Name	Class	Index Number

Anglo-Chinese School (Barker Road)

PRELIMINARY EXAMINATION 2024
SECONDARY FOUR EXPRESS

CHEMISTRY
6092/2

TIME: 1 HOUR 45 MINUTES

INSTRUCTIONS TO CANDIDATES:

Do not open this booklet until you are told to do so.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.

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

Sections B
Answer **one** question.
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 copy of the Periodic Table is printed on the last page.

FOR EXAMINER'S USE ONLY	
Section A	/ 70
Section B	/ 10
Total Score	**/ 80**

*This paper consists of **23** printed pages including the cover page and a blank page.*

Section A (70 marks)

Answer **all** questions.

A1 The formulae of some ions are given in the following list.

Ca^{2+} Cl^- Li^+ Na^+ O^{2-}

(a) Choose ions from the list to answer the questions. You may use each ion once, more than once, or not at all.

(i) Which ion has only two electrons?

…….... [1]

(ii) Which ions have the same arrangement of electrons as argon?

…….... [1]

(iii) Which **two** ions bond to form a compound which has the highest melting point?

…….... [1]

(b) What do you observe when aqueous bromine is added to aqueous Cl^- ions?

Explain your reasoning.

…..……..……..

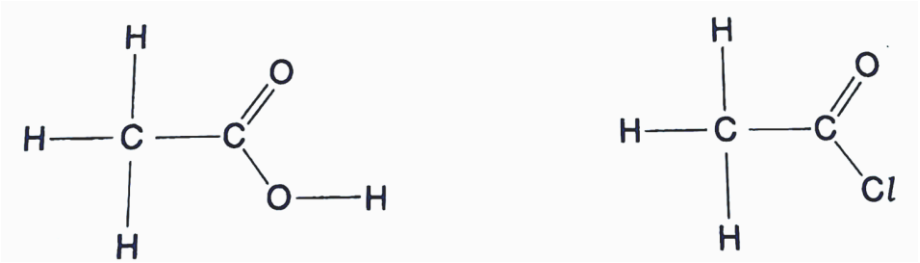
…..……..……..

…..……..……..

…..……..…….. [2]

[Total: 5]

A2 The structures of ethanoic acid and ethanoyl chloride are shown below.



ethanoic acid **ethanoyl chloride**

Both compounds react with **methanol** to make the same ester.

(a) Name and draw the full structural formula of the ester.

name of ester: …….. [2]

(b) Complete Table 2.1 to show the formula of the **other** product of each reaction.

Table 2.1

	formula
product formed from the reaction with ethanoic acid	
product formed from the reaction with ethanoyl chloride	

[2]

[Total: 4]

A3 Hydrogen peroxide, H_2O_2, is often used as a bleach and antiseptic, usually as a dilute solution for consumer use and in higher concentrations for industrial use.

(a) Hydrogen peroxide solution has to be freshly prepared as it decomposes to form water and oxygen gas under normal room conditions.

The equation shows the decomposition of hydrogen peroxide.

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

(i) Why is hydrogen peroxide solution usually put into the refrigerator after preparation?

……...

……... [1]

(ii) The peroxide ion has the formula O_2^{2-}. It has a single bond between the two oxygen atoms.

Draw a 'dot-and-cross' diagram to show the arrangement of electrons in a peroxide ion.

Show outer electrons only.

[2]

(b) Hydrogen peroxide can be prepared by various methods.

Hydrogen peroxide was once prepared using ammonium persulfate, $(NH_4)_2S_2O_8$.

Deduce the formula of the persulfate ion.

……..…….……..…… [1]

(c) Another method of preparing hydrogen peroxide bleach involves Group 1 metal peroxides reacting with water to form Group 1 metal hydroxides and hydrogen peroxide.

(i) Write a chemical equation for the reaction of sodium peroxide, Na_2O_2, with water. State symbols are not required.

……... [1]

(ii) When a solution of red litmus indicator is added to the reaction mixture in **(c)(i)**, the solution turns colourless.

One student makes this statement about the observation.

Paul: "The solution should have turned blue."

Does the information support the statement made by Paul?

Explain your reasoning.

……...

……...

……...

……... [2]

(d) Hydrogen peroxide can react with sulfuric acid to form highly reactive oxygen atoms as shown.

$$H_2SO_4 + H_2O_2 \longrightarrow HSO_4^- + H_3O^+ + O$$

These oxygen atoms can then react with the carbon impurity, which is usually unreactive to most aqueous solutions at room temperature. The final product of the reaction between carbon and oxygen atoms is a greenhouse gas.

