Section I
75 marks

Part A – 15 marks
Attempt Questions 1-15
Allow about 30 minutes for this part

Use the multiple choice answer sheet on page **7**

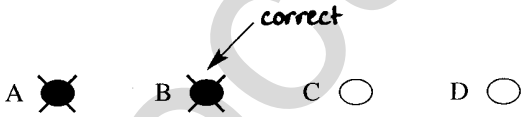
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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

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.

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.



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1. Consider the following reactions:

(i) $Ag^+ + Cl^- \rightleftharpoons AgCl$

(ii) $CH_4 + O_2 \rightarrow CO_2 + 2\,H_2O$

(iii) $Mg + 2\,HCl \rightarrow MgCl_2 + H_2$

(iv) $Mg(OH)_2 + HCl \rightarrow MgCl_2 + H_2O$

Which of the reactions can be considered an acid-base reaction(s).

(A) (i), (ii), (iii), (iv)

(B) (i), (iii) and (iv) only

(C) (iv) only

(D) (i) only

2. Which of the following equations represent the Haber process?

(A) $N + 3H \rightarrow NH_3$ $\Delta H = -91$ kJ

(B) $N_2 + 3H_2 \rightarrow 2NH_3$ $\Delta H = -91$ kJ

(C) $N_2 + 3H_2 \rightleftharpoons 2NH_3$ $\Delta H = +91$ kJ

(D) $N_2 + 3H_2 \rightleftharpoons 2NH_3$ $\Delta H = -91$ kJ

3. An unknown solution may contain one or more of the following ions: Mg^{2+}, SO_4^{2-}, CO_3^{2-}, Pb^{2+}, Cl^-
The solution gave a white precipitate with $Ba(NO_3)_2$ but no reaction with H_2SO_4.

Which of the ions may be present ?

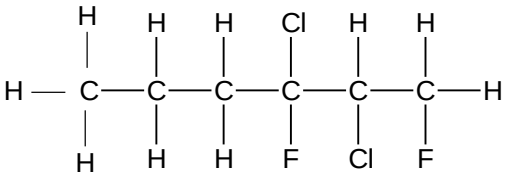
(A) Mg^{2+} and Cl^-

(B) Pb^{2+} and Cl^-

(C) Mg^{2+} and SO_4^{2-}

(D) Mg^{2+} and CO_3^{2-}

4. Consider the following haloalkane:



Which of the following is an isomer of the compound ?

(A) 1,1-dichloro-2-fluorohexane

(B) 1,2,5-trichloro-2-fluorohexane

(C) 1,3-dichloro-2,3-difluorohexane

(D) 2,3-dichloro-1,3-difluorohexane

5. A chemist wants to test for the presence of iron (III) ions in a water sample collected outside a factory. Which anion could be used to test for the presence of iron (III) ions in the water?

(A) SO_4^{2-}

(B) NO_3^-

(C) OH^-

(D) Cl^-

6. What is the product of adding bromine water to 2-hexene?

(A) 2,3-dibromohexene

(B) 2,3-dibromohexane

(C) 1,2-dibromohexane

(D) 1,2-dibromocyclohexene

7 Where on the Periodic Table would you most likely find elements which form basic oxides?

(A) Group 1

(B) Group 6

(C) Period 2

(D) Period 3

8. Which elements on the Periodic Table have radioisotopes?

(A) Only those elements after uranium.

(B) Only the actinides.

(C) Only elements with unstable proton-neutron ratio.

(D) Only metallic elements

9. A student constructed a galvanic cell using two different metals and electrolytes of the nitrates of the metals, under standard conditions.

Which combination of metals would give the greatest potential difference?

(A) copper and silver

(B) manganese and silver

(C) zinc and copper

(D) magnesium and zinc

10. The molar heat of combustion of propane is given in the data book as 2200 kJ mol^{-1}. What does this mean?

(A) 1 g of propane releases 2200 kJ of heat

(B) 44 g of propane releases 2200 kJ of heat

(C) 1 g of propane absorbs 2200 kJ of heat

(D) 44 g of propane absorbs 2200 kJ of heat

11. Which of the following is a common natural source of sulfur dioxide in the atmosphere?

(A) The action of sunlight on S and O_2

(B) Smelting metal ores

(C) Soil bacteria

(D) Volcanoes

12. Which of the following may be used as a catalyst in esterification?

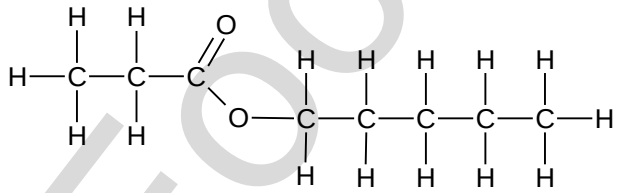
(A) H_2SO_4

(B) C_2H_5OH

(C) CH_3COOH

(D) H_2O

13. What is the name of the ester given below?



(A) butyl pentanoate

(B) pentyl butanoate

(C) propyl pentanoate

(D) pentyl propanoate

14 A soft drink may be decarbonated by heating. In observing the results, the equilibrium between gaseous and dissolved carbon dioxide can be examined.

