\cdot}(g) \rightarrow Cl{\cdot}(g) + O_2(g)$, and thus the Cl radical is regenerated and continues to destroy $O_3$ molecules.

**27(b)**

| Marking Criteria | Marks |
|---|---|
| • Identifies ozone depletion results in increased UV radiation reaching the Earth, **AND** one consequence of this increased UV radiation | 2 |
| • Identifies that ozone depletion results in increased UV radiation reaching the Earth, **OR**<br>• Identifies one consequence of increased UV radiation reaching the earth. | 1 |

**Sample answer**
Ozone depletion results in increased UV radiation reaching the Earth. The consequences of this include: increased rates of skin cancers and eye cataracts, phytoplankton damage or destruction resulting in disruption of ecosystems.

# PART B: NOYES ( 20 marks)

## Question 28 (4 marks)

**28.a.**

| Marking Guidelines | Marks |
|---|---|
| • Explains a weak acid<br>• Equation shows partial ionization | **2** |
| • Describes a weak acid as partial ionisation<br>**OR**<br>• Equation does not show partial ionization | **1** |

**Sample answer:**

Carbonic acid is only slightly ionised in water, producing a low concentration of hydrogen ions.

$CO_{2(g)} + H_2O <-> H_2CO_3 <-> HCO_3^- + H^+$

**28.b.**

| Marking Guidelines | Marks |
|---|---|
| • States Le Chatelier's Principle<br>• Predicts the change in equilibrium<br>• Descries the change in $H^+$ and pH | **2** |
| • States Le Chatelier's Principle<br>**OR**<br>• Predicts the change in equilibrium<br>**OR**<br>• Descries the change in $H^+$ and pH | **1** |

**Sample answer:**

Le Chatelier's Principle states that when a system reaches equilibrium and a change occurs in one of the conditions then the system adjusts so that it can return to equilibrium.

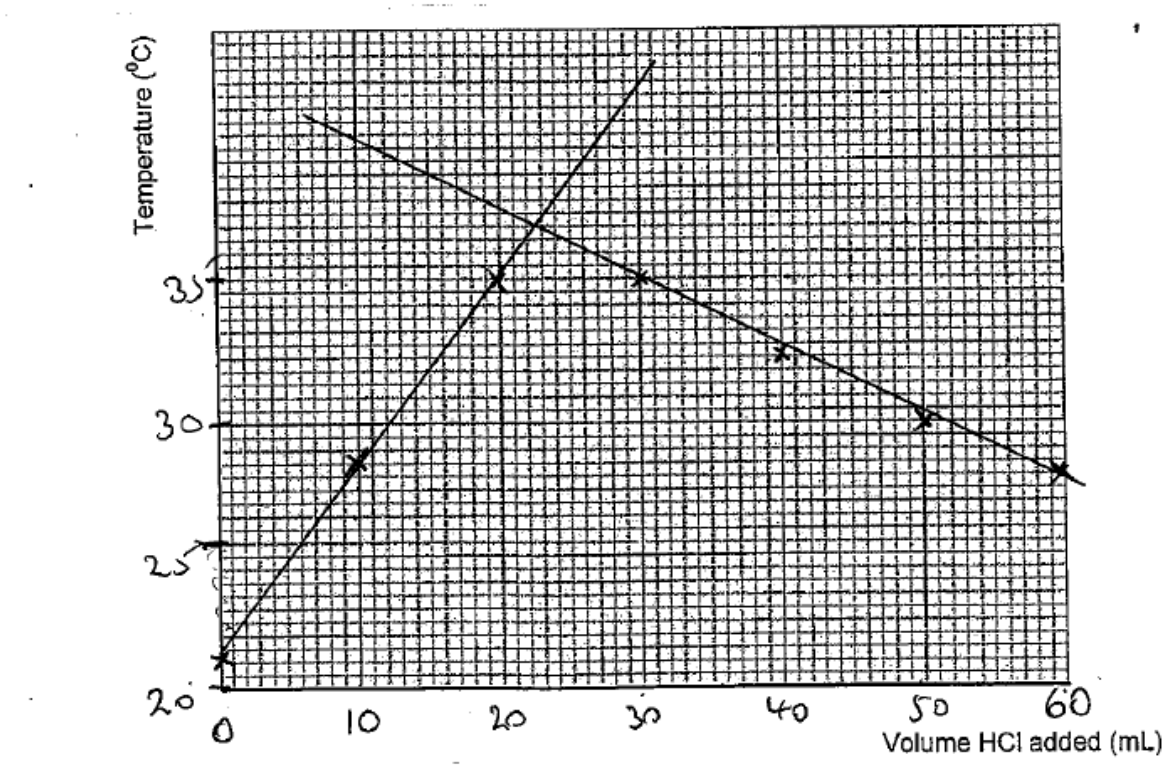
On opening, the pressure is reduced, causing the above equilibrium to move to the left, as concentration of gaseous carbon dioxide decreases. As a result, the hydrogen ion concentration decreases and the pH increases.