(i) Write the chemical equation for the reaction between carbon and oxygen **atoms**. State symbols are not required.

……... [1]

(ii) Describe the potential environmental effects of increased levels of greenhouse gases.

……...

……...

……... [1]

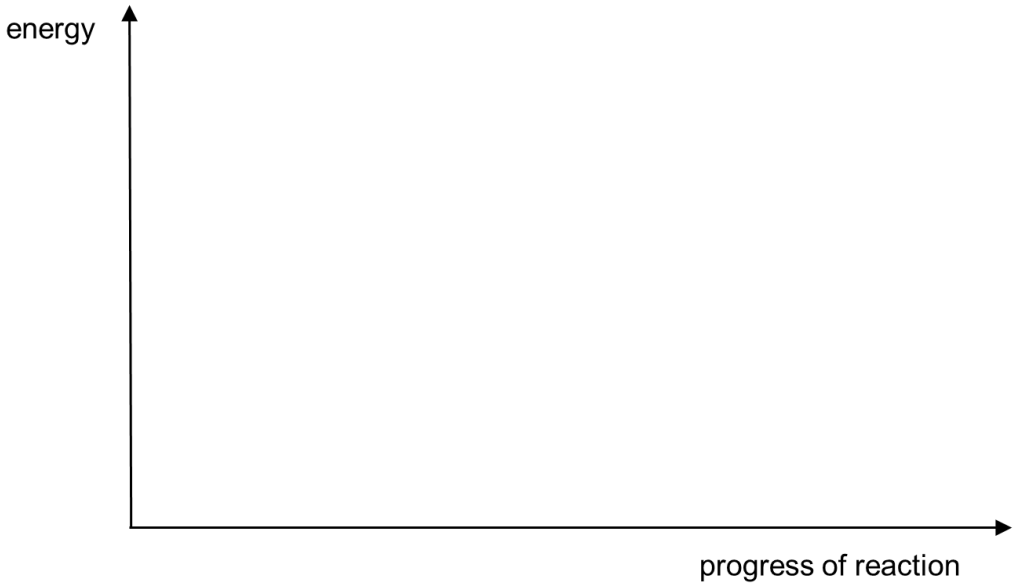
[Total: 9]

A4 Butane is a gaseous fuel commonly used in aerosol cans and for domestic cooking.

(a) Draw the energy profile diagram for the combustion of butane.

Your diagram should show:

- the balanced chemical equation,
- the enthalpy change of reaction, Δ*H,* and
- the activation energy, E_a, of the reaction.



[4]

(b) When burnt, it releases 120 kJ for every 1 dm^3 of butane used at room temperature and pressure.

Calculate the energy **released** when 1 mole of butane is allowed to undergo complete combustion.

[1]

(c) Butane gas is made from crude oil and burning it produces air pollutants.

State **another** disadvantage of using butane as a fuel.

……

……. [1]

(d) Explain, in terms of collisions, why a lower pressure decreases the rate of combustion of butane.

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..... [2]

(e) Propane is a more popular choice of fuel than butane for portable stoves used during barbecues because of its lower boiling point than butane. This makes propane able to retain its ability to vaporise even in cold weather.

Use ideas about structure and bonding to explain why the boiling point of propane is lower than the boiling point of butane.

.....

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..... [2]

[Total: 10]

A5 In the Haber process, ammonia is formed from hydrogen and nitrogen under the conditions of varying temperature and pressure.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Table 5.1 shows the percentage of ammonia present at equilibrium varying at different temperatures and pressures.

Table 5.1

pressure (atm)	**temperature (°C)**			
	100	300	400	500
10	88.2	14.7	3.9	1.2
100	96.7	52.5	25.2	10.6
200	98.4	66.7	38.8	18.3
400	99.4	79.7	55.4	31.9
1000	99.9	92.6	79.8	57.5

(a) Use the information to describe how the percentage of ammonia present at equilibrium varies with the conditions of temperature and pressure.

...

...

... [1]

(b) **(i)** State the temperature and pressure that will produce the highest percentage of ammonia at equilibrium.

temperature: …….. pressure: ……. [1]

(ii) Explain why these conditions are not used commercially in industries to produce ammonia.

……...

……...

……...

……...