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

What conclusion can be drawn about this reaction?

(A) The forward reaction is exothermic.

(B) Only the reverse reaction rate is increased with heating.

(C) Heat is absorbed in the reaction shown above.

(D) Only the forward reaction rate is increases with heating.

15. Which correctly describes the relationship between an acid and its conjugate base?

(A) They are ions of opposite charge.

(B) They both contain H atom.

(C) They neutralize each other to form a salt.

(D) They have formulae that differ by a proton.

Student Number ……

Section I **Marks-----/15**
Part A

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 ●

Section I (continued)

Part B - 60 marks
Attempt Questions 16 to 28.
Allow about 1 hour and 45 minutes for this part

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations

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Marks

Question 16 (5 marks)

A buffer is known to contain two of these substances:

sodium dihydrogen phosphate sodium hydrogen phosphate
ethanoic acid sodium ethanoate

(a) Define a buffer **1**

A solution that contains comparable amounts of a weak acid and its conjugate base and which is therefore able to maintain an approximately constant pH even when significant amounts of strong acid or base are added to it.

(b) Using an equation, explain how the substances can be used as a buffer. **2**

$CH_3COOH\,(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$ (1 mark)

When an acid (H_3O^+) is added to the buffer solution, the ethanoate ion combines with the hydronium ion, in effect, shifting the equilibrium to the left, reducing the hydronium concentration.
When a base is added, the OH^- combines with the hydronium, shifting the equilibrium to the right to replenish the hydronium which combined with the OH^-, maintaining the pH.

(c) Use balanced ionic equations to demonstrate how one of the above compounds can behave as an amphiprotic substance. **2**

$HPO_4^{2-} + H_3O^+ \rightleftharpoons H_2PO_4^- + H_2O$ *as a base* *(1 mark)*

$HPO_4^{2-} + OH^- \rightleftharpoons PO_4^{3-} + H_2O$ *as an acid* *(1 mark)*

Marks

Question 17 (8 marks)

Sulfate in fertilizer may be analysed gravimetrically by precipitating the sulfate with barium ion and weighing the sulfate produced after filtering and drying. To test the technique, which is exactly what YOU did in the lab, a group of students performed the analysis on pure ammonium sulfate. They obtained the following results.:

Mass of sample of ammonium sulfate: 2.34 g

Mass of filter paper: 0.203 g

Mass of filter paper + 'dried' precipitate: 4.65 g

(a) Calculate:

(i) the theoretical percentage of sulfate in ammonium sulfate **2**

Answer:

$$theoretical\ percentage = \frac{M\ sulfate}{M\ ammonium\ sulfate}\ x\ 100\ \% = \frac{32.07\ +\ 4(16.00)}{2[(14.01)+4(1.008)\ +\ 32.07\ +\ 4(16.00)} = 72.7\ \%$$

Criteria	*Mark*
Correct formula for ammonium sulfate and correct answer	2
Incorrect formula for ammonium sulfate but correct equation for theoretical percentage	1

(ii) the experimental percentage of sulfate in ammonium sulfate **3**

mass of $BaSO_4$ = 4.65 g – 0.203 = 4.447 g

mole of SO_4^{2-} = mole of $BaSO_4 = \frac{mass\ of\ BaSO_4}{M\ of\ BaSO_4} = \frac{4.447}{233.37} = 0.01906$ mole (1 mark)

mass of SO_4^{2-} = 0.01905 x M sulfate = 1.83 g (1 mark)

$$Experimental\ percentage\ = \frac{mass\ of\ sulfate}{mass\ of\ sample}\ x\ 100\ \% = \frac{1.83}{2.34}\ x\ 100\ \% = 78.2\ \%$$ *(1 mark)*

(b) Assess the accuracy of the above determination. Identify and explain two possible sources of error that can contribute to this particular discrepancy. **3**

The analysis is inaccurate by about 6%. This is more than the normal expected error in chemical analyses: Two reasons for a higher value are:

