Name: _____ Index Number: _____ Class: _____

TEMASEK SECONDARY SCHOOL
Preliminary Examination 2024
Secondary 4 Express

CHEMISTRY **6092/02**

Paper 2 (Section A) Total duration for Sections A and B: 1 hour 45 minutes

Candidates answer on the Question Paper.
No additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer all questions in the spaces provided on the question paper.

At the end of the examination, submit **Section A and B separately**.

The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on page **7** in Section B.

The use of an approved scientific calculator is expected, where appropriate.

FOR EXAMINER'S USE	
Section A	/70

Section A
Answer all the questions in this section in the spaces provided.
The total mark for this section is 70.

A1 The list below shows the chemical formulae of some substances.

$(NH_4)_2SO_4$	Ag_2CO_3	NaBr
$ZnCl_2$	$CaCl_2$	$FeSO_4$
Al_2O_3	KNO_3	SiO_2

Use the list to answer the questions below. The substances can be used once, more than once, or not at all.

(a) State one substance that is coloured.

……... [1]

(b) State one substance that reacts with both an acid and an alkali.

……... [1]

(c) State one substance that can be prepared by precipitation.

……... [1]

(d) State one substance that is commonly used as a fertiliser.

……... [1]

(e) State one substance that is used as a catalyst in the cracking of large hydrocarbons into useful shorter fractions.

……... [1]

[Total: 5]

A2 Fig. 2.1 shows the arrangement of the apparatus for an experiment that is carried out to study the reactivity of metals.

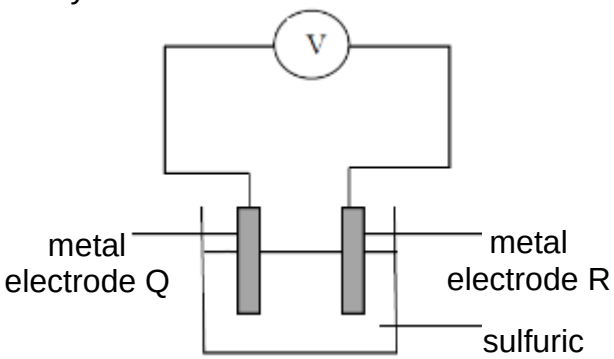


Fig. 2.1

Table 2.1 shows the results obtained from the experiment using metal electrodes P, Q, R and S.

Table 2.1

pair of metal electrodes	voltmeter reading/ V	negative terminal
Q and R	2.7	metal Q
R and S	1.1	metal S
S and P	0.3	metal S
Q and S	X	metal Q
P and R	0.8	metal P

(a) Explain, in terms of structure and bonding, why the metal electrodes can conduct electricity.

……...……...

……...……...

……...…….. [2]

(b) Based on Table 2.1, arrange the metals P, Q, R and S in decreasing reactivity.

…….. [1]

(c) Suggest the value of X.

……... [1]

(d) Name the process that took place at the negative terminal.

……... [1]

(e) Will any reaction occur when metal P is heated with oxide of metal R? Explain your answer.

……...

……... [2]

[Total: 7]

A3 Amino acids may be separated by using two-dimensional paper chromatography. This involves putting a spot of the mixture on the corner of a piece of chromatography paper and allowing a solvent to soak up the paper. The paper is then dried, turned through 90° and placed in a second solvent. This method gives better separation than a one solvent method.

Table 3.1 shows the R_f values for some amino acids in two different solvents.

Table 3.1

amino acid	R_f in solvent 1	R_f in solvent 2
A	0.1	0.2
B	0.0	0.4
C	0.3	0.0
D	0.8	0.9

(a) State the amino acid that is the most soluble in both solvents.

……... [1]

(b) State the amino acid which did not move at all in solvent 2.
State a conclusion that you can make from this observation.

……... [2]

(c) Use the grid in Fig. 3.1 to plot the positions of the amino acids after two-dimensional paper chromatography using solvent 1 followed by solvent 2.

The positions of amino acid B and C have been plotted for you.

