



2009
FORM VI
TRIAL HSC EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes.
- Working time – 3 hours
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your candidate number and master's initials at the top of each page in Part B and on the answer booklet

CHECKLIST

Each boy should have the following :

1 Question Paper	
1 Multiple Choice Answer Sheet	
1 5 - Page Booklet	

Chemistry Classes.

1 MMB	2 AKBB	3 MTK
4 TW	5 EJS	6 JAG

Section I Pages 2 - 22

Total marks (100)

This section has two parts, Part A and Part B

Part A

Total marks (15)

- Attempt Questions 1-15
- Allow about 25 minutes for this Section

Part B

Total marks (69)

- Attempt Questions 16-29
- Allow about 2 hours for this Section

Section II Pages 23-26

Total marks (16)

- Attempt Question 30 in this section.
- Allow about 35 minutes for this Section

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Part A**Total marks (15)****Attempt Questions 1-15****Allow about 25 minutes for this Part**

Use the multiple-choice Answer Sheet.

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

Sample $2 + 4 =$

(A) 2 (B) 6 (C) 8 (D) 9

A B C D

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

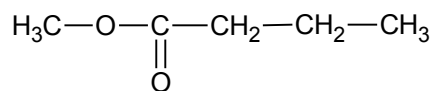
A B C D

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

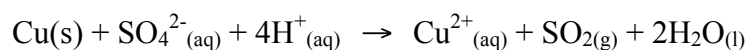
A B C D

correct

- 1 What is the correct name for the following compound?



- (A) methyl propanoate
(B) butyl methanoate
(C) methyl-4-butanol
(D) methyl butanoate
- 2 Which of the following is a common natural source of sulfur dioxide in the atmosphere?
- (A) Action of sunlight on sulfur and oxygen
(B) Smelting of metal ores
(C) Volcanic emissions
(D) Action of soil bacteria
- 3 Which of the following correctly describes the relationship between an acid and its conjugate base?
- (A) They are ions of opposite charge.
(B) They are both amphiprotic.
(C) They neutralize each other to form a salt.
(D) They have formulae that differs by a proton.
- 4 In which part of the Periodic Table would you find radioactive elements?
- (A) Anywhere in the table.
(B) Only amongst elements with an atomic number greater than 82.
(C) Only amongst the transuranic elements.
(D) Only amongst metal elements.
- 5 Consider the following equation:



Which of the following statements is correct?

- (A) Cu is the oxidant, the oxidising agent.
(B) H^+ is being reduced.
(C) Cu is the reductant, the reducing agent.
(D) H^+ is being oxidised.

- 6 Which of the following would you expect to observe when adding bromine water ($\text{Br}_{2(\text{aq})}$) to an alkene and an alkane in direct sunlight?
- (A) The $\text{Br}_{2(\text{aq})}$ would decolourise the alkene immediately and the alkane after about an hour.
 - (B) The $\text{Br}_{2(\text{aq})}$ would decolourise the alkane immediately but there would be no reaction with the alkene.
 - (C) Only the alkane would decolourise the $\text{Br}_{2(\text{aq})}$.
 - (D) Neither of them would decolourise the $\text{Br}_{2(\text{aq})}$.
- 7 Which of the following conditions promotes the fermentation of sugars?
- (A) An anaerobic environment.
 - (B) A slightly basic environment.
 - (C) A temperature of $80\text{ }^{\circ}\text{C}$.
 - (D) The addition of the enzyme catalase.
- 8 Eutrophication promotes rapid growth of algae, which can leave waterways stagnant and unable to support life. Which of the following pairs of ions can lead to eutrophication?
- (A) Carbonate and phosphate ions
 - (B) Magnesium and calcium ions
 - (C) Chloride and hydrogen ions
 - (D) Phosphate and nitrate ions
- 9 What is the name of the homologous series of carbon compounds with the general formula C_nH_{2n} ?
- (A) Alkanes
 - (B) Alkenes
 - (C) Alkyl alkanoates
 - (D) Alkanoic acids
- 10 Which of the following is a major source of hydrogen for the Haber process?
- (A) The reaction of steam and methane
 - (B) Atmospheric hydrogen
 - (C) Electrolysis of water
 - (D) Catalytic cracking of hydrocarbons

- 11 Which of the following is a qualitative test for water hardness?
- (A) EDTA titration
 - (B) Nephelometry
 - (C) Agitation with soap flakes
 - (D) Atomic absorption spectrophotometry (AAS)
- 12 Which of the following indicators is most suitable for use in weak acid/strong base titrations?
- (A) Phenolphthalein
 - (B) Universal Indicator
 - (C) Methyl Orange
 - (D) Bromothymol Blue
- 13 Robert plans to make the ester 1-propyl pentanoate. Which of the following combinations of alkanols and alcanoic acids would be viable reactants?
- (A) 1-pentanol and propanoic acid
 - (B) 1-pentanol and pentanoic acid
 - (C) pentane and propanoic acid
 - (D) 1-propanol and pentanoic acid
- 14 A student needs to test for barium ions in a local creek. Which of the following reagents would react with a solution containing barium ions?
- (A) silver nitrate solution
 - (B) sodium sulfate solution
 - (C) sodium nitrate solution
 - (D) sodium acetate solution
- 15 Which of the following is closest to the pH of 0.001M sulfuric acid solution?
- (A) 2.1
 - (B) 3.0
 - (C) 2.7
 - (D) 3.1

Part B**Total marks (69)****Attempt ALL Questions****Allow about 2 hours for this Part**

Masters' Initials

Candidate Number

Answer the questions in the spaces provided

Show **all** relevant working in questions involving calculations**Question 16** (4 marks)**Marks**

Ethylene is a reactive gas and an important industrial chemical and starting point for a number of chemical reactions.

- (a) Draw the structural formula for ethylene and explain why it is so reactive.

2

- (b) Ethylene may be modified by replacing a hydrogen atom with a different chemical species. One such substance is styrene. When styrene molecules react with one another they make polystyrene.

- (i) Draw a section of polystyrene which includes at least 6 carbon atoms.

1

- (ii) State the systematic name for styrene.

1

Question 17 (6 marks)**Marks**

Consider the pH of 0.1M solutions of the following three acids:

Acids	pH
0.1M acetic acid	2.9
0.1M citric acid	2.1
0.1M hydrochloric acid	1.0

- (a) Identify the systematic name for citric acid.

1

- (b) Explain the difference in pH between the three acids.

3

- (c) Calculate the final pH of a solution produced from diluting 100mL of 0.1M hydrochloric acid with 400mL of deionised water.

2

Masters' Initials

Candidate Number

Question 18 (6 marks)**Marks**

Solid sodium hydrogencarbonate, commonly called bicarb soda, is soluble in water.

- (a) State whether the resultant solution is acidic, neutral or basic.

1

- (b) Write an equation to justify your answer to part (a).

1

- (c) The hydrogencarbonate ion can react with both $\text{HCl}_{(\text{aq})}$ and $\text{NaOH}_{(\text{aq})}$. Write equations for these reactions illustrating the amphiprotic nature of the hydrogencarbonate ion.