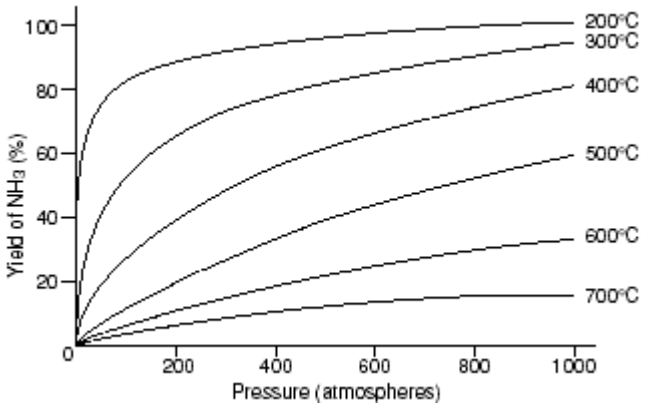
(a) The $BaSO_4$ was not dried properly. Moisture in the $BaSO_4$ precipitate increases the mass of the precipitate and hence calculated as $BaSO_4$

(b) *The precipitate was not washed properly to remove excess $BaCl_2$. This increased the mass of the '$BaSO_4$ ' precipitate.*

Marks

Question 18 (6 marks)

The graph shows the variation in percentage yield of the product with pressure at various temperatures for the Haber process.



(a) Based on the graph, what conditions of temperature and pressure give the best yield for this process? Justify your answer. **2**

According to the graph, the best conditions to obtain maximum yield is between 800 - 1000 atm of pressure and 200 ^0C . at this temperature and pressure, the yield is almost 100 %. (2 marks)

(b) In industry, the conditions usually used are 400 ^oC and 500 atm pressure. Explain the reason(s) for the use of these conditions. **2**

These are compromise conditions. The higher temperature than the optimum (200^0C) is adapted to hasten the attainment of equilibrium. Use of a lower temperature may maximise yield but will be slow to attain equilibrium. The lower pressure is for economic considerations as well, since, high pressure equipment are more expensive and are also expensive to run.

*(*Both temperature and pressure must be dealt with to get the 2 marks

(c) Identify the chemical composition of the catalyst used in this reaction and explain its role. **2**

A catalyst (Fe_3O_4 – Fe) magnetite (surface reduced to Fe) is a catalyst used for the Haber process. A catalyst enables the process to use a moderate temperature and still maintain a reasonable rate of reaction. The catalyst lowers the activation energy for this reaction by serving as a surface on which the reaction can occur efficiently.

1 mark for mentioning a catalyst and 1 mark for the role of the catalyst in maintaining a reasonable rate.

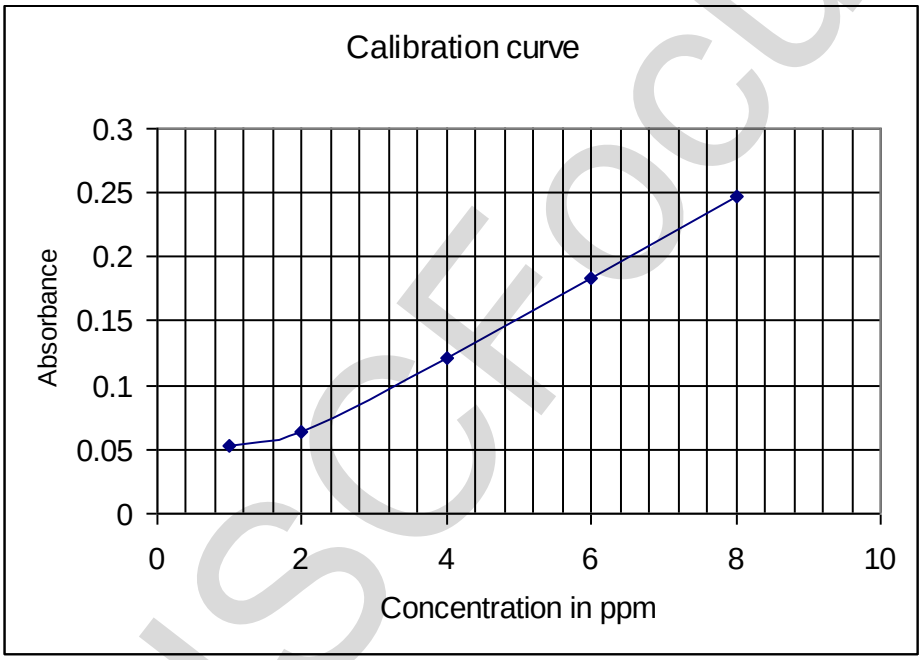
Marks

Question 19 (5 marks)