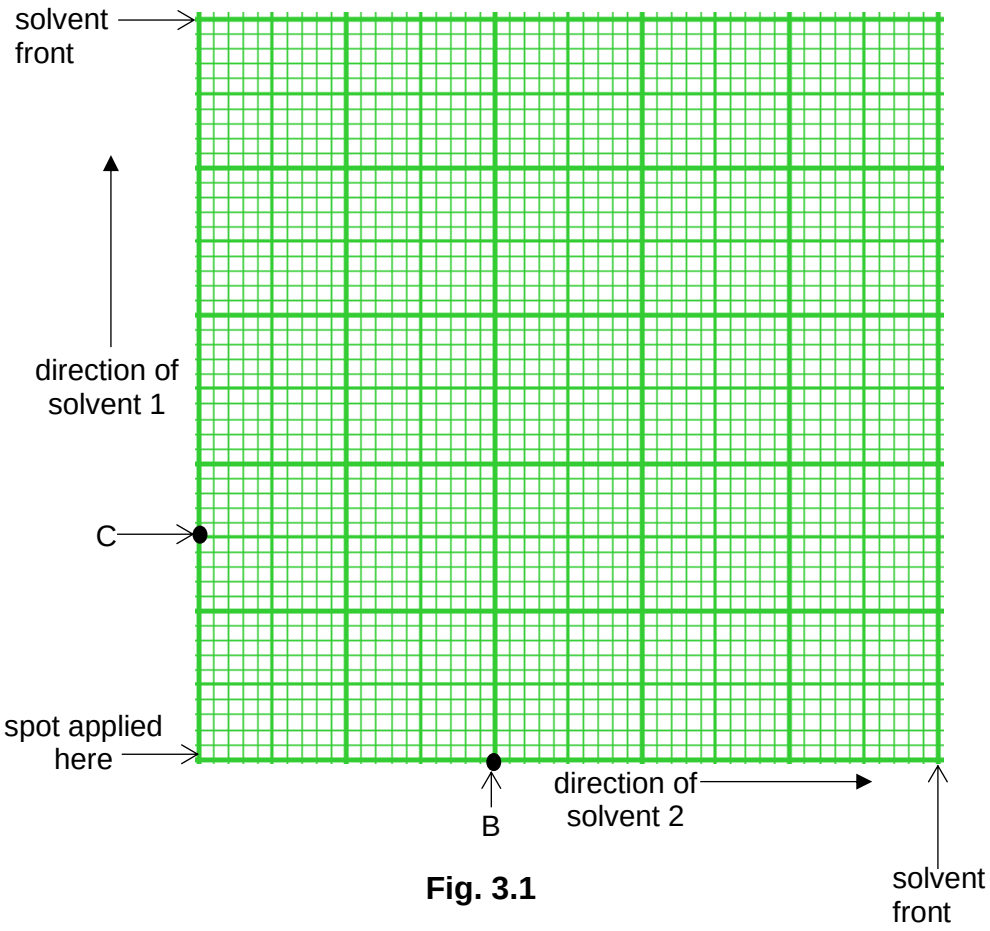


Fig. 3.1

[2]

(d) Amino acids are colourless.

Briefly explain what must be done before measurements of R_f values can be taken.

…… [1]

[Total: 6]

A4 Naphtha is a fraction of crude oil.
The molecules in naphtha are hydrocarbons with 5 to 12 carbon atoms.
Naphtha can undergo cracking in an oil refinery.

(a) State an industrial use of the fraction naphtha.

……... [1]

(b) One molecule in naphtha is a saturated hydrocarbon with 5 carbon atoms.

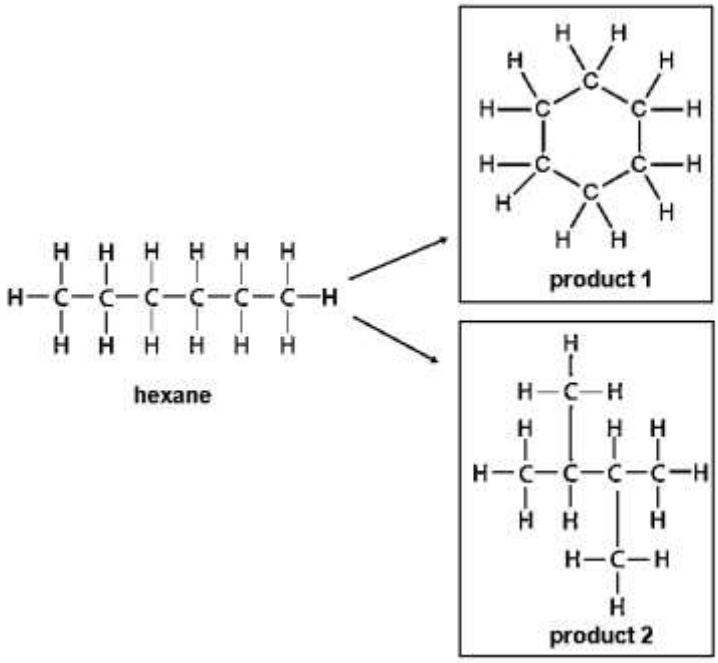
When this molecule undergoes cracking, it produces ethene and another product.