2

- (d) The hydrogencarbonate ion is an integral part of the buffer system of our blood and in fresh and salt water. Describe the effect that buffers have in these natural systems.

2

Question 19 (6 marks)**Marks**

A titration was carried out using $0.246 \text{ molL}^{-1} \text{ HCl}_{(\text{aq})}$ to standardise 25.0 mL samples of a solution of sodium carbonate. An appropriate indicator was chosen to show the end point of the neutralisation. The results are shown in the table below.

<i>Titre</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>
<i>Final reading (mL)</i>	23.60	45.80	23.00	46.20
<i>Initial reading (mL)</i>	0.50	23.60	0.70	23.90

- (a) Before performing the titration, it is important to rinse your apparatus with the appropriate solutions. Identify the chemical used to rinse the following:

Burette: _____

Pipette: _____

Conical flask: _____

2

- (b) Calculate the molar concentration of the sodium carbonate solution.

2

- (c) Identify an indicator that should be used for this titration, and explain your choice.

2

Masters' Initials

Candidate Number

Question 20 (5 marks)

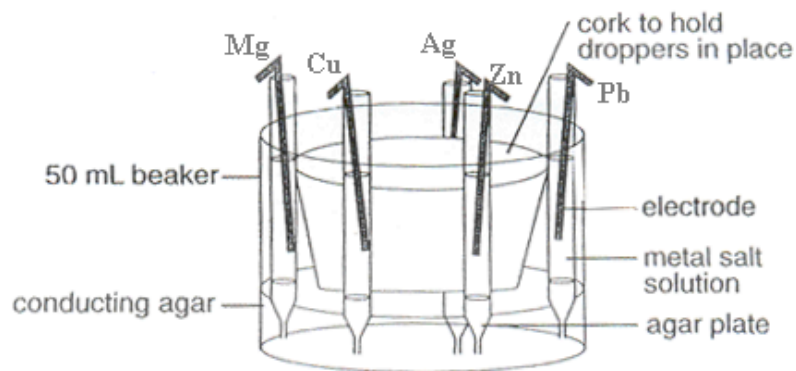
Marks

Describe the production of a specific named biopolymer and evaluate its uses or potential uses in terms of the properties of the biopolymer.

5

Question 21 (3 marks)**Marks**

During an experiment a student immersed a series of different metals rods in an aqueous gel salt bridge as shown in the diagram below. The metal rods were then connected to each other, two metals at a time using connecting wires and a voltmeter.



Assembled beaker containing five half cells. Each electrode is submerged in its own salt solution. The conducting agar serves as the salt bridge.

- (d) Identify which combination of metal pairs you would expect to have the highest potential difference and state the theoretical value of this voltage.

1

- (e) The measured voltages were found to vary somewhat from the theoretical results. Other than faulty equipment, explain why this might be.

1

- (f) After a sufficiently long period of time the voltage of all cells approached zero. Suggest a reason for this.

1

Masters' Initials

Candidate Number

Question 22 (4 marks)**Marks**

During the course of the year you have performed a first-hand investigation to measure the potential difference between metals connected in a galvanic cell.

Draw a fully labelled diagram of your experimental set-up, identifying the metals and solutions used, the anode and the cathode and the direction of electron flow.

4

Question 23 (6 marks)**Marks**

A chemist wishes to make ethyl butanoate, which has a pineapple odour, in the laboratory. Describe the apparatus, reagents and procedure needed to synthesise this ester. Include a diagram in your answer. Explain how you would isolate this ester successfully using the data table below.

compound	boiling point ($^{\circ}\text{C}$)
ethyl butanoate	120
ethanol	78
butanoic acid	163

6

Masters' Initials

Candidate Number

Question 24 (5 marks)**Marks**

“The condensation polymer cellulose may be used as a starting material from which ethylene may be produced.”

Discuss this statement, including the chemical steps required, a definition of the term condensation polymer and any relevant equations.

5

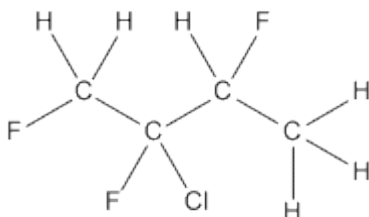
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Masters' Initials

Candidate Number

Question 25 (2 marks)**Marks**

(a) Identify the following compound:



1

(b) Draw the structural formula for 1,1,2,2-tetrachloropropane.

1**Question 26** (3 marks)

Describe a quantitative test for total dissolved solids that you have performed on a water sample.

3

Question 27 (6 marks)**Marks**

Oxygen exists as two allotropes, O₂ and O₃.

- (a) Draw Lewis electron dot diagrams for each of these allotropes.

2

- (b) Compare the effects of ozone in the lower atmosphere with its effects in the upper atmosphere.

2

- (c) Describe the effect of compounds such as CFC's on ozone in the upper atmosphere.

2

Masters' Initials

Candidate Number

Question 28 (5 marks)**Marks**

The following method was used to gravimetrically determine the concentration of chloride ions in a sample of seawater.

1. 10 mL of seawater were pipetted into a 100 mL conical flask.
2. 1.0 mL of 1M nitric acid was added to the conical flask.
3. Using a burette and constantly stirring, 0.50 M silver nitrate was slowly added to the solution until no more precipitate appeared.
4. The suspension was heated to just below boiling and then allowed to settle.
5. The precipitate was collected by filtration with a pre-weighed filter paper.
6. The filter paper was dried in a drying oven, and then re-weighed.

The mass of the filter paper was found to be 0.452g and the mass of the filter paper and precipitate was 0.792g.

- (a) Write a net ionic equation for the reaction that occurs in step 3 above.

1

- (b) Calculate the concentration of chloride ions in the seawater (in g L^{-1}).

2

- (c) Discuss the effectiveness of the method used above to find the concentration of chloride ions in seawater.

2

Question 29 (8 marks)**Marks**

Ammonia is a choking alkaline gas which is an important industrial chemical.

- (a) Identify two industrial uses of ammonia.

2

- (b) Write the equation for the Haber process and state whether the reaction is exothermic or endothermic.

2

- (c) The Haber process is typically performed at temperatures between 400°C and 500°C. Account for this choice of temperature.

2

Question 29 continued on next page.

Masters' Initials

Candidate Number

Question 29 continued.**Marks**

- (d) Explain why monitoring the reaction vessel used in the Haber process is essential.

