Name:		Index Number:		Class:	

CATHOLIC HIGH SCHOOL
Preliminary Examination
Secondary 4 'O' Level Programme

A

CHEMISTRY

6092/02

Paper 2

20 August 2024
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.

Section A
Answer **all** questions.
Write your answers in the spaces provided.

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

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

A maximum of 1 mark will be deducted from your total mark for failure to show your working with clear statements in calculations and misuse of units and/or significant figures, i.e. failure to quote units where necessary, the inclusion of units in quantities defined as ratios or quoting answers to an inappropriate number of significant figures.

For examiner's use only:

Section A	/ 70
working / units / significant figures	□ –1 if checked

This document consists of **18** printed pages and **2** blank pages.

Section A

Answer **all** questions.

1 Some chemical and word equations, **A** to **J**, are shown.

A glucose → ethanol + carbon dioxide

B $HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

C water → hydrogen + oxygen

D $C_{12}H_{26} \rightarrow C_8H_{18} + C_4H_8$

E ethanoic acid + ethanol ⇌ ethyl ethanoate + water

F ethene + steam → ethanol

G $2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$

H $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$

I $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

J $2HCl + Pb(NO_3)_2 \rightarrow PbCl_2 + 2HNO_3$

Use the equations to answer the questions that follow.
Each equation may be used once, more than once, or not at all.

Write down the letter, **A** to **J**, for the equation which represents:

(a) cracking

.... [1]

(b) neutralisation

.... [1]

(c) precipitation

.... [1]

(d) respiration

.... [1]

(e) substitution

.... [1]

[Total: 5]

2 Table 2.1 shows the structural formula of monomers, structure of repeat unit of polymers and type of reaction used to form polymers **A** and **B**.

Complete the table by filling in the missing information.

Table 2.1

polymer	structural formula of monomer(s)	structure of repeat unit of polymer	type of reaction used to form polymer
A	$CH_3CH=CH_2$		....
B	$HOOC–(CH_2)_4–COOH$ $H_2N–(CH_2)_6–NH_2$		....

[4]

[Total: 4]

3 Car engines are adjusted to work in a particular ratio of air to fuel.

The amount of air that is mixed with the fuel affects the temperature of the engine, the amount of pollutant gases that form and how efficiently the catalytic converter works.

Table 3.1 shows some information about lean burn engines compared to normal car engines.

Table 3.1

type of engine	air to fuel ratio	operating temperature	concentration of carbon monoxide in exhaust gases	concentration of nitrogen oxides in exhaust gases
normal	lower	higher	higher	higher
lean burn	higher	lower	lower	lower

(a) Suggest why lean burn engines produce a lower concentration of nitrogen oxides.

....

.... [1]

(b) Suggest why lean burn engines produce a lower concentration of carbon monoxide.

....

.... [1]

(c) Nitrogen oxides are removed from car exhaust emissions by catalytic converters.

In a catalytic converter, nitrogen monoxide reacts with carbon monoxide.

(i) Write a chemical equation for this reaction.

.... [1]

(ii) Without a catalyst, the reaction between carbon monoxide and nitrogen monoxide is slow.

Use ideas about energy and collisions to explain why carbon monoxide and nitrogen monoxide react faster in a catalytic converter.

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……………………………………………………………………………………………………… [3]

[Total: 6]

4 This question is about making salts.

(a) Copper(II) nitrate can be prepared by reacting excess copper(II) oxide with dilute nitric acid.

(i) Describe how pure, dry crystals of copper(II) nitrate is obtained after excess copper(II) oxide is added to dilute nitric acid.

....

....

....

.... [3]

(ii) Explain why copper cannot be used to prepare copper(II) nitrate.

....

.... [1]

(b) Sodium sulfate is used in the manufacture of laundry detergents.

(i) State the formulae, with state symbols, of the reagents used to prepare sodium sulfate.

reagent 1 ....

reagent 2 .... [2]

(ii) Explain why the method described in **(a)** **cannot** be used to prepare pure sodium sulfate.

....

.... [1]

[Total: 7]

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5 **(a)** Fig. 5.1 shows an experiment in which steam was passed over 5.6 g of hot iron filings. The products of the reaction are iron oxide, Fe_3O_4, and a gas.