A group of students were assigned to determine the copper ion content of a certain brand of spring water. They prepared a series of standard copper ion solutions in *distilled* water and analysed the standard solutions and the undiluted spring water with the AAS instrument. They also tested some *distilled* water which they used to prepare the standard solutions. The results are given below:

Solution	*Cu^{2+} ion concentration (ppm)*	*Absorbance*
Standard 1	1.0	0.0521
Standard 2	2.0	0.0634
Standard 3	4.0	0.1205
Standard 4	6.0	0.1834
Standard 5	8.0	0.2467
Spring water	unknown	0.0412
distilled water	unknown	0.0501

(a) Construct a well labelled calibration curve for this determination. **3**



Criteria	*Mark*
proper orientation of graph (dependent/independent variable)	1
labelled axes with correct units/proper scaling	1
correct plotting	1

Marks

(b) Comment on the validity of the distilled water as a control. **2**

The distilled water is not valid as a control because it gives an absorbance reading which is higher than the absorbance reading for the spring water.

Question 20. (2 marks)

Identify and describe two everyday uses of indicators. **2**

Possible answer:

- *Indicators may be used to test the pH of swimming pools. Pool test kits using a certain indicator (phenol red) ensures that pool pH is within the accepted level of acidity (pH 7.2 – 7.6).*
- *Soil pH testing allow farmers to determine the suitability of the soil for certain crops*

Question 21 (8 marks)

Compare addition and condensation polymers using named examples of each type of polymer. **8**

- *Addition polymer: polyethene, monomer = ethene* (1 mark)
  Condensation polymer: cellulose, monomer = glucose (1 mark)

- *Addition polymerization-* *long chain molecules produced by small monomer molecules adding together without the loss of any atoms. The double bond "opens out" to form single bonds with neighbouring molecules.* (1mark)
- *Condensation polymerization-* *a long chain molecule produced from smaller molecules (monomers) via the removal of a small molecule, in this case, water.* (1 mark)

Reactions: (2 marks)

Addition polymerization

$n\ CH_2{=}CH_2 \rightarrow —(CH_2 - CH_2)_n—$

Condensation polymerization

$n\ (HO – C_6H_{10}O_4 – OH) \rightarrow H —(O- C_6H_{10}O_4)_n—OH + (n-1)\ H_2O$

Uses: (2 marks)

polyethene – making milk bottles, soft toys, cling wrap, rubbish bins etc

cellulose - major structural component of plant material or biomass (strengthens cell walls) using cellulose to make ethanol for energy production etc.

Marks

Question 22 (6 marks)

Ethylene can be transformed into many useful substances other than plastics.

(a) Complete the table for two substances derived from ethene other than plastics **4**

Name of useful substance	*Use*
ethanol	*fuel, solvent* (1 mark)
ethylene glycol	*antifreeze* (1 mark)

(b) Write a balanced chemical equation to describe the formation of one of the substances listed in (a). **2**

$$C_2H_4(g) + H_2O(l) \xrightarrow{sulfuric\ acid} C_2H_5OH\ (aq)$$

Criteria	*Mark(s)*
balanced equation including any conditions	2

Marks

Question 23 (8 marks)

A student made these observations after doing the reactions:

- Metal X did not react with 1 molL^{-1} solution containing Y^{2+} ions.
- Metal Y in a 1 molL^{-1} solution of Z^{2+} ions formed metal Z
- Metal Z did not react with a 1 molL^{-1} solution of X^{2+}

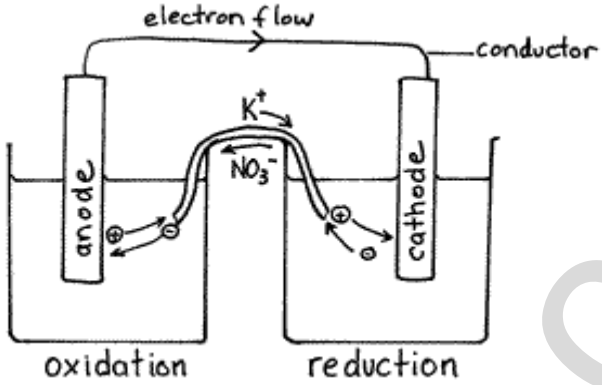
(a) List the metals X, Y and Z in order of increasing ease of oxidation. **1**

Z, X, Y (1 mark)

(b) List the ions in order of increasing ease of reduction. **1**

Y^{2+}, X^{2+} , Z^{2+} (1 mark)

(c) Draw a labelled diagram of an electrochemical cell made with two of the above metals that would produce the greatest voltage. Indicate on your diagram which is the anode and cathode and the direction of electron flow. **5**