2

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Section II**16 marks****Attempt question 30 in this section.****Allow about 35 minutes for this section.**

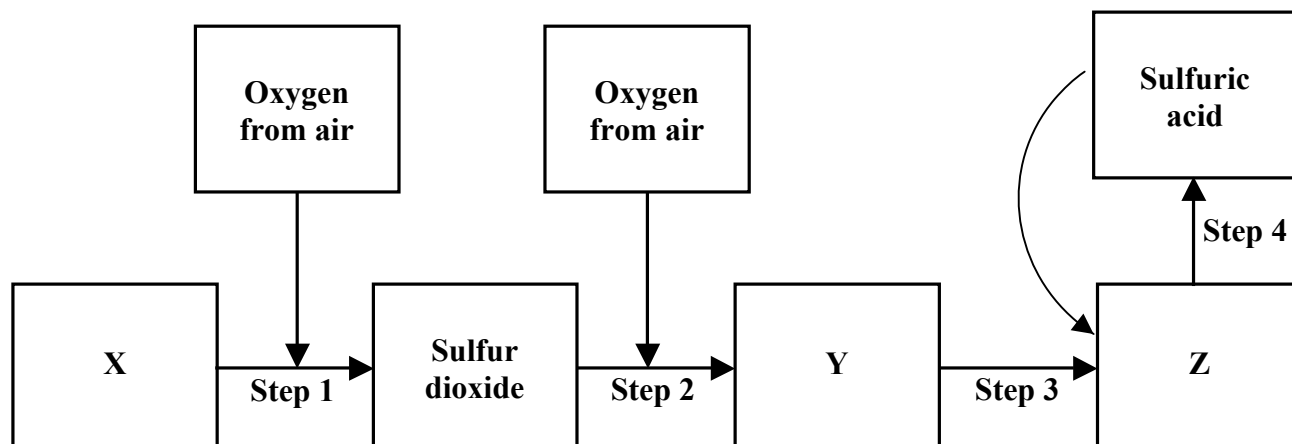
Answer the question in a **writing booklet**. Extra writing booklets are available.
Show **all** relevant working in questions involving calculations.

	Pages
Question 30	Industrial Chemistry.....25-26
Question 31	Elective 2
Question 32	Elective 3
Question 33	Elective 4
Question 35	Elective 5

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Question 30 (16 marks)**Marks**

- (a) This diagram summarises the steps in the industrial production of concentrated sulfuric acid.



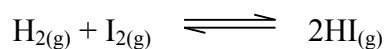
- (i) Identify X, Y and Z above in the process. 2
- (ii) Outline the chemistry of the production of concentrated sulfuric acid starting from X. Include chemical equations for steps 1 and 3 in your answer. 4
- (iii) State and justify the conditions used to maximize the rate and yield in the second step of the Contact process. 2

Question 30 continued on next page.

Marks

(b) Explain how concentrated (18.4 M) sulfuric acid is diluted in the laboratory. Include all necessary safety precautions needed for the dilution of this concentrated acid. **3**

(c) (i) 5 mol of hydrogen gas, 4 mol of iodine gas and 1.6 mol of hydrogen iodide gas were mixed together in a 2 L vessel at 900 K. After equilibrium had been attained, the vessel contained 3.6 mol of hydrogen. Calculate a value for the equilibrium constant for this reaction at 900 K: **4**



(ii) Identify the change in conditions that will alter the value of K. **1**



CRIB

Class

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Student Number

2009
HIGHER SCHOOL CERTIFICATE
TRIAL EXAMINATION

Chemistry
Section I Part A
ANSWER SHEET

General Instructions

- Write your class and candidate number in the space provided.
- Attempt all questions 1 – 15
- Use a blue or black pen
- Select the alternative A, B, C, or D that best answers the question.
- Fill in the response circle completely.

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

MTK

Masters' Initials

CRIB

Candidate Number

Part B**Total marks (69)****Attempt ALL Questions****Allow about 2 hours for this Part**

22

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations

Question 16 (4 marks)**Marks**

Ethylene is a reactive gas and an important industrial chemical and starting point for a number of chemical reactions.

- (a) Draw the structural formula for ethylene and explain why it is so reactive.

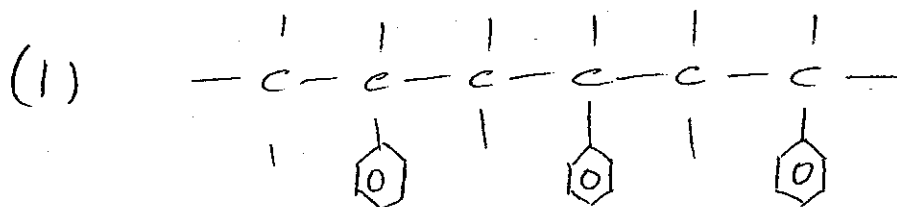


(1) double bond explanation

2

- (b) Ethylene may be modified by replacing a hydrogen atom with a different chemical species. One such substance is styrene. When styrene molecules react with one another they make polystyrene.

- (i) Draw a section of polystyrene which includes at least 6 carbon atoms.



1
must be 6 x C_{chain}
as per question

- (ii) State the systematic name for styrene.

phenylethene OR ethenylbenzene 1
OR vinyl benzene (accepted)

* spelling was marked (eg ethyl benzene not accepted)

Question 17 (6 marks)

Marks

Consider the pH of 0.1M solutions of the following three acids:

Acids	pH
0.1M acetic acid	2.9
0.1M citric acid	2.1
0.1M hydrochloric acid	1.0

- (a) Identify the systematic name for citric acid.

2-hydroxypropane-1,2,3-tricarboxylic acid
 - v. poorly done especially given it is a dot point.

- (b) Explain the difference in pH between the three acids.

see next page

3

- (c) Calculate the final pH of a solution produced from diluting 100mL of 0.1M hydrochloric acid with 400mL of deionised water.

$$c_1 V_1 = c_2 V_2$$

$$100 \times 0.1 = c_2 \times 500 \quad c_2 = 0.02 \text{ M} \quad (1)$$

2

$$\text{pH} = -\log_{10} [\text{H}^+] = 1.7 \quad (1)$$

*'carry error' paid if 400 used in dilution.

Question 17 (6 marks)**Marks**

Consider the pH of 0.1M solutions of the following three acids:

Acids	pH
0.1M acetic acid	2.9
0.1M citric acid	2.1
0.1M hydrochloric acid	1.0

(b) Explain the difference in pH between the three acids.

Marked holistically

Marks	Marking guidelines
3	<ul style="list-style-type: none"> Links pH to hydronium ion concentration. Links hydronium ion concentration to degree of ionisation or strength. Recognises that given same concentrations, links pH to strength. Correctly explains why HCl > citric > acetic in terms of strong and weak acids and degree of ionisation.
2	<ul style="list-style-type: none"> Identifies 2-3 of the points listed for 3 marks, but must include explanation.
1	<ul style="list-style-type: none"> Identifies any one of the points listed for 3 marks.

Notes:

- Many boys stated that citric > acetic because, being triprotic, it released 3 protons compared to 1 for the monoprotic acetic. There was no indication that the 3 protons are not equally ionised and that the degree of ionisation is mainly due to step 1 of the 3 ionisation steps.

Sample 3-mark answer

Given the acids are of equal concentration, the pH (being a measure of $[H_3O^+]$) is directly related to the degree of ionisation or differing strength. HCl is a strong, monoprotic acid, hence fully ionises such that the $pH = -\log_{10}[0.1] = 1$.

Acetic and citric acids are both weak acids, hence they are not fully ionised, leading to lower $[H_3O^+]$ and higher pH's. Citric acid has a greater degree of ionisation than acetic acid, hence it has a pH that is less than acetic but greater than HCl.