## Question 29 (10 marks)

**29.a.**

| Marking Guidelines | Marks |
|---|---|
| • Constructs even and appropriately sized scales on axes, and correctly plots all points. | **3** |
| • Axes or points have one error. | **2** |
| • Scales or points are correct. | **1** |

**Sample answer:**




**29.b.**

| Marking Guidelines | Marks |
|---|---|
| • Draws 2 straight lines that cross at about 37.5 mL | **1** |

**29.c.**

| Marking Guidelines | Marks |
|---|---|
| • Identifies the correct volume of HCl required to completely neutralise the NaOH, showing working on the graph. | **1** |

**Sample answer:**

22 – 23 mL.

**29.d.**

| Marking Guidelines | Marks |
|---|---|
| • Correctly calculates the concentration of the HCl, based on the answer to 25(c). | **2** |
| • Calculation contains one error. | **1** |

**Sample answer:**

Volume of HCl is 22.5 mL.
Moles of NaOH used = C x V = 0.145 x 0.025 = $3.625 \times 10^{-3}$
Moles of HCl used therefore = $3.625 \times 10^{-3}$ (because HCl + NaOH → NaCl + $H_2O$)
Concentration of HCl = n/V = $3.625 \times 10^{-3}$ / 0.0225 = 0.161M.

**29.e.**

| Marking Guidelines | Marks |
|---|---|
| • Calculates grams which match volumetric flask<br>• Describes the method<br>• Correct rinsing<br>• Fills to calibration mark | **3** |
| • Calculates grams<br>**AND**<br>• Describes the method<br>**OR**<br>• Correct rinsing<br>**OR**<br>• Fills to calibration mark | **2** |
| • Identifies volumetric flask<br>**OR**<br>• Calculates moles<br>**OR**<br>• Identifies one part of method | **1** |

**Sample answer:**

1. A 250 mL volumetric flask was used which was rinsed with distilled water..
2.Calculate the number of grams of $H_2C_2O_4$ needed.

n $H_2C_2O_4$ = M x V(L) = 0.1 x .25 = .025

g = n x MM = .025 x ( 1.002 x2 + 12 x 2 + 16 x 4) = .025 x 90.004 = 2.25 g

3. Weigh out 2.25 g of $H_2C_2O_4$ into a clean beaker.
4. Dissolve in distilled water and decant in to the 250mL volumetric flask.
5. Fill to the calibration mark , stopper and invert.