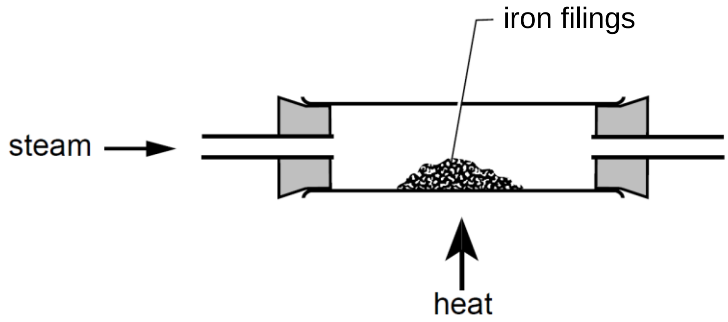


Fig. 5.1

(i) State the gas produced and describe a test to identify the gas.

....

....

.... [2]

(ii) Describe and explain the change in mass of the solid during the experiment.

....

....

.... [2]

(iii) The experiment is repeated using the same amount of magnesium and again using the same amount of lead.

Predict the order of change in mass of the solid for iron, magnesium and lead, starting with the metal with the least change in mass.

Explain your reasoning in words or by means of a calculation.

order of change in mass ....

reasoning ....

....

.... [3]

(b) The Statue of Liberty in New York is made from an iron frame covered with copper plates.

In 2004, work had to be carried out to stop the iron frame from rusting.

The iron frame was rusting much faster than normal where it was in contact with the copper.

Explain why copper in contact with iron causes the iron to rust faster than normal.

………

………

………

…………………………………………………………………………………………………… [2]

[Total: 9]

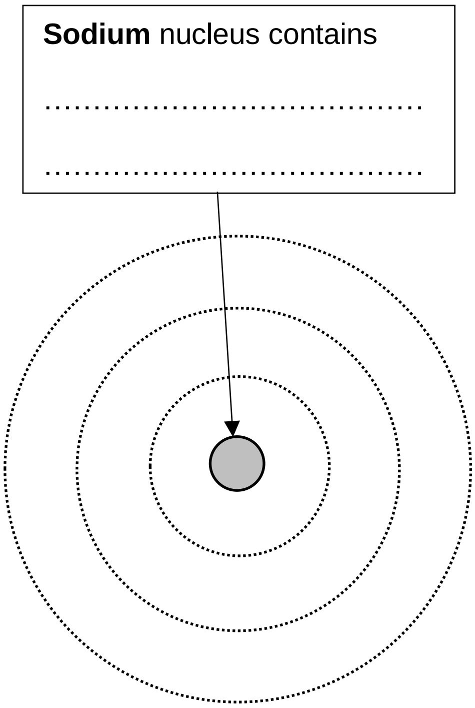
6 Ionisation is the process in which electrons are removed from atoms and cations. The energy required for this process is called ionisation energy.

The equations show the removal of electrons from Na atoms and Na^+ ions, with the energy changes involved.

first ionisation energy:	$Na(g) \rightarrow Na^+(g) + e^-$	$\Delta H_1 = +494$ kJ/mol
second ionisation energy:	$Na^+(g) \rightarrow Na^{2+}(g) + e^-$	$\Delta H_2 = +4560$ kJ/mol

(a) **(i)** Complete the diagram of an atom of sodium to show:

- the names and numbers of each particle in the nucleus
- the arrangement of the electrons.



[1]

(ii) Hence, explain why the value of ΔH_2 is much higher than that of ΔH_1.

…………………………………………………………………………………………………

………………………………………………………………………….………………… [1]

(b) Sodium is a Group 1 element.

Describe the trend in reactivity **and** melting point down Group 1.

……………………………………………………………………………………………….. [1]

The energy change when electrons are gained by atoms and anions is called electron affinity.

The equations show the gaining of electrons by O atoms and O^- ions, with the energy changes involved.