Y (anode) in $Y^{2+}_{(aq)}$ *Z cathode in* $Z^{2+}_{(aq)}$

Marking Scheme: *1 mark each for*

- *correct choice of Y and Z;*
- *Y labeled anode in* Y^{2+} *;*
- *Z labeled cathode in* Z^{2+}*,*
- *salt bridge labeled;*
- *electron flow correct,*

(d) Write a balanced net ionic equation for the chemical reaction. occurring in the electrochemical cell

$Y(s) + Z^{2+}(aq) \rightarrow Z(s) + Y^{2+}(aq)$ (1 mark)

1

Marks

Question 24 (5 marks)

Consider the properties of three acids.

Acids	*pH*
0.1 $molL^{-1}$ acetic acid	2.9
0.1 $molL^{-1}$ citric acid	2.1
0.1 $molL^{-1}$ hydrochloric acid	1.0

(a) Give the systematic name for citric acid **1**

2-hydroxypropane-1,2,3-tricarboxylic acid

1 mark for the correct name

(b) Explain the difference in pH between the three acid solutions. **2**

Marking Criteria	***Marks***
Explains the complete and incomplete ionisation of acids and links to pH	*2*
Identifies HCl as a strong acid and acetic and citric acids as weak acids	*1*

(c) Calculate the pH after 100mL of 0.1 $molL^{-1}$ hydrochloric acid solution is diluted by the addition of 400mL of distilled water. **2**

Possible answer:

$c1v1 = c2v2$

$0.1 \times 0.1 = c2 \times 0.5$

$c2 = 0.02\ molL^{-1}$

$pH = -\log [H^+]$

$= \mathbf{1.7}$

Correctly calculates pH with relevant working,(1 mark.)

Marks

Question 25 (3 marks)

A source of sulfur dioxide in the atmosphere is the burning of coal in power stations. Calculate the volume of sulfur dioxide released at 25^0C and 100kPa when 10.0 million kg of coal containing 0.01% sulfur, is burnt. **3**

Calculation:

mass of sulfur = 10^6 g

mol of sulfur = 3.12 x 10^4 mol

mol of sulfur = mol SO_2

volume SO_2 = mol x 24.79

= 7.73 x 10^5 L

Marking Criteria	Marks
Correct answer showing all relevant working	3
2 of those below	2
Multiplies incorrect moles by 24.79 ***or*** *Correct equation* ***or*** *Correct calculation of mol of sulfur* ***or*** *Correct calculation of mass of sulfur*	1

Question 26 (4 marks)

An ester is prepared in the laboratory by refluxing a mixture of appropriate alkanol and alkanoic acid using acid catalysis.

Identify two potential safety hazards and describe the experimental procedures that may be used to minimize these hazards in the preparation of the ester. **4**

Possible answer

- *The components being heated are flammable. The reflux condenser allows the flammable components to condense and return to the reaction vessel.*
- *Build-up of gas pressure. The top of the condenser is open so that no build -up of pressure can take place.*

Marking Criteria	***Marks***
Two hazards identified and safety steps described to minimize the hazard	*4*
Two hazards identified and one safety step described to minimize the hazard	*3*
Two hazards identified or one hazard and one safety step described	*2*
One hazard identified	*1*

Chemistry

Section II

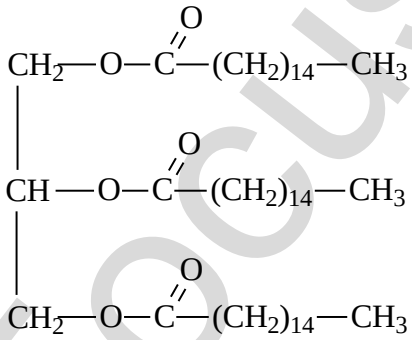
25 marks

Attempt question 27
Allow about 45 minutes for this section

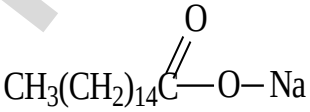
Answer the question in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations.

Question 27 (5 marks) **Outcomes ~ H8, 9** **MARKS**

(a) Glyceryl tripalmitate is a raw material used to make soap…



(i) Construct the structural formula of the soap formed from glyceryl tripalmitate. **1**



(ii) Identify the special type of mixture which forms when the soap is shaken with glyceryl tripalmitate **1**

The mixture of soap, water and glyceryl tripalmitate would form an emulsion.