## Question 30 (6 marks)

**30.a.**

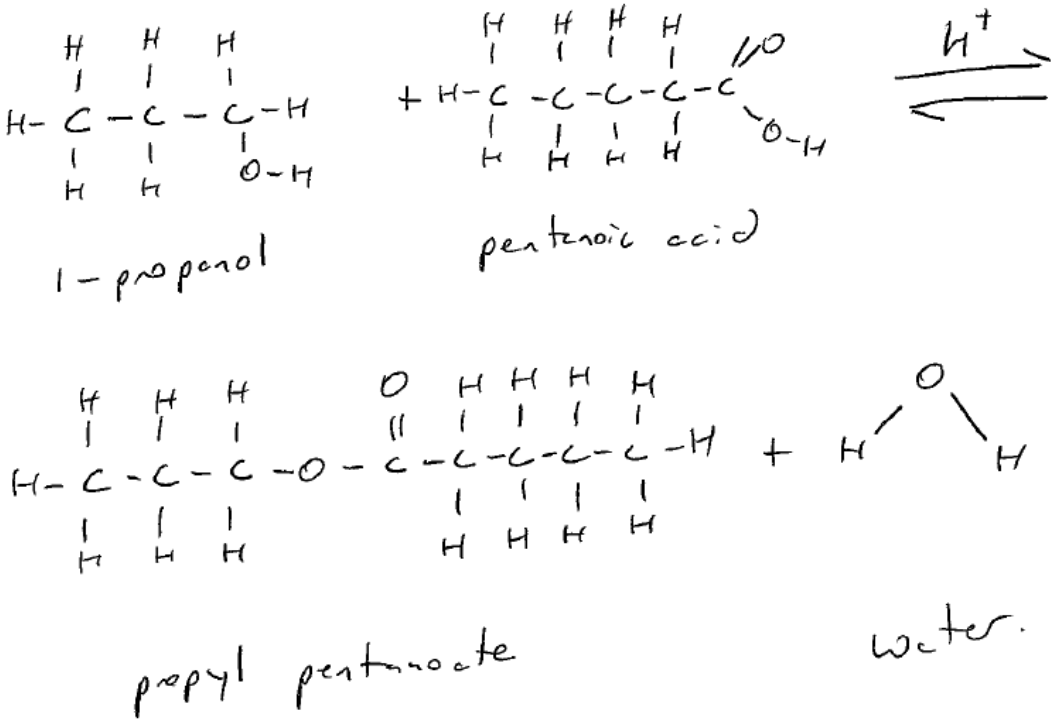
| Marking Guidelines | Marks |
|---|---|
| • Identifies a use | **1** |

**Sample answer:**
Flavourings; perfumes; food colourings

**30.b.**

| Marking Guidelines | Marks |
|---|---|
| • Correct equation (must be at equilibrium) | **2** |
| • Both reactants correctly drawn<br>**OR**<br>• Both products correctly drawn | **1** |

**Sample answer:**



**30.c.**

| Marking Guidelines | Marks |
|---|---|
| • Identifies refluxing ; catalyst<br>• Amounts of reactants<br>• Draws a labelled diagram | **3** |
| • Identifies refluxing or a condenser or catalyst<br>**AND**<br>• Draws a diagram | **2** |
| • Identifies refluxing or a condenser or catalyst<br>**OR**<br>• Draws a diagram (not labelled) | **1** |

**Sample answer:**

1. Add 10 mL of 1-propanol and 10 mL of propanoic acid into a flask.
2. Add 2 drops of concentrated sulphuric acid.
3. Add 3 boiling chips.
4. Heat under reflux (see diagram), using a hot water bath, for at least 15 minutes.

(Note esterification reactions are slow and the reaction usually does not proceed to completion)