……. [2]

(c) Calculate the maximum mass of ammonia produced at equilibrium when 1 tonne of nitrogen was reacted with excess hydrogen at **200 atm and 400 °C**.

1 tonne = 1000 kg

maximum mass of ammonia produced …….. [2]

(d) Ammonia can be used to treat industrial waste gases containing nitrogen oxides.

The equation shows how the treatment converts nitrogen monoxide to nitrogen and water.

$$6NO + 4NH_3 \rightarrow 5N_2 + 6H_2O$$

(i) Explain, in terms of oxidation states, if ammonia is oxidised or reduced.

……...

……...

……... [2]

(ii) Use the equation in **(d)** to state the effect on the composition of the gases released into the atmosphere when an insufficient amount of ammonia was added to nitrogen monoxide.

……...

……...

……... [1]

(iii) Describe how nitrogen monoxide affects the environment.

……...

……...

……...

…..…… [2]

[Total: 11]

A6 Table 6.1 shows some information about the first five members of the aldehyde homologous series.

Table 6.1

number of carbon	aldehyde	chemical formula	chemical formula of compound formed when aldehyde is oxidised
1	methanal	HCHO	HCOOH
2	ethanal	CH_3CHO	CH_3COOH
3	propanal	C_2H_5CHO	C_2H_5COOH
4		C_3H_7CHO	C_3H_7COOH
5	pentanal	C_4H_9CHO	

(a) Use all the information from Table 6.1 to state why these aldehydes belong to the same homologous series.

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... [3]

(b) Complete the table with the two missing information. [2]

(c) A reagent can be used to oxidise aldehydes.

Given that aldehydes are colourless solutions, state the reagent and the observation when added to aldehydes.

reagent: ……

observation: ……

…… [2]

(d) **(i)** Draw the full structural formula of the compound formed when propanal is oxidised.

[1]

(ii) Draw an isomer of your answer in **(d)(i)**.

[1]

(e) Ethanal can react with oxygen in the air to form ethanoic acid.

Complete the equation of this reaction by showing the full structural formulae of the substances involved in this reaction.

\+ O=O ⟶

[2]

[Total: 11]

A7 Fossil Fuels

Fossil fuels like crude oil are known to be non-renewable and are limited in supply. They are still used as fuels because getting energy from their combustion is still considered an economical and convenient method. In order to ensure that the supply of crude oil lasts longer for our use, we need to conserve crude oil.

Alternative Energy Source - Biogas

Biogas is a renewable fuel that is produced when organic matter, such as food or animal waste, is broken down by bacteria in the absence of oxygen. Biogas, that can be derived from cow dung from farms, contains biomethane.

Table 7.1 shows a typical composition of biogas.

Table 7.1

compound	formula	percentage by volume	additional information
biomethane	CH_4	50 - 80	colourless, odourless
carbon dioxide	CO_2	15 - 50	colourless, odourless
nitrogen	N_2	0 - 10	colourless, odourless
hydrogen sulfide	H_2S	0 – 1	colourless, pungent, toxic