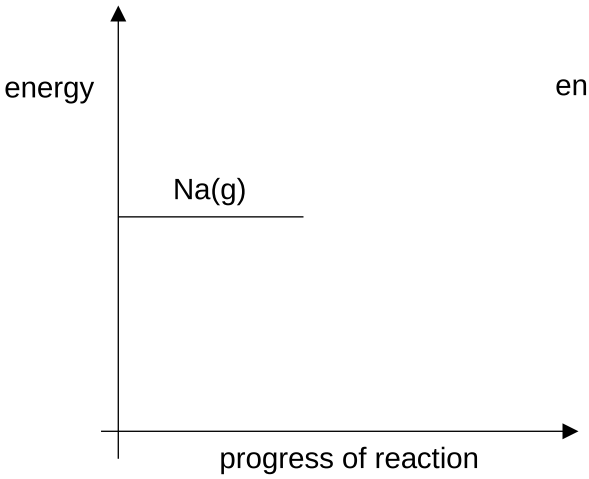
first electron affinity:	$O(g) + e^- \rightarrow O^-(g)$	$\Delta H_3 = -142$ kJ/mol
second electron affinity:	$O^-(g) + e^- \rightarrow O^{2-}(g)$	$\Delta H_4 = +786$ kJ/mol

(c) Suggest a reason to explain why ΔH_4 is positive.

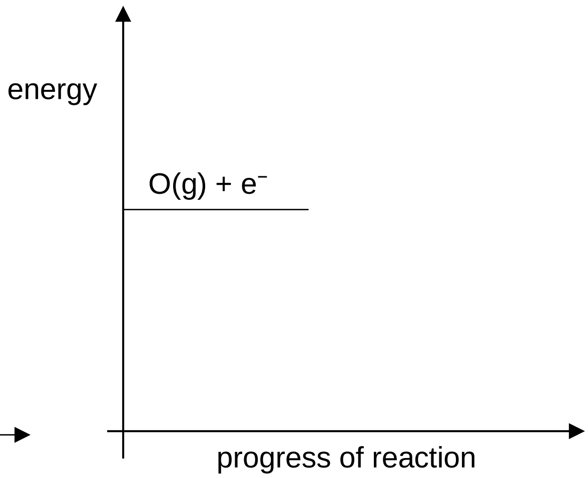
....

.... [1]

(d) Complete and label the energy level diagrams to show the products and energy changes for the first ionisation energy of sodium and first electron affinity of oxygen.



first ionisation energy of sodium



first electron affinity of oxygen

[3]

[Total: 7]

7 Fig. 7.1 shows the electrolysis of concentrated and dilute aqueous sodium chloride using graphite electrodes. Gases are produced and collected in each of the test-tubes W, X, Y and Z.

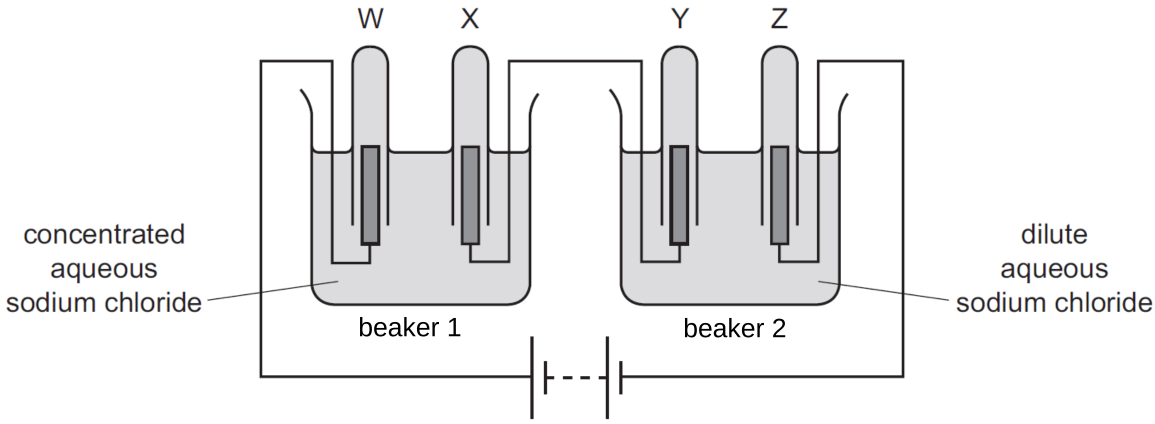


Fig. 7.1

(a) Describe the differences between what happens when electricity passes through the graphite electrodes compared to what happens when electricity passes through dilute aqueous sodium chloride.

....

....

....

.... [2]

(b) **(i)** Identify the gases collected in test-tubes Y and Z.

gas collected in test-tube Y ....

gas collected in test-tube Z .... [1]

(ii) The ratio of the volume of gases collected in test-tubes Y and Z is observed to be 1:2.