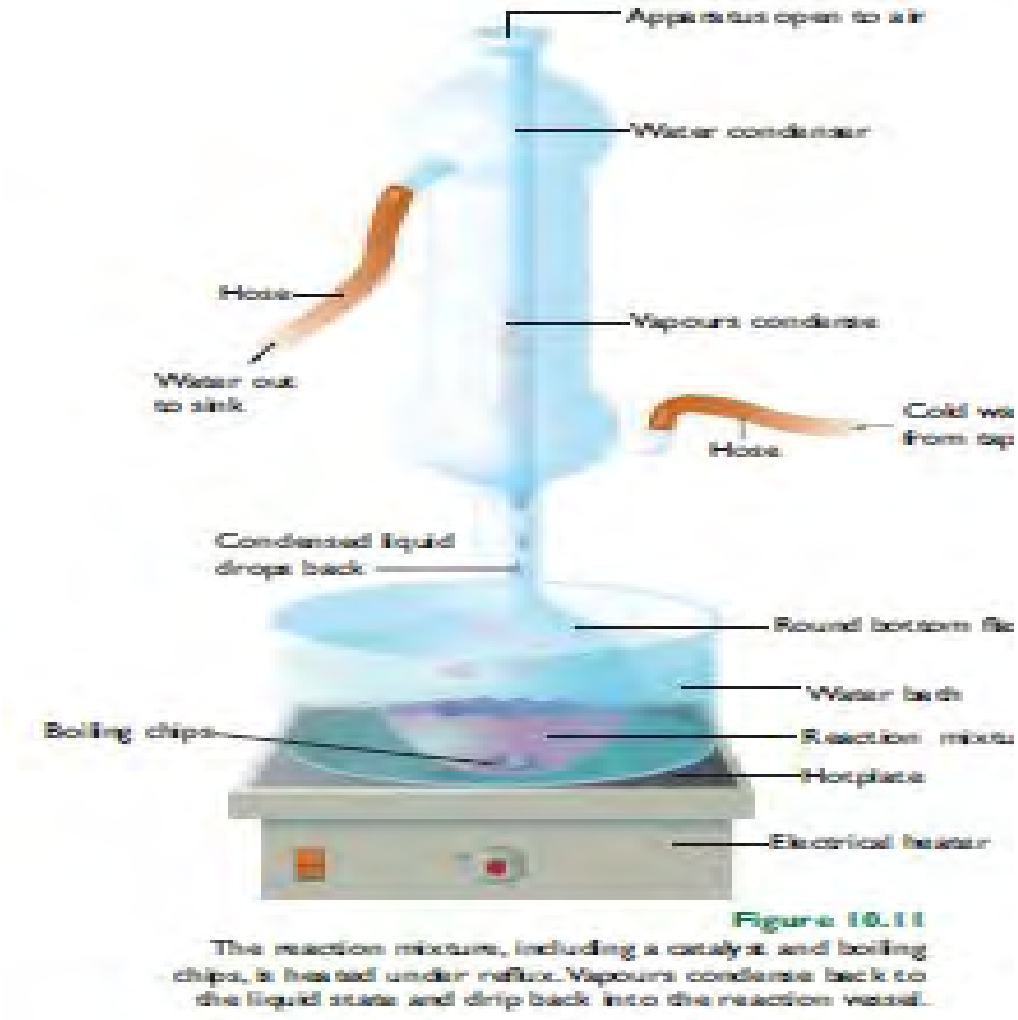



Figure 10.11
The reaction mixture, including a catalyst and boiling chips, is heated under reflux. Vapours condense back to the liquid state and drip back into the reaction vessel.

## PART B: HAYES ( 16 marks)

**Question 31 (4 marks)**
**Marking guidelines**

| Criteria | Marks |
|---|---|
| Correctly determines the moles of **both** reactants<br><br>AND<br><br>Correctly identifies that HCl is the limiting reagent (or that there is an excess of $Na_2S$)<br><br>AND<br><br>Determines the moles of $H_2S$ produced (using the limiting reagent)<br><br>AND<br><br>Determines the volume of $H_2S$ (based on the moles of $H_2S$ calculated) **correct to 2 significant figures** | 4 |
| Correctly determines the moles of **both** reactants<br><br>AND<br><br>Correctly identifies that HCl is the limiting reagent (or that there is an excess of $Na_2S$)<br><br>AND<br><br>Determines the moles of $H_2S$ produced (using the limiting reagent)<br><br>AND<br><br>Determines the volume of $H_2S$ (**but not correct to 2 significant figures)** | 3 |
| • Any two of the above steps processed correctly | 2 |
| • Any one of the above steps processed correctly | 1 |