Write an equation, showing **full structural formulae**, for this reaction.

[2]

(c) In another process, hexane is passed over a heated catalyst and several products are formed.

Two of the products are shown below.



Which one of the two products is an isomer of hexane?
Explain your reasoning.

……...

……...

……... [2]

[Total: 5]

A5 0.100 mol/dm^3 sodium hydroxide solution is added from a burette to a beaker of 50.0 cm^3 of 0.100 mol/dm^3 of hydrochloric acid. The change in pH is plotted against the volume of sodium hydroxide added.

In a separate experiment, the 0.100 mol/dm^3 sodium hydroxide solution is added to another beaker of 50.0 cm^3 ethanoic acid and the change in pH is plotted in the same axes as show in Fig. 5.1.

The colour change interval of two indicators: phenolphthalein and methyl red, are also shown in Fig. 5.1.

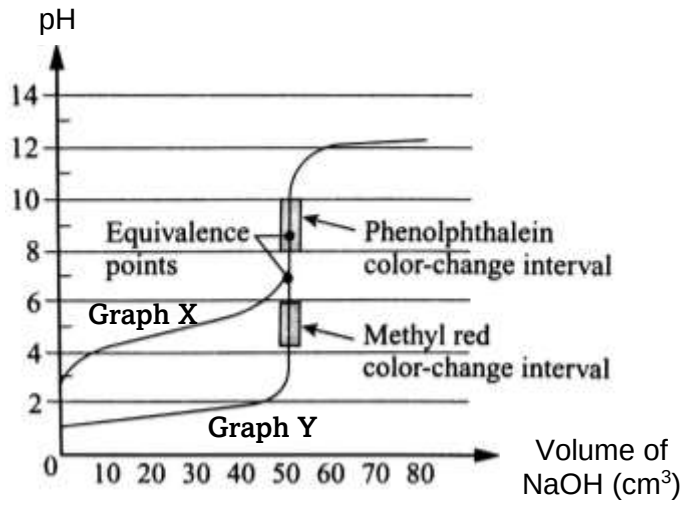


Fig. 5.1

The equivalence point, also known as the end-point, is the point where the reactants are mixed in the right proportion according to the balanced equation.

(a) Identify the graph in Fig. 5.1 that represents ethanoic acid.
Explain your answer.

……...

……...

……... [2]

(b) State how Fig. 5.1 shows that the concentration of ethanoic acid is the same as that of hydrochloric acid.

……...

……... [1]

(c) Suggest the indicator that is more suitable to determine the end-point of the reaction between ethanoic acid and sodium hydroxide solution.

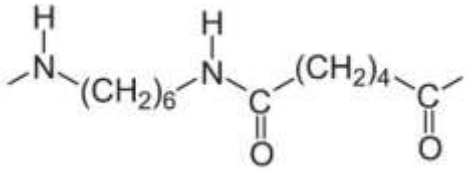
Explain your answer.

……...

……... [2]

[Total:5]

A6 The repeat unit of a polymer, C, is shown below. It is made up of monomers A and B.



(a) Name the linkage which joins monomers A and B.

……... [1]

(b) Draw the structures of monomers A and B that react to form polymer C.

[2]

(c) A sample of polymer C has a relative molecular mass of 20800.

Determine the number of repeat units in this sample of polymer C. Show your working and give your answer as a whole number.

[2]

[Total: 5]

A7 Boosters are stored in many cars to increase the power of the car engines. Two such boosters are hydrazine and dinitrogen monoxide. These boosters decompose under heat to increase the rate of combustion in the engine.

Table 7.1 shows some information about the boosters.

Table 7.1

compound	chemical formula	enthalpy change in kJ
hydrazine	N_2H_4	-280
dinitrogen monoxide	N_2O	–1864

Hydrazine decomposes to form ammonia, nitrogen and hydrogen gases upon heating as shown in the equation below.

$$2N_2H_4(g) \rightarrow 2NH_3(g) + N_2(g) + H_2(g)$$

(a) Draw the 'dot-and-cross' diagram for hydrazine.
Show outer electrons only.

[2]

(b) Table 7.2 shows the bond energies of some bonds.