(iii) Other than glyceryl tripalmitate identify another fat or oil which can be used to make soap. **1**

Tallow, lard, coconut oil, olive oil, rice bran oil, etc. (Common or chemical name)
► Not palm oil

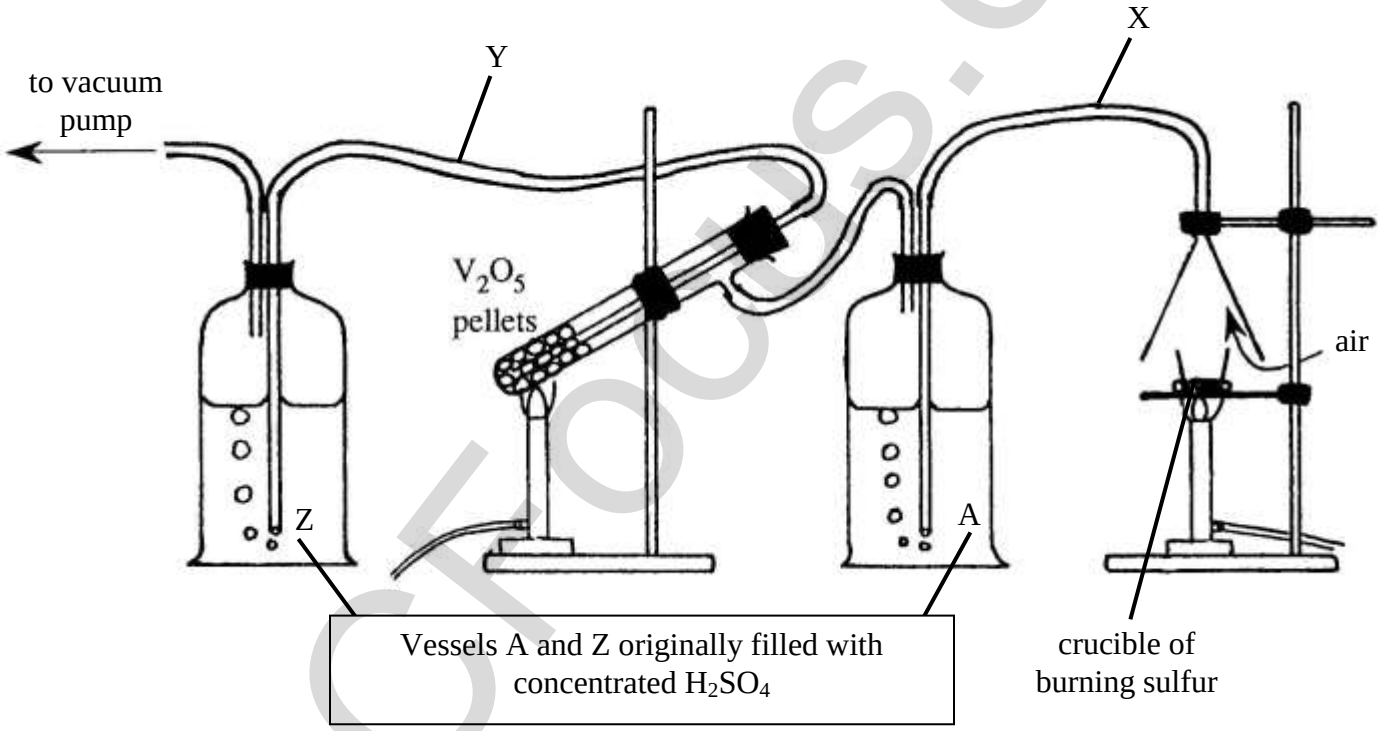
(iv) Compare the environmental impacts of the use of soaps and non–phosphate detergents. **2**

The use of soap has a low impact on the environment because of their biodegradability.
(1 mark)

Detergents have a higher impact on the environment because they are less biodegradable and they contain other ingredients (e.g. zeolites) which can cause harm to aquatic ecosystems.
(1 mark)

<u>Outcomes</u> ~ H8, 11

(b) In his quest for the *BHP Science Prize*, Ken Chemiski plans to prepare sulfuric acid using this relatively simple apparatus. Sulfur is burned in a crucible and the gas flow is forced through the apparatus using a vacuum pump.



(i) Evaluate the feasibility of Ken's apparatus to produce sulfuric acid ignoring safety issues **2**

Ken's apparatus is perfectly feasible as a small scale Contact Process.
The apparatus provides all the raw materials and conditions necessary to produce sulfuric acid.

Supporting evidence (1 mark) ***Judgement (1 mark)***

(ii) Compare the gas composition in tube X with tube Y. **2**

Tube X contains SO_2 <u>and</u> air. (1 mark) Tube Y contains SO_3. (1 mark)

(iii) Identify the role of the concentrated sulfuric acid in vessel A **1**

The concentrated H_2SO_4 dehydrates the air before it reaches the V_2O_5.