**Sample answer**

- Moles HCl = .025 x 0.10 = $2.5 \times 10^{-3}$
  Moles $Na_2S$ = 0.15/2x22.99 + 32.07 = $1.92 \times 10^{-3}$
- $2HCl_{(aq)} + Na_2S_{(S)}$ ----------> $H_2S_{(g)} + 2NaCl_{(aq)}$
  HCl is limiting reagent: since $2.5 \times 10^{-3}$ moles react with $1.25 \times 10^{-3}$ moles of $Na_2S$ (there is an excess of $Na_2S$)
- Therefore from equation: Moles of $H_2S$ gas produced = $1.25 \times 10^{-3}$
- Volume at 25C and 100kPa = $1.25 \times 10^{-3}$ x 24.79L = 0.031L or 31mL

(2significant figures)

*Outcomes assessed: H2, H6, H13*

**MARKING GUIDELINES**

| Criteria | Marks |
|---|---|
| • Identifies the bonding using a Lewis electron-dot diagram | 2 |
| • Draws Lewis electron-dot diagram<br>OR<br>• Identifies the position of the coordinate covalent bond<br>OR<br>• Identifies the position of the double covalent bond | 1 |

**Question 32 is now worth 1 mark and so**

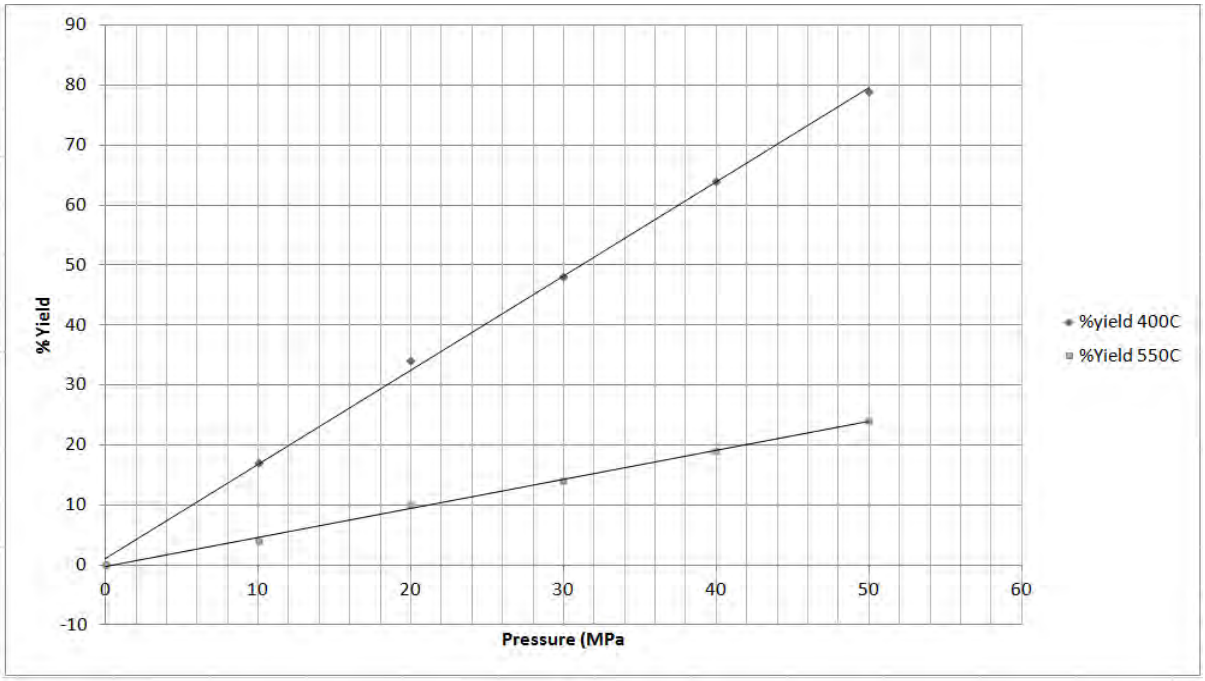
| Criteria | Marks |
|---|---|
| Identifies the bonding using a correctly drawn Lewis electron dot diagram | 1 |
| A correctly drawn electron dot diagram | 1/2 |