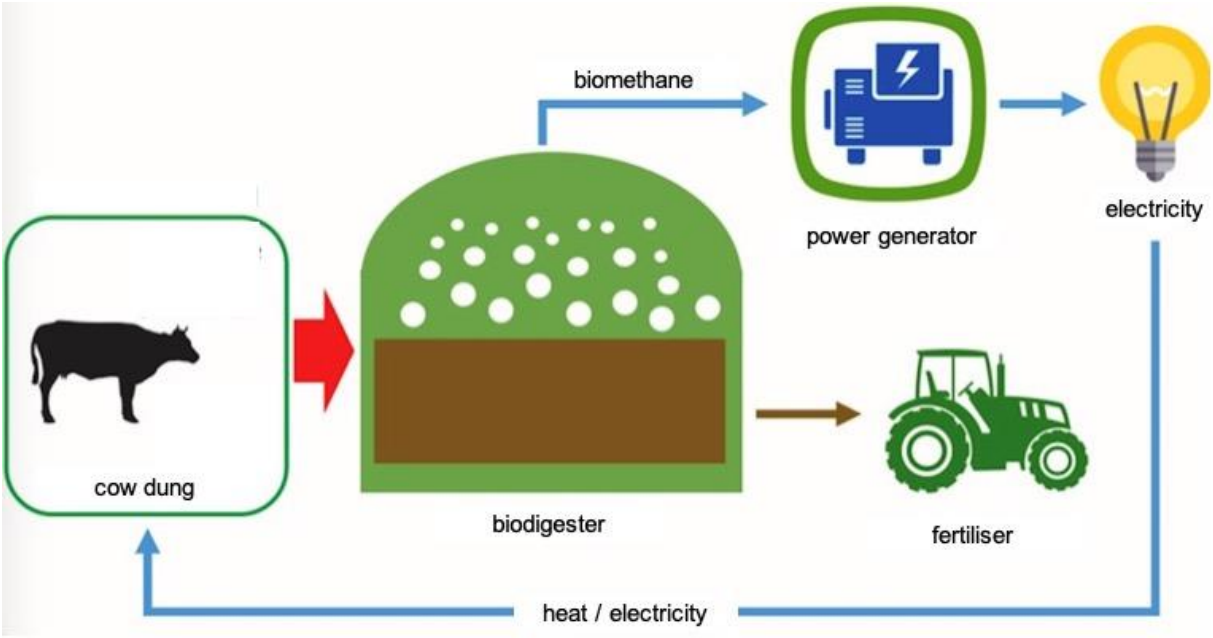
The biogas produced on the farm contains traces of hydrogen sulfide. To prolong the lifespan of the metal machinery parts, hydrogen sulfide has to be removed from the biogas, otherwise when it is combusted, it produces sulfur dioxide and sulfuric acid.

Burning biomethane releases greenhouse gases like carbon dioxide, but allowing cow dung to degrade naturally also releases methane. Converting cow dung into biomethane to be used as biofuel instead of letting it degrade naturally is found to cut down greenhouse gases by 4%. This is because methane has a much greater global-warming power than carbon dioxide. To reduce the carbon impact, that source of destructive pollution has to be transformed into a cleaner fuel. Most of the biomethane produced at the farm can be used to generate sufficient electricity to power several homes. The remaining is then used as fertiliser on the farm, allowing for a reduction in the use of synthetic fertilisers made from fossil fuels.

Biomethane produced from cow dung is a biofuel with high performance and high purity. Obtaining biomethane from cow dung starts right on the farm, where cow dung is collected and put into an on-site biodigester. A biodigester is a sealed container where the bacteria breaks down cow dung into biomethane and fertiliser through a natural process. The biomethane then spins a power generator to produce electricity. The fertiliser produced from the biodigester can also be readily used by farmers.

Fig. 7.1 shows the process of obtaining biomethane.

Fig. 7.1



Alternative Energy Source - Metal Powders

Using tiny metal particles to power external-combustion engines is novel. Unlike the internal-combustion engines used in petrol-powered cars, external-combustion engines use heat from an outside source to drive an engine. For decades, the idea of burning metal powders has been used in fireworks and also in rocket propellants, such as the solid-fuel booster rockets of space shuttles.

The potential for metal powders to be used as a recyclable fuel in a wide range of applications has been largely overlooked by scientists. When metal powders are burned, they react with air to form a non-toxic solid oxide product that can be easily collected for recycling, unlike the carbon dioxide emission produced from the burning of fossil fuels that escape into the atmosphere. Iron could be the primary candidate for this purpose as millions of tonnes of iron powders are already produced annually for the chemical and electronic industries. However, more research needs to be done to avoid carbon dioxide emissions associated with traditional iron production using coal. While not perfected and commercialised yet, the use of low-cost metallic fuels, like iron powder, is a worthy alternative to petrol and diesel fuels.

(a) **(i)** Farmers can easily detect when levels of hydrogen sulfide in the biogas increase.

Explain why this is so.

……...

……... [1]

(ii) Explain why hydrogen sulfide has to be removed from the biogas.

……...

……...

……... [2]

(b) Burning biomethane from cow dung also produces greenhouse gases. However, many people still think that it is worth using cow dung to generate electricity on the farms.

Use the information to suggest **environmental** and **economical** reasons why many people think this.

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.... [5]

(c) Iron powder burns in air to form iron(III) oxide, which can be easily collected and then converted back to iron.

(i) Suggest a reactant to convert iron(III) oxide back to iron.

.... [1]

(ii) Use the information to explain why iron powder is considered a recyclable fuel as compared to fossil fuels.

....

....

.... [1]

[Total: 10]

A8 Polyacrylonitrile and nylon are polymers used to make strong fibres and waterproof ropes.