Masters' Initials

Candidate Number

Question 18 (6 marks)

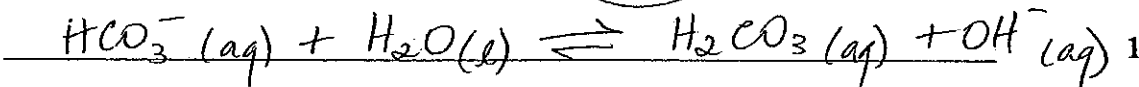
Marks

Solid sodium hydrogencarbonate, commonly called bicarb soda, is soluble in water.

(a) State whether the resultant solution is acidic, neutral or basic.

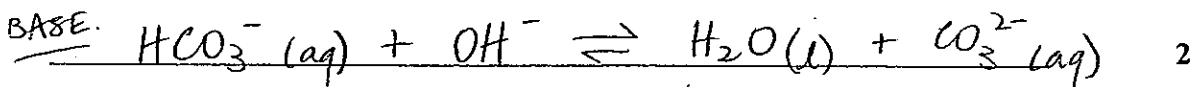
basic 1

(b) Write an equation to justify your answer to part (a)



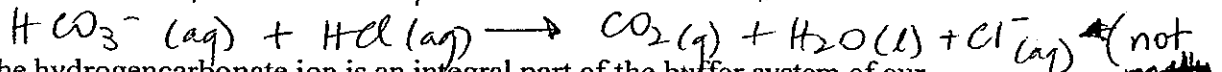
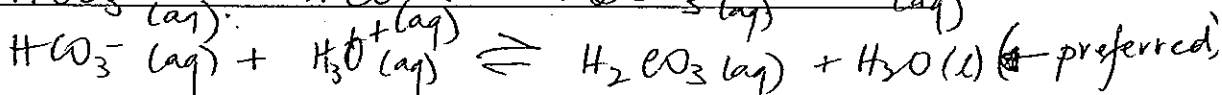
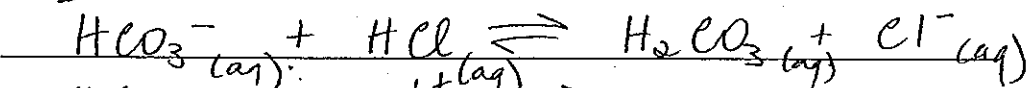
CE = carry error if part (a) is wrong, but eqⁿ justifies

(c) The hydrogencarbonate ion can react with both $\text{HCl}_{(\text{aq})}$ and $\text{NaOH}_{(\text{aq})}$. Write equations for these reactions illustrating the amphoteric nature of the hydrogencarbonate ion.



* paid inclusion of Na^+ also in equation

FOR ACID ∴ PAID EITHER.



(d) The hydrogencarbonate ion is an integral part of the buffer system of our blood and in fresh and salt water. Describe the effect that buffers have in these natural systems.

(1) maintain pH in a narrow range by resisting 2
change when small quantities of either
acid or base added.

(1) allow biochemical processes to occur at
optimal rate OR prevents damage to system.

* Many boys described reactions rather than effect.

marked together for errors - marked easily HSC style. i.e. small error in stated + change permitted.

Question 19 (6 marks)

Marks

A titration was carried out using $0.246 \text{ mol L}^{-1} \text{ HCl}_{(\text{aq})}$ to standardise 25.0 mL samples of a solution of sodium carbonate. An appropriate indicator was chosen to show the end point of the neutralisation. The results are shown in the table below.

Titre	1	2	3	4
Final reading (mL)	23.60	45.80	23.00	46.20
Initial reading (mL)	0.50	23.60	0.70	23.90
	23.1	22.20	22.30	22.30

- (a) Before performing the titration, it is important to rinse your apparatus with the appropriate solutions. Identify the chemical used to rinse the following:

Burette: 0.246 M HCl

Pipette: Na_2CO_3 solution

Conical flask: distilled/deionised water

2

- (b) Calculate the molar concentration of the sodium carbonate solution.

$$\begin{aligned} \text{Avg titre with } 1^{\text{st}} \text{ ignored} &= 22.67 \text{ mL} \\ n_{\text{HCl}} &= 22.67 \times 10^{-3} \times 0.246 = 5.48 \times 10^{-3} \text{ mol} \\ n_{\text{Na}_2\text{CO}_3} &= \frac{1}{2} n_{\text{HCl}} = 2.74 \times 10^{-3} \\ c &= \frac{n}{V} = \frac{2.74 \times 10^{-3}}{25 \times 10^{-3}} = 0.110 \text{ M} \end{aligned}$$

2

* 1 mark given if working shown one small error.

- (c) Identify an indicator that should be used for this titration, and explain your choice.

(1) methyl orange or bromothymol blue

2

(1) Explanation of either:

better answer → (a) strong acid-weak base with end pt in acidic range
OR (b) resulting salt (NaCl) is neutral, so indicator in 7. range used.

AKBB
Masters' InitialsCR1B
Candidate Number

Question 20 (5 marks)

Marks

Describe the production of a specific named biopolymer and evaluate its uses or potential uses in terms of the properties of the biopolymer.

5

Holistically marked, but needed
to mention following points in
logical sequence and increasing
level of sophistication.

1. Name of biopolymer
2. Name of main organism or enzyme used in the production of above named biopolymer.
3. Specific properties of above named biopolymer
4. Use linked to above property.
5. Evaluation of information discussed above.

This was generously marked. In the HSC it may be necessary to provide the name of organism (or enzyme) species and/or equations.

Masters' Initials

Candidate Number

Question 20 (5 marks)

Exemplar

Marks

Describe the production of a specific named biopolymer and evaluate its uses or potential uses in terms of the properties of the biopolymer.

Biopolymer: PLA ($C_3H_4O_2$) (Polylactic acid)

5

A ~~polymer~~ polymer is a long chain hydrocarbon made of repeating monomer units. A biopolymer is a polymer derived from renewable biological sources. This can be synthesised in a natural system (eg. Cellulose) or chemically synthesised from biological starting materials.

Process: $C_6H_{10}O_5 + H_2O \xrightarrow[\text{bacteria}]{\text{cell}}$ $C_6H_{12}O_6$ - Lactic acid is hydrolysed to glucose.

$C_6H_{12}O_6 \xrightarrow[\text{bacteria}]{} C_3H_6O_3$ - The bacteria *lactobacillus cruyflavus* turn the glucose to $C_3H_6O_3$

$C_3H_6O_3 \xrightarrow[\text{cell}]{\text{cell}}$ $C_3H_4O_2 + H_2O$ - Condensation polymerisation to PLA.

PLA's potential uses stems from the fact that it can be drawn out into a thread which has many potential uses in the textile industry. Currently it is used for:

- Medical stitching (sutures) as it has the ability to dissolve over time
- The hydrogen bonds of PLA will interact with water which means PLA has a certain affinity with water in which the fibre can absorb it. This means it can be used in for clothing etc. which requires to get wet. eg. shoes.
- PLA is highly elastic - this is due to the fact that it is able to keep a constant density.
- PLA has a low refractive index which allows bright coloured dyes to be used with it. Hence this can be used in textiles.