Table 7.2

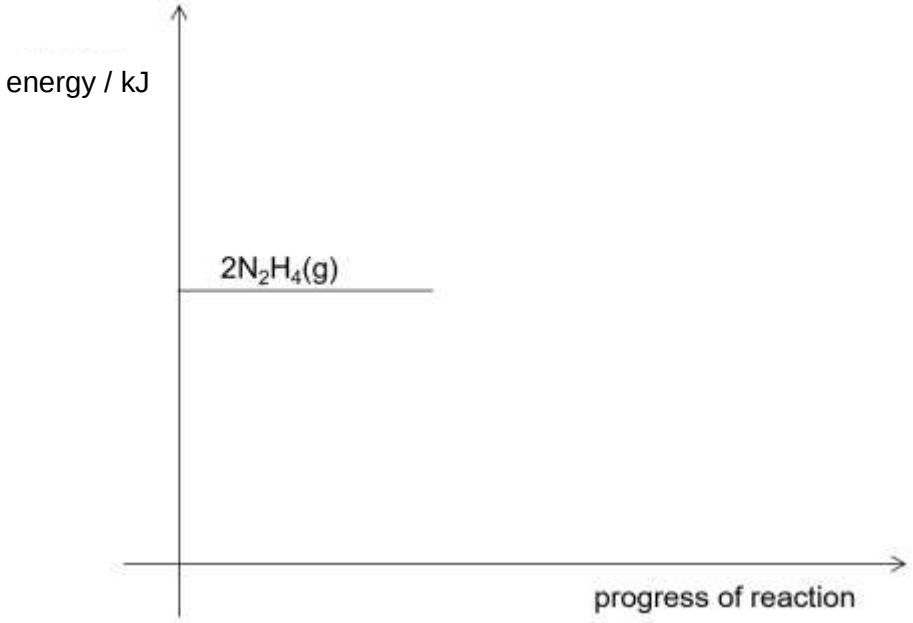
covalent bond	bond energy in kJ/mol
N–N	160
N=N	410
N≡N	944
N–H	390
H–H	436

Using Table 7.2, show that the enthalpy change for the decomposition of hydrazine is -280 kJ.

[3]

(c) Complete the energy level diagram for the decomposition of hydrazine.

Your diagram should include
- the **formulae of the products** of the decomposition,
- a label for the **enthalpy change of reaction**.



[2]

(d) Dinitrogen monoxide is a greenhouse gas.

Describe two hazardous impact of releasing dinitrogen monoxide into the environment.

……...

……...

……... [2]

[Total: 9]

A8 Magnesium reacts with dilute nitric acid according to the equation shown below:

$$Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2$$

Fig. 8.1 shows two graphs obtained when the reaction of magnesium with dilute nitric acid were conducted in two different experiments. The beaker and its contents were weighed every two minutes and the loss in mass was recorded.

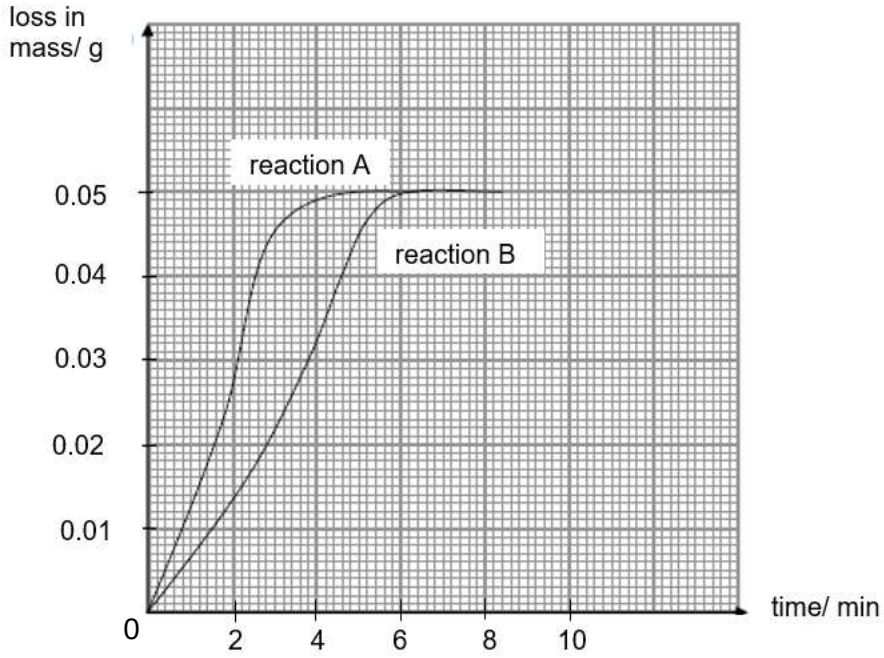


Fig. 8.1

(a) (i) In reaction A, 1.20 g of magnesium was added to 250 cm^3 of dilute nitric acid of 0.500 mol/dm^3 in a beaker.