Explain this observation.

Your answer should include half-equations for the reaction at each electrode.

....

....

....

....

....

.... [4]

(c) **(i)** Identify the gases collected in test-tubes W and X.

gas collected in test-tube W …………………………………………………………………...

gas collected in test-tube X ………………………………………………………..…. [1]

(ii) State the ratio of the volume of gases collected in test-tubes W and X.

……………………………………………………………………………………..…. [1]

(d) Universal Indicator is added to the solution in beakers 1 and 2 after the electrolysis.

Predict the colour of the Universal Indicator in beakers 1 and 2.

colour in beaker 1 ………………………………………..

colour in beaker 2 ………………………………………..

Explain your reasoning.

…………………………………………………………………………………………………….

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…………………………………………………………………………….............................. [3]

[Total: 12]

8 This question is about elements, from Period 2 and Period 3, and their compounds.

(a) Table 8.1 shows some properties of aluminium fluoride and aluminium chloride.

Table 8.1

compound	melting point / ^{o}C	electrical conductivity when molten
aluminium fluoride	1290	good
aluminium chloride	180	poor

(i) Draw a 'dot-and-cross' diagram to show the bonding in aluminium fluoride.

Show outer electrons only.

[2]

(ii) Use ideas about structure and bonding to explain why the properties of aluminium chloride shown in Table 8.1 are unusual.

……...

……...

……...

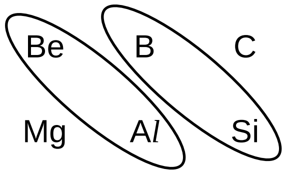
……...

……...

…………………………………………………..……………………………………….… [3]

(b) Period 2 and Period 3 elements that are diagonal to each other in the Periodic Table have similar physical and chemical properties. These elements have a diagonal relationship.

For example, beryllium and boron are the first elements of Group 2 and Group 13 respectively. Some of their properties do not resemble the properties exhibited by the other elements in their group. Instead, their properties resemble the properties of the second element in the following group.



(i) Beryllium and aluminium have a diagonal relationship.

Suggest **one** difference in the chemical property of beryllium oxide and magnesium oxide.

………………………………………………………………………………………………………...

………………………………………………...…………………………………...…… [1]

(ii) Boron and silicon have a diagonal relationship.

Silicon has a giant covalent structure.

Suggest **two** physical properties of boron.

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………………………………………………...……………………………...………… [2]

[Total: 8]

9 Using chlorine as a disinfectant in swimming pools

Swimming pools need to be disinfected. Disinfectants work by killing bacteria. Originally, chlorine gas, stored in gas cylinders, was added to water in the swimming as a disinfectant.

Chlorine reacts with the water to form chloric(I) acid and hydrochloric acid, as shown in equation 1.

equation 1: $Cl_2(aq) + H_2O(l) \rightleftharpoons HClO(aq) + HCl(aq)$

The total amount of chloric(I) acid present in a swimming pool can be found by redox titration.

All the chloric(I) acid present in a sample of water in the swimming pool reacts with an excess of acidified potassium iodide solution, as shown in equation 2. The amount of iodine produced can be found by titration with a known concentration of sodium thiosulfate solution. Equation 3 shows the reaction between sodium thiosulfate and iodine. From the results obtained from this titration, the total amount of chloric(I) acid present in the sample can be found.

equation 2: $HClO + 2I^- + H^+ \rightarrow Cl^- + I_2 + H_2O$

equation 3: $2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$

Guidelines on the use of chlorine as disinfectants

Chlorine gas can irritate our eyes and lungs, and inhalation of chlorine in higher concentrations may result in choking sensations, vomiting, chest pain and difficulty in breathing. Instead of adding chlorine gas directly into swimming pools, operators use sodium chlorate(I) solution, $NaClO$ or solid calcium chlorate(I), $Ca(ClO)_2$, which are safer. Care must also be taken to ensure that chemicals are not illegally disposed of into the sewage system.

Solubility of chlorine

Researchers studying the solubility of chlorine in pure water at different temperatures compiled the data from different sources in Table 9.1.

Table 9.1

Source	Temperature / ^{o}C	Solubility of chlorine
A	0	1.46 g per 100 cm^3
B	10	310 cm^3 per 100 cm^3
C	20	0.70 g per 100 cm^3
D	25	6300 mg per 1000 cm^3
E	30	177 cm^3 per 100 cm^3
F	30	0.57 g per 100 cm^3

The units of solubility are converted to mol/dm^3 as shown in Table 9.2 .