(iv) Construct a chemical equation for the reaction of gas Y as it bubbles through vessel Z. **1**

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

(c) Chlorine gas can be prepared industrially by this equilibrium reaction…

$$4HCl_{\,(g)} + O_{2\,(g)} \rightleftharpoons 2Cl_{2\,(g)} + 2H_2O_{\,(g)}$$

An industrial chemist performs a small scale synthesis of this reaction in a two litre stainless steel tank and records this data…

	HCl	O_2	Cl_2	H_2O
Initial moles	0.548	0.625	0	0
Final moles at equilibrium	0.200	0.538	0.174	0.174

(i) Calculate the equilibrium constant from the data. **3**

[HCl] = 0.200 mol ÷ 2.00 L = 0.100 mol L^{-1}
[O_2] = 0.538 mol ÷ 2.00 L = 0.269 mol L^{-1}
[Cl_2] = 0.174 mol ÷ 2.00 L = 0.0870 mol L^{-1}
[H_2O] = 0.174 mol ÷ 2.00 L = 0.0870 mol L^{-1}

Conversion from moles to mol/L (1 mark)

$$K_{eq} = \frac{[Cl_2]^2 \times [H_2O]^2}{[HCl]^4 \times [O_2]}$$

K_{eq} expression (1 mark)

$$= \frac{(0.0870)^2 \times (0.0870)^2}{(0.100)^4 \times (0.269)}$$

$$= 2.13$$

K_{eq} Evaluation (1 mark)

(ii) Identify how the value of the equilibrium constant could be changed. **1**

The only factor that changes the value of the K_{eq} is temperature.

(iii) Explain, using Le Châtelier's principle, how a change in volume will affect the equilibrium. **2**

The reaction equation shows the change in the gas volumes…

4 vol HCl + 1 vol O_2 $\rightleftharpoons$ 2 vol Cl_2 + 2 vol H_2O

According to Le Châtelier's principle, a reduction in volume (realised by a increase in pressure) would shift the equilibrium to the right or vice versa. (2 marks)

(iv) Calculate the theoretical volume of chlorine produced at 25°C and 100 kPa, if the reaction went to completion. **2**

HCl is the limiting reactant.

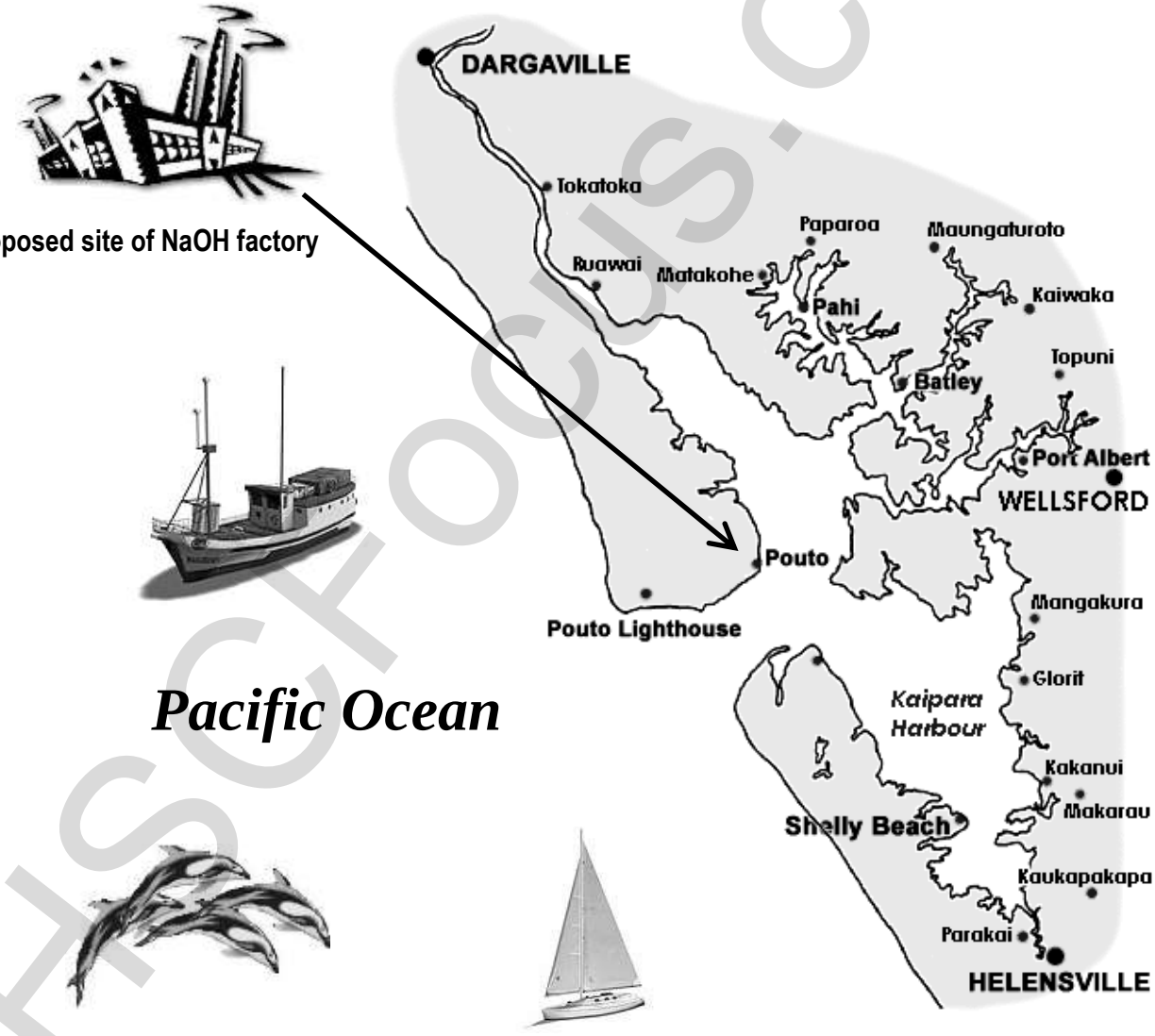
Moles Cl_2 = ½ moles HCl = ½ × 0.548 mol = 0.274 mol (1 mark)