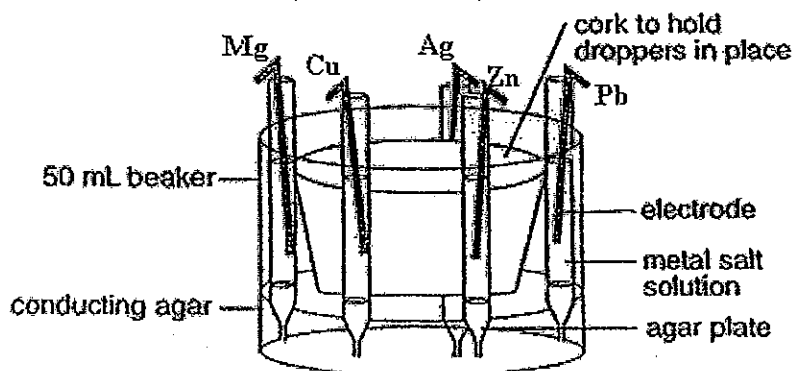
Evaluation: PLA has many potential uses as it is derived from renewable resources and as a biopolymer - it is biodegradable. Thus it will not contribute to greenhouse gases and other ~~pollution~~ unlike other petrochemical polymers it will not run out over time. However, at the moment production of PLA is inefficient - but as technology improves - the production methods shall be improved over time as well as the cost. Thus it can potentially replace petrochemicals in the future, especially in the textile industry as the amount of crude oil decreases and efficient methods of PLA production are developed.

Excellent

Question 21 (3 marks)

Marks

During an experiment a student immersed a series of different metals rods in an aqueous gel salt bridge as shown in the diagram below. The metal rods were then connected to each other, two metals at a time using connecting wires and a voltmeter.



Assembled beaker containing five half cells. Each electrode is submerged in its own salt solution. The conducting agar serves as the salt bridge.

- (d) Identify which combination of metal pairs you would expect to have the highest potential difference and state the theoretical value of this voltage.

Magnesium and Silver 1
 $2.36 - (-0.8) = 3.16 \text{ V}$

- (e) The measured voltages were found to vary somewhat from the theoretical results. Other than faulty equipment, explain why this might be.

Non standard conditions. 1
Oxidation of (Mg) electrode.

NB - internal resistance (eg through agar gel will effect current not voltage).

- (f) After a sufficiently long period of time the voltage of all cells approached zero. Suggest a reason for this.

@ Anode metal fully oxidised. 1

@ cathode cations fully reduced.

Reactants fully consumed - reaction has come to end

Masters' Initials

Candidate Number

Question 22 (4 marks)

Marks

During the course of the year you have performed a first-hand investigation to measure the potential difference between metals connected in a galvanic cell.

Draw a fully labelled diagram of your experimental set-up, identifying the metals and solutions used, the anode and the cathode and the direction of electron flow.

4

Good scientific drawing/labels Touching - 1 MARK
Correct set up including salt bridge & volt meter - 1 MARK
Identification of anode/cathode & electron flow - 1 MARK
Named metal electrodes plus all solutions - 1 MARK

Question 23 (6 marks)

Marks

A chemist wishes to make ethyl butanoate, which has a pineapple odour, in the laboratory. Describe the apparatus, reagents and procedure needed to synthesise this ester. Include a diagram in your answer. Explain how you would isolate this ester successfully using the data table below.

compound	boiling point (°C)
ethyl butanoate	120
ethanol	78
butanoic acid	163

Synthesis

Reflux (Heat & Condense)

Add conc H_2SO_4 to act as catalyst

Extra detail

est $CaCl_2$ added to neutralise acid

Reactants & products flammable and volatile; no naked flames

* Reflux on need for refluxing

* Production of 2 layers (aqueous

& ester) with different densities etc.

3 MARKS

Diagram - correct scientific drawing of reflux apparatus

1 MARK

Separation - name of process

justification in terms of data

2 MARKS

Exemplar

Question 23 (6 marks)

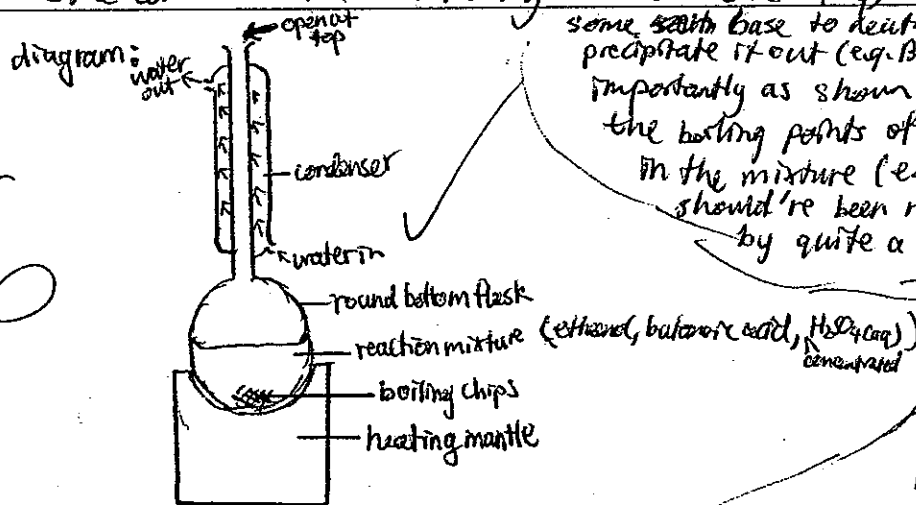
Marks

A chemist wishes to make ethyl butanoate, which has a pineapple odour, in the laboratory. Describe the apparatus, reagents and procedure needed to synthesise this ester. Include a diagram in your answer. Explain how you would isolate this ester successfully using the data table below.

compound	boiling point (°C)
ethyl butanoate	120
ethanol	78
butanoic acid	163
water	100

Reagents: ethanol, $\begin{matrix} H & H & H \\ | & | & | \\ H-C & -C & -C & -C-OH \\ | & | & | \\ H & H & H \end{matrix}$, butanoic acid $\begin{matrix} & & & O \\ & & & || \\ H & -C & -C & -C & -C-OH \\ | & | & | & | \\ H & H & H & H \end{matrix}$

To make this ester, the apparatus shown in the diagram below is set up, called "heating under reflux" equipment. The reagents ethanol & butanoic acid are added in calculated amounts to the round bottom flask. A few drops of concentrated $H_2SO_4(aq)$ are added as both a catalyst & a dehydrating agent (to increase equilibrium yield). The boiling chips are to prevent bumping. The condensers to prevent loss of ethanol & the product ester, both of which are volatile. The heating mantle is turned on for gentle heating after apparatus are all set up. The heating increases the rate of reaction for synthesising this ester. After a few hours, there should be some products formed in the reaction mixture. To separate the ester successfully first we ^{can} remove the $H_2SO_4(aq)$ by adding ^{some} ~~butanoic acid~~ some weak base to neutralise it or a salt to precipitate it out (e.g. $Ba(NO_3)_2$). But most importantly as shown from the table, the boiling points of the 3 substances in the mixture (excluding $H_2SO_4(aq)$ which should've been removed) all differ by quite a margin. Hence in this circumstance fractional/distillation can be performed to separate the ester from the 2 reagents. However there will be some impurity as water can cling or ethanol could cling on.



alternatively, water can be separated before fractional distillation to a reasonable extent by using separating funnel.