**Question 33**
**MARKING GUIDELINES**
**Criteria Marks**

**Marking criteria for graph**

| Criteria | Marks |
|---|---|
| Assigns variables to the correct axis and uses a suitable scale<br><br>Plots all data points with accuracy<br><br>Draws and labels both lines of best fit on the same graph | 3 |
| Two of the above | 2 |
| One of the above | 1 |
| | |

**Sample graph**




## 33 (b)

| Criteria | Marks |
|---|---|
| Constructs reaction equation, including an energy term or ΔH as -ve (1 mark)<br><br>Explains the effect of Temperature (1 mark)<br><br>Explains the effect of Pressure (1 mark) | 3 |

| Criteria | Marks |
|---|---|
| Constructs reaction equation, including an energy term (1 mark)<br><br>Identifies the effect of Temperature (1/2 mark)<br><br>Identifies the effect of pressure (1/2 mark) | 2 |

| Criteria | Marks |
|---|---|
| Constructs reaction equation, including an energy term<br><br>OR identifies the effect of Temperature and pressure | 1 |

*1/2 mark awarded here for equation without energy term

**Sample answer**

$N_{2(g)} + 3H_{2(g)}$ <-----> $2NH_{3(g)}$ + heat

Since the forward reaction is exothermic an increase in temperature will cause the equilibrium to shift to the left and therefore decrease the yield of ammonia.
Increasing the pressure causes the equilibrium to shift to the right as there are fewer gaseous molecules on the product side and therefore the yield of ammonia is increased.

**Question 34**

**MARKING GUIDELINES**
**(i)**

| **Criteria** | **Marks** |
|---|---|
| Correctly determines concentration of iron from graph | 1 |

**(ii)**

| **Criteria** | **Marks** |
|---|---|
| Correctly calculates the mass of iron | 2 |
| Shows one correct step in the calculation | 1 |

| **Criteria** | **Marks** |
|---|---|
| Outlines how a calibration curve is obtained | 2 |
| Identifies one aspect of the preparation or use of a calibration curve | |

Sample answer

(i) 4.5ppm

(ii) answer: 4.5ppm is equal to 4.5mg in 1L

therefore in 600mL there is 0.6 x 4.5mg = 2.7mg

Sample answer

(iii) To obtain a calibration curve the chemist would need to make a series of standard solutions containing $Fe^{2+}$, and the range of concentrations should include the expected concentration of the $Fe^{2+}$ in the waterway. Then the absorbance of each solution is measured at the same wavelength and the graph plotted.

# PART C: CARRINGTON ( 15 marks)

# OPTION-INDUSTRIAL CHEMISTRY

## Question 35 (15 marks)

**(a)**

(i)

| Marking Criteria | Marks |
|---|---|
| • Identifies temperature | 1 |

**Sample Answer**

*Temperature*

(ii)

| Marking Criteria | Marks |
|---|---|
| • Calculates the numerical value for K with correct working | 2 |
| • Identifies the correct K expression<br>OR<br>• Substitutes into an incorrect K expression. | 1 |

**Sample answer**

$K= [CO_2]\ [H_2] / [CO]\ [H_2O]$

| | ***CO*** | ***$H_2O$*** | ***$CO_2$*** | ***$H_2$*** |
|---|---|---|---|---|
| ***Initially*** | ***1.3*** | ***2.4*** | ***0*** | ***0*** |
| ***At eqm.*** | ***0.7*** | ***1.8*** | ***0.6*** | ***0.6*** |