Volume Cl_2 = n × 24.79 L mol^{-1} = 0.274 mol × 24.79 L mol^{-1} = 6.79 L (1 mark)

(d) Kaipara Harbour has a surrounding population of 75,000 with a mixed economy including dairy farming, market gardens, commercial prawn trawling in the harbour and offshore tuna fishing. Three companies have expressed interest in building a sodium hydroxide production facility at Pouto located in Kaipara Harbour.

HGCL Ltd. has plans for a mercury process plant; ***Mem-chlor-tech*** is proposing a membrane process plant;
and ***Chlorox Industries*** has plans for a diaphragm process plant.

Imagine you are an Environmental Chemist for the Kaipara Regional Planning Authority and have been given the task of writing an environmental risk assessment comparing all three plant proposals and making recommendations as to which proposal should be approved. **6**



►

Environmental Risk Assessment
for
Proposed Sodium Hydroxide Plant at Puoto

All three proposed sodium hydroxide plants pose environmental risks to Kaipara Harbour. Outlined below are the specific risks associated with the method of production…

HGCL Ltd. ~ mercury process

This process uses sizeable amounts of liquid mercury in the production process.

- Mercury can and does escape from plants. Escaped mercury can be converted into dimethyl mercury by marine micro-organisms. Dimethyl mercury readily enters the food chain and bio-accumulates in higher organisms, e.g. tuna and man.
  Japan has banned the use of mercury process plants due to their inherent toxic hazards.
- Hydrogen gas is a by-product of the process and poses explosive risk.
- Leakage of caustic sodium hydroxide is a possibility.

Mem-chlor-tech ~ membrane process

This process is the most modern having undergone continuous development since the 1980s.

- The membrane process is 'clean' with no inherent environmental hazards.
- Hydrogen gas is a by-product of the process and poses explosive risk.
- Leakage of caustic sodium hydroxide is a possibility.

Chlorox Industries ~ diaphragm process

This process makes use of asbestos as a separator between the electrodes.

- Asbestos is considered a high risk to workers and the surrounding community.
  The asbestos is routinely replaced during periodic maintenance and strict protocols must be followed in its handling and disposal.
- Hydrogen gas is a by-product of the process and poses explosive risk.
- Leakage of caustic sodium hydroxide is a possibility.

RECOMMENDATION

(1) Mem-chlor-tech's membrane plant poses a manageable risk and should be considered for approval.
(2) The proposals of HGCL Ltd. and Chlorox Industries should be rejected due to significant inherent environmental risks.

Risks

Description of mercury risk (1 mark)

Description of asbestos risk (1 mark)

Description of hydrogen risk (1 mark)

Description of sodium hydroxide risk (1 mark)

Citing hydrogen and sodium hydroxide as common to all processes (1 mark)

Recommendation

Recommend Mem-chlor-tech (1 mark)