However, accurate repetitions of fractional distillation should successfully isolate the ester from the water, ethanol, & butanoic acids up to a decent degree. (e.g. 97%)

Good

6

JAG of fractional distillation can be performed to separate the ester from the 2 reagents. However there will be some impurity as water can cling or ethanol could cling on.

Masters' Initials

 Candidate Number

Question 24 (5 marks)

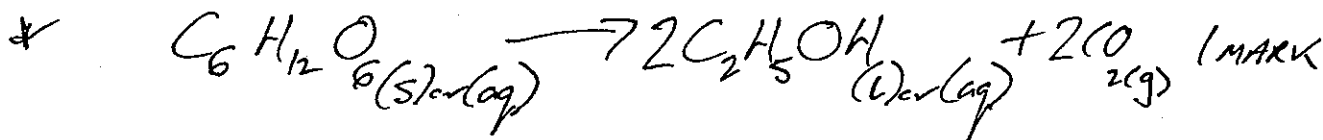
Marks

"The condensation polymer cellulose may be used as a starting material from which ethylene may be produced."

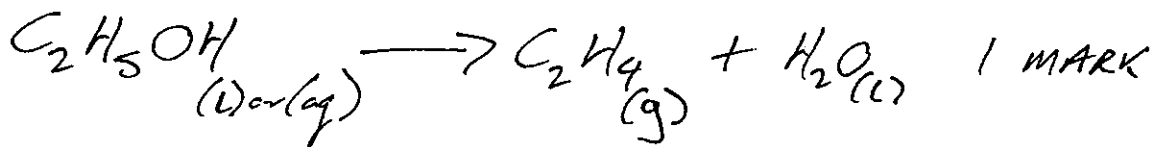
Discuss this statement, including the chemical steps required, a definition of the term condensation polymer and any relevant equations.

- * Defn of condensation polymer (produced by ejecting small molecule - NOT necessarily H_2O) } 5
 * Cellulose can be decomposed (by bacteria or acid hydrolysis) into glucose - NOT REQUIRED } 1 MARK

- * Glucose fermented to ethanol + 2 or more conditions } 1 MARK



- * Ethanol dehydrated to ethene with use of conc H_2SO_4 } 1 MARK



Many candidates didn't realise ethylene is a gas. Many candidates provided states on equations which were eligible.

Masters' Initials

Candidate Number

Exemplar

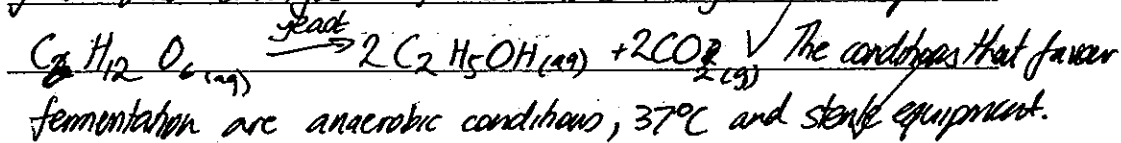
Question 24 (5 marks)

Marks

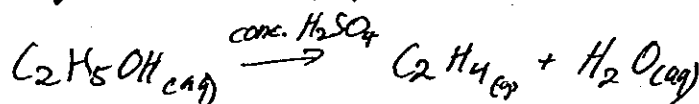
"The condensation polymer cellulose may be used as a starting material from which ethylene may be produced."

Discuss this statement, including the chemical steps required, a definition of the term condensation polymer and any relevant equations.

The condensation polymer cellulose is a major component of biomass, and can be used as the starting material from which ethylene may be produced. A condensation polymer is a long carbon chain formed by ^{the joining of} monomers and in the process ^{which} a small molecule such as water is a product. Cellulose can be hydrolysed into glucose, a costly and ^{heavy} energy requiring process. From here glucose can be fermented into ethanol, with the addition of yeast which catalyze the fermentation. The fermentation process is:



The ethanol mixture obtained from fermentation would now be distilled to get a pure ethanol mixture. This ethanol is then heated at approximately 180°C with the aid of a concentrated $H_2SO_4(aq)$ catalyst. The resulting products are ethylene and water:



Thus the condensation polymer cellulose can be used as the starting material from which ethylene is produced through the steps of hydrolysis, fermentation, distillation and fermentation.

Masters' Initials

Candidate Number

Exemplar

Question 24 (5 marks)

Marks

"The condensation polymer cellulose may be used as a starting material from which ethylene may be produced."

Discuss this statement, including the chemical steps required, a definition of the term condensation polymer and any relevant equations.

5

Cellulose is ~~one~~ ^{the most} abundant form of biomass in the world and if it could be harnessed to produce ethylene, we would be extremely excited. At the moment cellulose due to its strong linear structure and strong 1,4-glycosidic bonds is very difficult to break down. Nevertheless, it is a condensation polymer which is a polymer in which many monomers are added together with the release of a small molecule, usually water. If cellulose can be broken down as scientists in Japan are starting to do more effectively the polymer can produce glucose monomers which ~~would~~ are extremely vital. In the case of cellulose it has β -glucose monomers. Glucose monomers from here can be ~~be~~ fermented in order to form ethanol. As such $C_6H_{12}O_6 \xrightarrow[35^\circ C]{\text{yeast}} 2C_2H_5OH(aq) + 2CO_2(g)$. Thus, by using a low oxygen environment only $CO_2(g)$ can be released and hence can produce a greater amount of ~~ethanol~~ ethanol. The ethanol itself can be created into ethylene by using concentrated sulfuric acid as a dehydrating agent i.e. $C_2H_5OH(aq) \xrightarrow[\text{H}_2SO_4]{\text{concentrated}} C_2H_4(g) + H_2O(l)$. The dehydration of ethanol from here does form ethylene. Although the chemical steps follow as such the statement is slightly more difficult to perform than stated. In the case of cellulose as I said earlier, the difficulties in trying to break down its strong β -wire structure is extremely difficult and hence, although cellulose could be a good starting material it cannot be harnessed at this very moment.

ESS

Masters' Initials

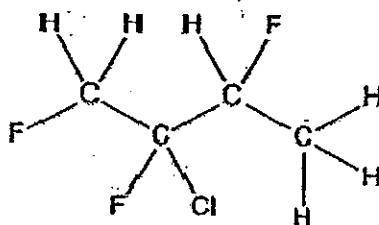
CR18

Candidate Number

Question 25 (2 marks)

Marks

(a) Identify the following compound:

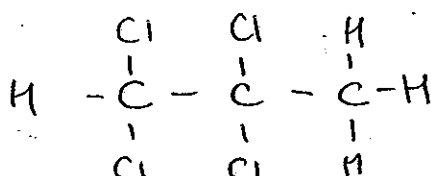


* needed
 - correct numbering
 - correct punctuation
 - trifluoro
 - BUTANE not propane

2-chloro-1,2,3-trifluorobutane

1

(b) Draw the structural formula for 1,1,2,2-tetrachloropropane.



1

Question 26 (3 marks)

Describe a quantitative test for total dissolved solids that you have performed on a water sample.