Table 9.2

Source	Temperature / ^oC	Solubility of chlorine	Solubility of chlorine in mol/dm^3
A	0	1.46 g per 100 cm^3	0.206
B	10	310 cm^3 per 100 cm^3	0.13
C	20	0.70 g per 100 cm^3	0.099
D	25	6300 mg per 1000 cm^3	0.089
E	30	177 cm^3 per 100 cm^3	
F	30	0.57 g per 100 cm^3	0.080

Problem caused by poor hygiene in swimming pools

Researchers also found out that many people do not shower before entering the swimming pool. Urine and sweat, which contain ammonia, are released into the water in the swimming pool. The ammonia released reacts with chloric(I) acid, $HOCl$, to form chloramines, NH_2Cl, $NHCl_2$ and NCl_3.

Fig. 9.1 shows the molar ratio of chloramines formed at different pH values at 25 ^oC. Trichloramine, NCl_3, causes the water in the swimming pool to smell bad.

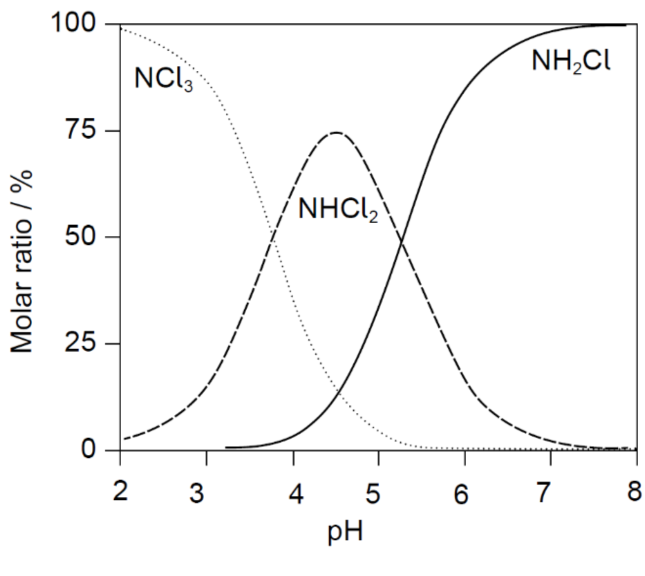

Fig. 9.1

(a) **(i)** Use oxidation states to prove that the reaction shown in equation 3 is a redox reaction.

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………………………………………………………………………………………….. [2]

(ii) A swimming pool is suspected to contain excessive amounts of chloric(I) acid. Hence, a sample of the water in the swimming pool was tested to measure the amount of chloric(I) acid it contained. An excess of acidified potassium iodide solution was added. The resulting mixture reacted with 24.70 cm^3 of 0.100 mol/dm^3 sodium thiosulfate.

Calculate the amount, in moles, of chloric(I) acid present in this sample of the water in the swimming pool

[2]

(b) Company **X** claims that using chlorine gas is the most cost-effective method of disinfection compared to sodium chlorate(I) solution, $NaClO$, or solid calcium chlorate(I), $Ca(ClO)_2$ because it has the highest chlorine content by mass.

Do you agree with the company's claim?

Explain your answer by means of a calculation.

[2]

(c) **(i)** Apart from the use of different units, identify another problem in comparing the data from different sources in Table 9.1.

…………………………………………………………………………………………………..

……………………………………………………………………………………………..… [1]

(ii) Calculate the solubility of chlorine, in mol/dm^3, for source E.

Assume the density of chlorine is 2.86 g/dm^3 at 30 ^{o}C.

[2]

(iii) Some indoor swimming pools are heated as the heat from the water relaxes muscles.

Suggest **one** reason why operating an unheated swimming pool causes **less** environmental problems.

…………………………………………………………………………………………………..

……………………………………………………………………………………………..… [1]

(d) **(i)** Ammonia and chloric(I) acid react to form dichloramine and water.

Write a chemical equation for the reaction.

……………………………………………………………………………………………….. [1]

(ii) State **one** condition needed to prevent the bad smell of the swimming pool caused by trichloramine.

…………………………………………………………………………………………………..

……………………………………………………………………………………………..… [1]

[Total: 12]

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