State the reason for the loss in mass.

……

…….. [1]

(ii) With the aid of calculations, determine the limiting reactant. Show your working clearly.

[3]

(b) State the change made to the experiment to produce the graph for reaction B in Fig. 8.1.

……... [1]

(c) A third reaction, C, is repeated with the addition of 50 cm^3 of aqueous copper(II) sulfate.

A student predicted the results of this experiment as follows:

"The loss in mass is lower as the aqueous copper(II) sulfate reacts with one of the reactants."

Do you agree with this statement? Explain your reasoning.

……...

……...

……...

……... [3]

[Total:8]

A9 The Statue of Liberty was presented to the people of United States of America as a gift from the people of France in 1886.

The 'skin' of the Statue of Liberty is composed of 300 individual copper plates that were originally connected to an iron frame by copper straps.

However, by the 1980s, it was observed that the iron was badly rusted. The rusting was worst when the copper was connected to the iron framework. A further problem was the layers of paint and tar applied to the statue's interior over the years. These layers made it difficult to assess the extent of the corrosion.

(a) State two factors needed for rusting to occur.

…….. [1]

(b) Explain why the interior of the statue was covered with paint and tar.

……..

…….. [1]

(c) Suggest a reason why the rusting was worse when the copper was connected to the iron frame.

……..

…….. [1]

(d) Due to the rusting, the iron frame was replaced with the one made of stainless steel. At the same time, the copper sheets were cleaned.

After cleaning, the copper sheets quickly turned green. This green layer on the copper sheets is a compound of copper. Test done on the green substance produced the following results:

test	observations
add dilute acid	gas produced formed a white precipitate in limewater

Suggest the chemical name of this green substance.

…….. [1]

(e) Other than being used in the Statue of Liberty, copper can be used for electrical wiring, which needs to have a very high purity.

Pure copper is obtained by electrolysis, using aqueous copper(II) sulfate as an electrolyte.

Fig. 9.1 shows the experimental set up for the purification of copper.

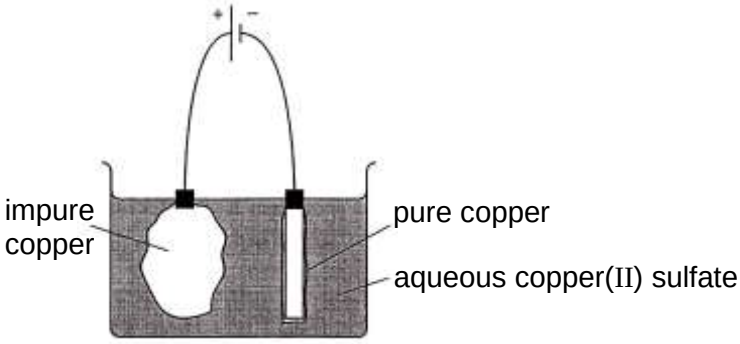


Fig. 9.1

(i) Write equations for the reactions at each electrode.

Cathode: ……

Anode: …… [2]

(ii) Describe what happens to the concentration of the aqueous copper(II) sulfate during the electrolysis.

Explain your answer.

……

……

…… [2]

[Total: 8]

A10 Brine is a saturated solution of sodium chloride, containing about 25 % by mass of sodium chloride. Industrial electrolysis of brine can be carried out in a **diaphragm** cell and a **membrane** cell.

Fig. 10.1 shows how the **diaphragm** cell works.

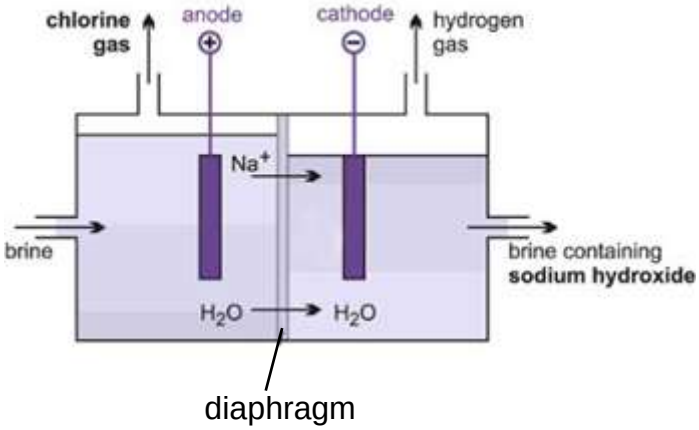


Fig. 10.1

The brine is contained in the anode compartment and the electrode which is used can either be made up of graphite or titanium. However, graphite is commonly preferred over titanium.