- ① - filter OR ② conductivity meter 3
 - weigh beaker/evap basin used to measure ion
 - evap water concentration. Needs to
 - re weigh be calibrated to
 - final - initial standards.
 (wholistic)

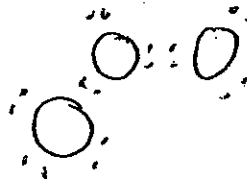
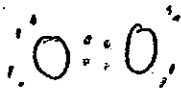
"gravimetric analysis" = 1

Question 27 (6 marks)

Marks

Oxygen exists as two allotropes, O₂ and O₃.

(a) Draw Lewis electron dot diagrams for each of these allotropes.



-1 if gave both Lewis electron dot & structural.

2

(b) Compare the effects of ozone in the lower atmosphere with its effects in the upper atmosphere.

lower: ^{damaging to environment} greenhouse gas, toxic to living things, can destroy lung tissue.

2

upper: protect earth / living things from harmful UV radiation

(c) Describe the effect of compounds such as CFC's on ozone in the upper atmosphere.

description (destruction of O₃, not prevention of O₃ formation) + equation (or very good description of full reaction) had to use Cl⁰ correctly
Cl⁰: not Cl⁻ or Cl atom

Masters' Initials

Candidate Number

Question 28 (5 marks)

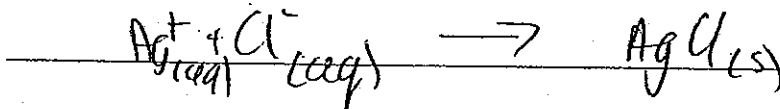
Marks

The following method was used to gravimetrically determine the concentration of chloride ions in a sample of seawater.

1. 10 mL of seawater were pipetted into a 100 mL conical flask.
2. 1.0 mL of 1M nitric acid was added to the conical flask.
3. Using a burette and constantly stirring, 0.50 M silver nitrate was slowly added to the solution until no more precipitate appeared.
4. The suspension was heated to just below boiling and then allowed to settle.
5. The precipitate was collected by filtration with a pre-weighed filter paper.
6. The filter paper was dried in a drying oven, and then re-weighed.

The mass of the filter paper was found to be 0.452g and the mass of the filter paper and precipitate was 0.792g.

- (a) Write a net ionic equation for the reaction that occurs in step 3 above.



needed
- starts
- balanced
- NET 1

- (b) Calculate the concentration of chloride ions in the seawater (in g L⁻¹).

mass AgCl = 0.340 g

moles AgCl = 2.37×10^{-3} (1)

mass Cl⁻ = 0.0841 g

Concentration = $\frac{0.0841 \text{ g}}{0.010 \text{ L}} = 8.41 \text{ g L}^{-1}$ (1)

- (c) Discuss the effectiveness of the method used above to find the concentration of chloride ions in seawater.

2 reasonable answers with a conclusion.

accepted * discussion of solubility

not accepted: * pipette might not be accurate

* slow (not "effective") * paper might not be dry.

* HNO₃(aq) to remove carbonates

* possibility of PO₄³⁻ or SO₄²⁻

* need for accurate balance and others.

* "other ions" if not specific

Question 29 (8 marks)

Marks

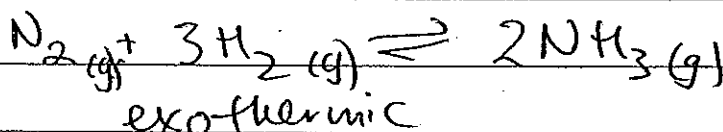
Ammonia is a choking alkaline gas which is an important industrial chemical.

- (a) Identify two industrial uses of ammonia.

fertiliser, cleaning product 2
 used to produce - fertilisers, nitric acid,
 dyes, nylons, acrylics, explosives

- (b) Write the equation for the Haber process and state whether the reaction is exothermic or endothermic.

\rightleftharpoons accepted, but do not use 2



needed - states - needed to state exothermic
 - balance lie. $\Delta H = -92 \text{ kJ mol}^{-1}$ (insufficient)

- (c) The Haber process is typically performed at temperatures between 400°C and 500°C. Account for this choice of temperature.

compromise or balance between the 2
 two factors (sufficient K.E. & favouring reverse rxn)
 Le Chat or v. good description

Question 29 continued on next page.

[]

Masters' Initials

[]

Candidate Number

Question 29 continued.

Marks

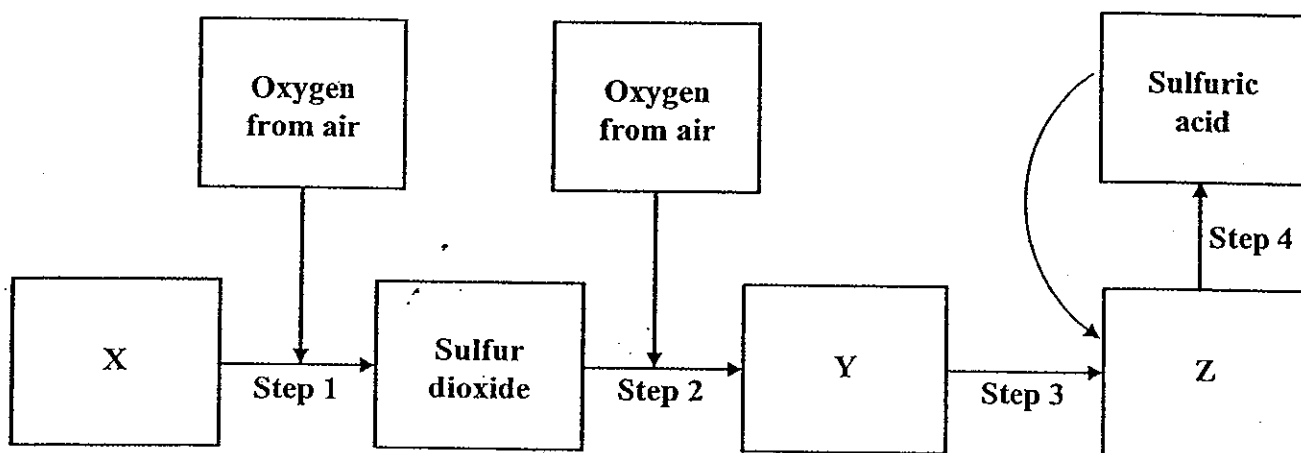
(d) Explain why monitoring the reaction vessel used in the Haber process is essential.

① Safety + details (e.g. pressure buildup) _____

② Maximise yield + details (e.g. catalyst poisoning, temp & pressure influences) _____

2

(a) This diagram summarises the steps in the industrial production of concentrated sulfuric acid.



(i) Identify X, Y and Z above in the process.

2

(ii) Outline the chemistry of the production of concentrated sulfuric acid starting from X. Include chemical equations for steps 1 and 3 in your answer.