$K= [0.6]\ [0.6] / [0.7]\ [1.8]$

$K= 0.2857$

**(b)**

| Marking Criteria | Marks |
|---|---|
| • Outlines an environmental issue associated with the extraction of sulfur. | 1 |

**Sample Answer**

*Sulfur is present naturally as a solid. When it is extracted from the ground, empty space remains where the sulfur once was. This can lead to surrounding land collapsing into the space, called land subsidence.*

**OR**

*The process of mining requires large amounts of land to be cleared, resulting in habitat loss, and ecosystem damage. In extreme cases it could result in a reduction of species diversity.*

**(c)**

| Marking Criteria | Marks |
|---|---|
| • Explains ionisation of sulphuric acid in 2 steps<br>• Includes a balanced equation for one ionisation | 2 |
| • Describes ionisation of sulphuric acid<br>**OR**<br>• Includes a correctly balanced equation for one ionisation | 1 |

**Sample Answer**

*The ionisation of sulfuric acid is exothermic, releasing lots of heat.*

*Sulfuric acid ionises in two steps.*

*Sulfuric acid is a strong acid in its first ionisation, but the $HSO_4^-$ ion formed in the first ionisation is a weak acid and only ionises slightly in the second ionisation.*

*In concentrated sulphuric acid there are only a few ions. When the acid is added to water it ionises liberating large amounts of heat.*

$H_2SO_{4(l)} \rightarrow H_2SO_{4(aq)}$ ***ΔH = -90 kJ/mol (is a typical value, depending on the degree of dilution)***

*1st Ionisation*

$H_2SO_{4(aq)} + H_2O_{(l)} \rightarrow H SO_4^-{}_{(aq)} + H_3O^+{}_{(aq)}$

*K is very large.*

*2nd Ionisation*

$HSO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+{}_{(aq)} + SO_4^{2-}{}_{(aq)}$

$(K= 1.2 \times 10^{-2})$

In the first step, an H-O bond is broken (endothermic) and a coordinate covalent bond between the hydrogen and a water molecule is formed (exothermic). The exothermic term is much greater than the endothermic term, hence the overall enthalpy change is negative.
The same process occurs in the second ionisation step, but because the $H^+$ ions has to leave the hydrogen sulfate ion, which already has a negative charge, it is a weak acid and so the reaction occurs to a lesser extent.

**(d)**

(i)

| Marking Criteria | Marks |
|---|---|
| • Outlines a first -hand investigation to model an equilibrium reaction **with equipment** and how it demonstrates equilibrium<br>OR<br>• Draws a diagram to explain how it demonstrates the equilibrium model | 2 |
| • Outlines a first -hand investigation to model an equilibrium reaction<br>OR | 1 |

| | |
|---|---|
| • Draws a diagram to model equilibrium | |

**Sample Answer (i)**

Two identical measuring cylinders are filled with different volumes of water. Water is transferred backwards and forwards from each cylinder using two differently sized pipettes until the volume of water in each cylinder remains constant (but at different levels).

- There are many models that could 'physically' model equilibrium in a closed system (that are 'non-chemical')
- Diagrams can be included

(ii)

| Marking Criteria | Marks |
|---|---|
| • Describes the requirements for the validity of the experiment | 2 |
| • Identifies a requirement for the validity of the experiment | 1 |

***Sample answer:***

The information collected while physically modelling equilibrium is valid to a point, in that it reflects many of the characteristics of a closed chemical system at equilibrium. These characteristics include initial macroscopic changes in concentrations (volumes of water) of both 'reactants', and 'products' that continue during the transfer of water backwards and forwards until there is no macroscopic change in water levels. This is despite the dynamic nature of the continued movement of water from one cylinder to another. However, the limitations of any model in reflecting all characteristics of an actual chemical equilibrium system does compromise its validity.