(a) Acrylonitrile, CH_2=CHCN, is a monomer used to make the polymer, polyacrylonitrile.

(i) Use the information to explain the type of polymerisation acrylonitrile undergoes to form polyacrylonitrile.

type of polymerisation: ……..…….……..…

reason: ……..……

……... [1]

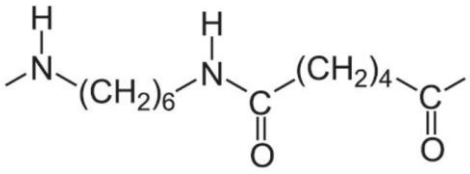
(ii) Draw the full structural formula of polyacrylonitrile, showing **two** repeating units.

[1]

(b) There are several types of nylon. The first type of nylon developed is nylon-6,6.

This is one repeating unit of nylon-6,6.

nylon-6,6



(i) Draw the structural formulae of the two monomers that react to form nylon-6,6.

[2]

(ii) To be suitable for making fibres, the chain length of the nylon must be controlled so that the nylon polymer molecules have an average relative molecular mass in the range 12 000 to 20 000. This length of the molecule gives enough strength but is still flexible enough to be spun into fibres easily.

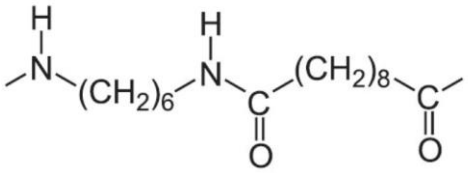
What is the **range** of the average number of repeating units in the nylon-6,6 molecules?

Show your working.

range of number of repeating units in the nylon-6,6 ……..…… [2]

(iii) The repeating unit of another nylon, nylon-6,10, is shown.

nylon-6,10



Give one difference between the structures of the repeating units of nylon-6,6 and nylon-6,10.

……...

……... [1]

(c) Plastics made from polyacrylonitrile and nylon are difficult to dispose of at the end of their useful life because they do not biodegrade. Furthermore, both cannot be recycled easily.

Hence various recycling methods need to be explored.

(i) The following description for the recycling of plastics is in a student's notebook.

Some words have been left out.

Complete the description by writing in the missing words.

"Recycling can be done by two methods - physical method and chemical method. During the physical method of recycling of plastics, small pieces of plastic waste are ……, cooled, pulled into long, thin strands and cut into pellets. These pellets can then be made into new products.

During the chemical method of recycling of plastics, plastic waste is converted into different raw materials through chemical reactions such as cracking. Short-chain alkanes can be used as …… while short-chain alkenes can be used to make other useful materials."

[2]

(ii) Plastics can also be recycled using a chemical method called depolymerisation. Similar to polyesters, nylon can be depolymerised by hydrolysis using an acid catalyst.

State the two **types** of monomers formed when nylon-6,10 undergo acid hydrolysis.

……...

……... [1]

[Total: 10]

Section B (10 marks)

Answer **one** question from this section.

B9 **(a)** The direct oxidation of alcohols in a fuel cell is an efficient method of obtaining useful energy from a renewable fuel.

(i) The first alcohol to be used successfully in a fuel cell was methanol. At the anode, methanol and water undergo the following reaction:

$$CH_3OH + H_2O \rightarrow CO_2 + 6H^+ + 6e^-$$

At the cathode, hydrogen ions move through the conducting polymer electrolyte, where they react with oxygen to form water. This is illustrated as follows:

$$4H^+ + 4e^- + O_2 \rightarrow 2H_2O$$

Write an equation for the overall reaction taking place in this fuel cell.

……..... [1]

(ii) Another possible fuel for use in fuel cells is hydrogen. Table 9.1 gives some data about these two fuels.

Table 9.1

fuel	melting point (°C)	boiling point (°C)	energy change of combustion (kJ/g)
hydrogen	–259	–252	–128
methanol	–97.7	64.5	–22.3

The table gives values for the energy change of combustion for each fuel in kJ/g.

Use the information in the table to discuss one advantage and one disadvantage of using hydrogen in cars as compared to methanol.

……...

……...

……...

……... [2]

(b) The hot water vapour formed from the reaction taking place in a fuel cell reacts with metal **X**.