4

(i) X - Sulfur,
 Y - sulfur trioxide
 Z - oleum

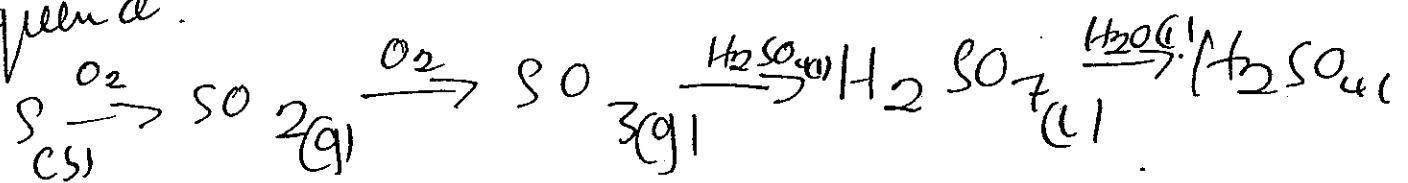
3 correct - 2 marks
 2 correct - 1 mark
 1, 0 - 0 marks

No penalty for 'ph' rather than 'f' in sulfur, but other spelling errors penalised.
 No penalty for wrong states if chemical formulae were quoted in this part (i).

(ii) Answer must include these two equations: (a) $S(s) + O_2(g) \rightarrow SO_2(g)$
 (or $SO_2(g)$ from an ore).

and (b) $SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7(l)$
 P.T.O.

And outline needs to include this sequence:



The outline may be done via more equations or description.

Equations cited on previous page + other steps above

Marks
4

All but one state must be correct in the equations

As above, but more than one error in states

3

Two correct equations from the previous page

2

Outline all four steps, but no equations

2

One equation from previous page and outline or 2-3 steps

2

A very basic attempt.

1

Page exemplar overleaf.

Q30.

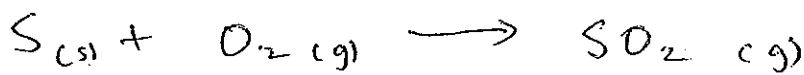
Example

- a) i) X = sulfur
Y = sulfur trioxide
Z = oleum

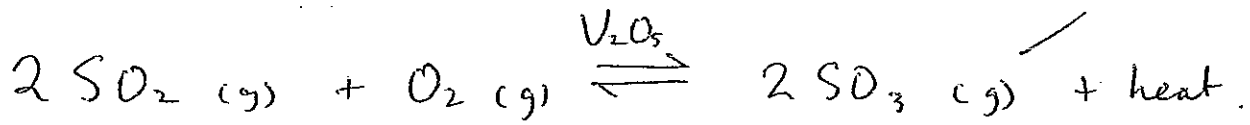
2

ii)

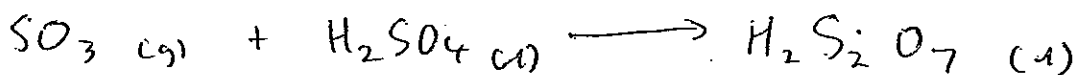
This sulfur is reacted with oxygen from air.



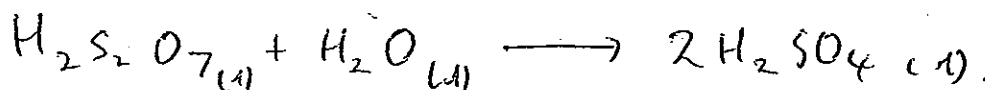
The sulfur dioxide reacts with oxygen in the air in the ~~equation~~ following eqn:



The $SO_3(g)$ produced is then reacted with sulfuric acid to form oleum.



The oleum is reacted with water to form concentrated sulfuric acid of about 18 M.



(11)

(iii)

State and justify the conditions used to maximize the rate and yield in the second step of the Contact process.

2

catalyst : V_2O_5
 (iii) temperature : $400 - 500^\circ C$
 pressure : 1-2 atmospheres. } (max

$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g) \Delta H < 0$
 while high temperatures drive the reaction to the left (in accordance with Le Chatelier's Principle), high temperatures are used in the process to improve reaction rates and hence the economic viability. While high pressure would favour the forward reaction, normal atmospheric pressure are usually used as high pressures require expensive equipment. A catalyst is used to increase reaction rates. (2)

3 conditions req'd : those above. Excess O_2 may also be included.

Marks

1

Justification of at least two conditions

1

See above example.
 Marking was 'tighter' than in (ii).

- (b) Explain how concentrated (18.4 M) sulfuric acid is diluted in the laboratory. Include all necessary safety precautions needed for the dilution of this concentrated acid.

3

Chemist needs to wear safety specs (or face shield), gloves and lab coat. 1 Mark

Dilution of 18.4 M H_2SO_4 in water
— strongly exothermic reaction 1

Conc. Acid must be added slowly, carefully into relatively larger volume of water so that local heating of the solution is avoided → stir the solution!

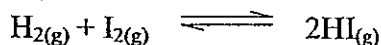
One mark for each point above.

See exemplar on following page.

b) The dilution of concentrated sulphuric acid is very exothermic. A large amount of heat is released in the dilution and this can cause the reaction to become violent and thus dangerous. Thus, the dilution of H_2SO_4 must be undertaken with strict procedure. Firstly, a SMALL amount of ACID should be added to a large amount of WATER. This allows the heat to spread over a large volume, and hence the dilution is safer. Further, whilst diluting the water must be continually stirred to allow for even (and safer) distribution of heat throughout water. To prevent any danger from acid splatter or chemical burning from the acid itself, full body protection must be worn. This includes a face mask (in case acid is sprayed), safety goggles, full labcoat, rubber acid resistant gloves.

- (i) 5 mol of hydrogen gas, 4 mol of iodine gas and 1.6 mol of hydrogen iodide gas were mixed together in a 2 L vessel at 900 K. After equilibrium had been attained, the vessel contained 3.6 mol of hydrogen. Calculate a value for the equilibrium constant for this reaction at 900 K:

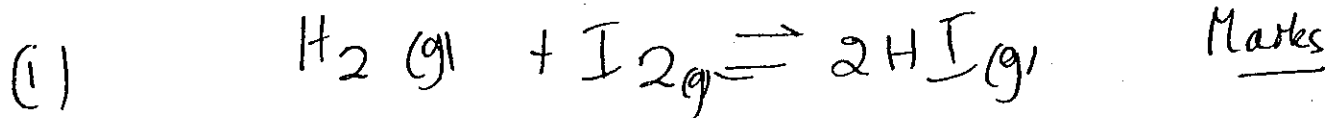
4



- (ii) Identify the change in conditions that will alter the value of K.

1

temperature only



n_{initial} 5 4 1.6

$n_{\text{at equilibrium}}$ (5 - 1.4) (4 - 1.4) (1.6 + 2.8)

$[]_{\text{at equilibrium}}$ $\frac{3.6}{2}$ $\frac{2.6}{2}$ $\frac{4.4}{2}$

$$K = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]}$$

$$= \frac{(2.2)^2}{1.8 \times 1.3}$$

$$= 2.1 \text{ (to 2sf)}$$

$$\text{or } 2 \text{ (to 1sf)}$$

one or two sf. only
accepted for full marks.

Marking - one error carried through
calculation - possibly 3 marks
if sig fig correct.

Expression for K and/or correct
substitution needs to be shown

One correct equilibrium concentration
+ correct method of
substitution in K expression

Marks

2