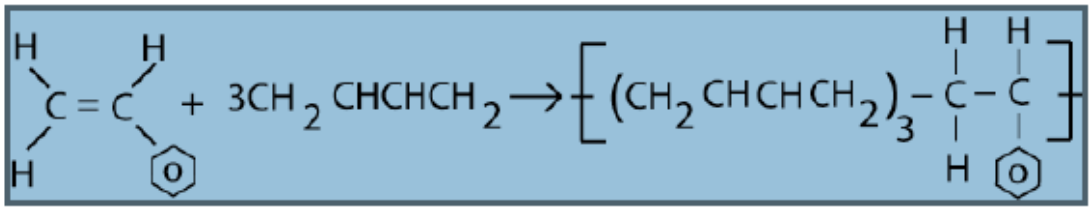
**(e)**

| MARKING GUIDELINES Criteria | Marks |
|---|---|
| • Identifies an appropriate natural product<br><br>• Provides characteristics and features of at least *TWO* issues associated with shrinking world supplies of the natural product<br>AND<br>• Provides characteristics and **features of progress** being made to find new replacement materials<br>OR<br>Identifies the replacement product<br>• Provides a response that demonstrates coherence and logical progression | 5 |
| • Identifies an appropriate natural product<br>AND<br>• Provides **characteristics and features** of *TWO* issues associated with shrinking world supplies of the natural product<br><br>OR<br>Identifies and provides **characteristics and features** of one issue associated with shrinking world supplies of the natural product<br><br>AND<br><br>• Provides characteristics and features of progress being made to find new replacement materials<br>OR<br>• Identifies an appropriate replacement product<br>……...<br><br>• Identifies an appropriate natural product<br>AND<br>• Provides **characteristics and features** of one issue associated with shrinking world supplies of the natural product<br><br>OR<br><br>• Provides characteristics and features of progress being made to find new replacement materials<br>**OR**<br>• Identifies an appropriate replacement product | 4<br><br>3 |
| • Identifies an appropriate natural product and a replacement material<br>OR<br>• Identifies an appropriate natural product<br>AND<br>• Identifies an issue (renewable/non-renewable)<br><br>OR<br>• Identifies an appropriate replacement product<br>AND<br>• Identifies an issue | 2 |
| • Identifies an appropriate natural product<br>OR | |

| | |
|---|---|
| • Identifies a replacement product<br>OR<br>• Identifies an issue (renewable/non-renewable) | 1 |

**Sample Answer**

*A natural product is one that is used with little or no modification. Raw rubber is an addition polymer that is also a natural product. Raw rubber is obtained from the sap of the rubber tree and is a very useful natural product. It is used in balls, shoes, tyres and as elastic bands. In the early 20th century demand for rubber outstripped supply. The supply of rubber was limited as rubber trees could only produce a certain amount of rubber each year. In addition, this production was mainly from Asia. As the demand for rubber grew, new alternatives needed to be produced. This situation became crucial during the first and second world wars. Rubber was needed for tyres for military vehicles and the limited supply of rubber greatly influenced the war. In the second world war, the Japanese had control of rubber producing areas which resulted in other nations needing scientists to develop synthetic rubber. Another issue that caused the rising demand for rubber was that the automobile industry was growing and car manufacturers needed rubber. Steps to solve the limited supply of rubber involved the development of synthetic rubbers. In the 1950s SBR (styrene butadiene rubber) was formed.*



*Synthetic rubber improved the properties of natural rubber as the rubber was vulcanised. Short sulfur chains formed crosslinks between polymer chains. This improved the properties of synthetic rubber, making it more durable, more resistant to chemical attack and stronger.*

*The progress made to improve and increase the supply of rubber has been very effective as the demand for synthetic rubber as a total percentage of rubber is around 80%.*

*Synthetic rubber has allowed the production of rubber to meet demand and maintain a low cost. New developments to rubber involve the use of non-petrochemicals as the cost of petroleum products has increased.*