On the cathode side, the hydroxide ions and hydrogen gas are formed due to the reduction of water. Due to the difference in the solution level between the anode and the cathode, there will be a gradual flow of sodium chloride from the anode into the cathode. However, there will not be any backflow of sodium ions into the anode. If chlorine and sodium hydroxide come into contact, chlorine turns into ClO^-, ClO_3^- and Cl^- ions.

Fig. 10.2 shows how the **membrane** cell works.

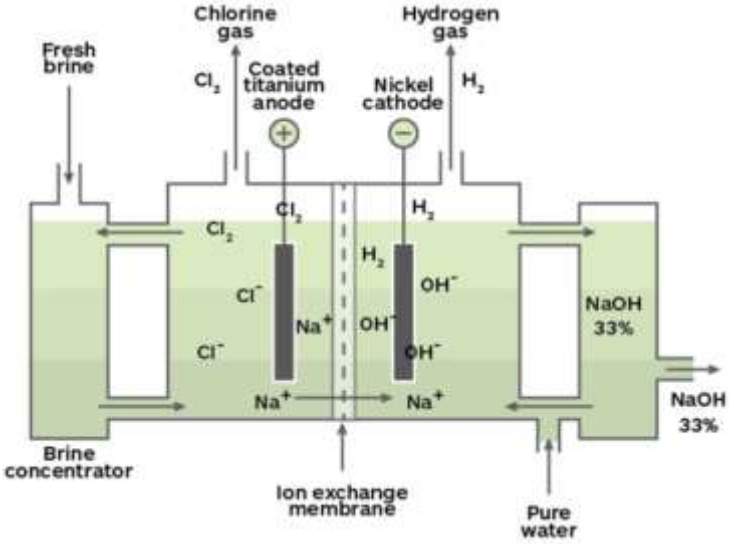


Fig. 10.2

In the membrane cell, the brine is fed to the brine concentrator and current passing through will result in the aqueous sodium chloride to split into sodium ions and chloride ions. The sodium ions will flow through the ion exchange membrane and react with the hydroxide ions that are produced through the reduction of water to form aqueous sodium hydroxide. Without the ion exchange membrane, the sodium hydroxide would not be pure because it would contain chloride ions.

Table 10.3 shows a comparison between the two types of cells.

Table 10.3

cell type	construction	operation of cell
diaphragm cell	relatively simple and inexpensive	• frequent replacement of diaphragm. • operates at 3.8 V.
membrane cell	cheap to construct and install	• requires high purity brine. • operates at 3.3V. • membrane changes every 2 to 3 years.

(a) (i) Construct a half equation for the cathode in the diaphragm cell.

..... [1]

(ii) Suggest a reason why graphite is preferred over titanium as the anode in the diaphragm cell.

……

…….... [1]

(b) When chlorine and sodium hydroxide come into contact, a disproportionation reaction happens.

Disproportionation happens when the oxidation state of the same element both increases and decreases in the reaction.

(i) Complete Table 10.4 by filling in the oxidation states of chlorine.

Table 10.4

substance	oxidation state of chlorine
ClO^-	
ClO_3^-	
Cl^-	

[2]

(ii) Using your answer in **(b)(i)**, explain why the reaction of chlorine and sodium hydroxide is a disproportionation reaction.

……

……

……

……. [2]

(c) The overall equation in the membrane cell is as follows:

$$2NaCl + 2H_2O \rightarrow Cl_2 + 2NaOH + H_2$$

Calculate the volume of hydrogen gas that can be produced from one tonne of brine in membrane cell at r.t.p.

[3]

(d) *"Industries should adopt using membrane cell to produce sodium hydroxide instead of diaphragm cell."*

Using the relevant information, explain one reason why such a statement was made.

……

……... [1]

(e) A student made the following comment.

"In school laboratory, I can obtain aqueous sodium hydroxide by using concentrated sodium chloride solution with graphite electrodes."

Explain whether you agree with the student.

……

……

……

…… [2]

[Total: 12]

End of Section A

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