To deduce the identity of metal **X**, a series of tests were conducted:

- The carbonate of metal **X** reacted with dilute sulfuric acid to form a colourless solution. When aqueous ammonia was added dropwise to the resultant solution, a white precipitate was formed. When more aqueous ammonia was added, the white precipitate dissolved to form a colourless solution.
- When metal **X** was added to a blue-green solution **Y**, a reddish-brown solid was formed on metal **X**. The blue-green solution **Y** also decolourised.

(i) Based on the above observations, deduce the identity of metal **X**.

……... [1]

(ii) Write an ionic equation for the reaction between metal **X** and solution **Y** and explain the observations.

……...

……...

……...

……...

……...

……... [3]

(iii) Compare the observations of metal **X** with cold water differ from sodium with cold water.

……...

……...

……...

……...

……...

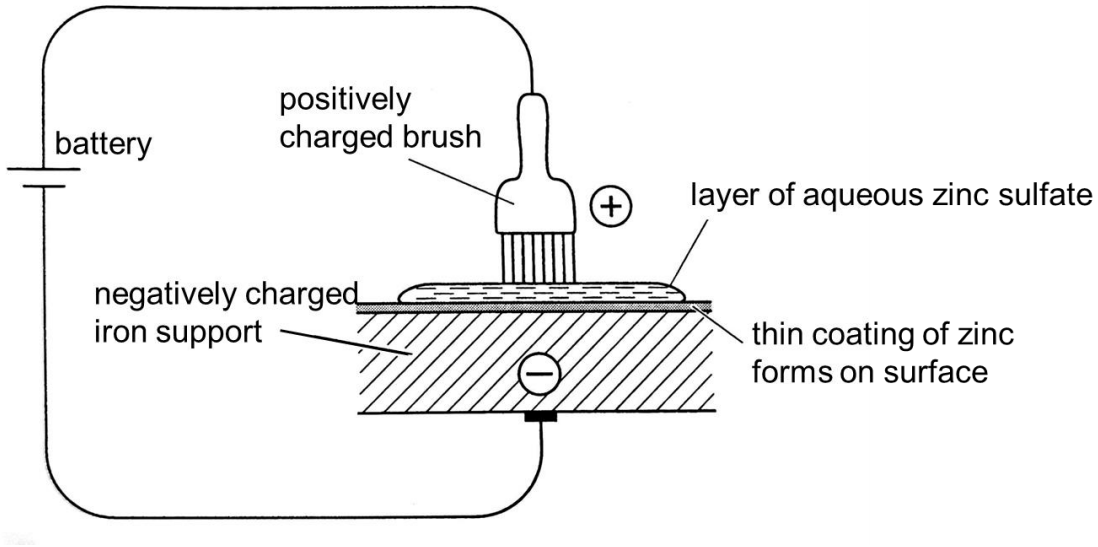
……... [3]

[Total: 10]

B10 "Brush electroplating" is used to electroplate zinc onto very large iron supports to be used in buildings. Fig 10.1 shows the set-up of "brush electroplating".

During the process, a metal brush spreads a layer of aqueous zinc sulfate over the iron surface. A battery gives the brush a positive charge and gives the iron support a negative charge. A thin coating of zinc then forms on the surface of the iron support.

Fig 10.1



(a) Two different types of metal brush are available – one type of brush is made from zinc, one type is made from platinum.

Platinum brushes are much more expensive than zinc brushes. However, zinc brushes need replacing regularly but platinum brushes do not.

Explain why.

...

...

...

... [2]

(b) During the process, a worker needs to hold the brush. Poly(ethene) is usually used as the material for the handle of the brush.

(i) Use ideas about structure, explain why poly(ethene) is a suitable material for the handle of the brush.

.....

.....

.....

..... [2]

(ii) The monomer of poly(ethene) is said to be unsaturated and is able to undergo addition reaction with hydrogen gas, in the presence of nickel catalyst at 200 ^{o}C.

Outline a simple test, including the expected observations, to distinguish the monomer of poly(ethene) and the product formed from the addition reaction of the monomer with hydrogen gas.

Your answer should include the identities of the monomer and the product formed.

…….

…….

…….

……. [3]

(c) Explain why the iron support coated with zinc does not rust, even if the zinc coating is scratched.

...…….

...…….

...…….

...……. [2]

(d) Electrolysis is said to be a non-spontaneous and endothermic reaction, which requires an external voltage to drive such reactions.

Based on your understanding of electrolysis, explain why “brush electroplating” is considered as an endothermic reaction.

...…….

...……. [1]

[Total: 10]

END OF PAPER

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The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).
The Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}