Name and Index Number: ( )	Class:

SENG KANG SECONDARY SCHOOL
2024 PRELIMINARY EXAMINATION

CHEMISTRY — 6092/01

Secondary 4 Express — 27 August 2024

Paper 1 Multiple Choice — 1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name and index number on all the work you hand in.

There are **forty** questions in this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice **in soft pencil** on the Multiple Choice Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 16.
The use of an approved scientific calculator is expected, where appropriate.

Parent's / Guardian's Signature: .....

This document consists of **15** printed pages and **1** blank page.

Do not turn over the page until you are told to do so.

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1 Which statement is correct?

A A filtrate is a substance that remains on the filter paper after filtration.

B A saturated solution has the maximum amount of solvent dissolved in the solute.

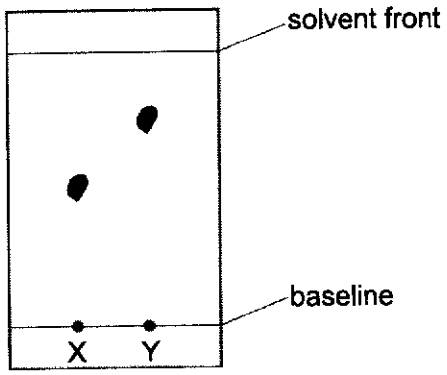
C A solution is a compound produced when a solute reacts with a solvent.

D A substance that remains in the heated flask after distillation is called a residue.

2 The results of a paper chromatography experiment are shown.

X is an aqueous solution of a salt of a Group 1 element.

Y is an aqueous solution of a salt of a transition element.



Which row is correct?

	larger R_f value	requires a locating agent
A	X	X
B	X	Y
C	Y	X
D	Y	Y

3 In which changes do the particles move further apart?

1 A gas is heated from 0 °C to 25 °C.

2 Pressure is applied to a gas at a constant temperature.

3 Steam condenses to form water.

4 Water evaporates at room temperature.

A 1 and 2 only **B** 1 and 4 only **C** 2 and 3 only **D** 3 and 4 only

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4 Data about two compounds is given. Both compounds have a simple molecular structure.

compound	melting point / °C	boiling point / °C
H_2S	−85	−61
PCl_3	−112	76

Two bottles are placed close together inside a large container at a temperature of 90 °C. One bottle contains 1.0 g of H_2S, the other bottle contains 1.0 g of PCl_3.

A detector is placed in the container 2.0 m away from the two bottles. The two bottles are opened at the same time.

Which row is correct?

	compound that reaches detector first	explanation
A	H_2S	gases diffuse faster than liquids
B	H_2S	H_2S has a lower M_r than PCl_3
C	PCl_3	gases diffuse faster than liquids
D	PCl_3	PCl_3 has a lower M_r than H_2S

5 The letters P, Q and R represent different atoms.

$^{40}_{19}P$ $^{39}_{19}Q$ $^{40}_{20}R$

Which statement is correct?

A P and Q are the same element.

B P and R are the same element.

C P has more protons than Q.

D R has more neutrons than Q.

6 Element Z, nucleon number 31, forms an ion Z^{3-}.

Where is Z found in the Periodic Table?

A Group 13 **B** Group 15 **C** Period 4 **D** Period 5

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7 The electronic configurations of elements X and Y are as shown.

X: 2,8,3

Y: 2,6

Element X and element Y react together to form a compound.

Which row shows the electron transfer that takes place and the type of compound formed?

	element X	element Y	type of compound
A	2 atoms each loses 3 electrons	3 atoms each receives 2 electrons	covalent
B	2 atoms each loses 3 electrons	3 atoms each receives 2 electrons	ionic
C	2 atoms each receives 3 electrons	3 atoms each loses 2 electrons	covalent
D	2 atoms each receives 3 electrons	3 atoms each receives 2 electrons	ionic

8 Brass is an alloy of copper and zinc.

Which statement is correct?

A Brass can be represented by a chemical formula.

B Brass is formed by a chemical reaction between copper and zinc.

C Brass will react completely with dilute nitric acid.

D The zinc in brass will react completely with dilute nitric acid.

9 Which statements about the relative atomic mass and relative molecular mass are correct?

1 The mass of the different isotopes does not affect relative atomic masses.

2 Only covalent compounds have a relative molecular mass.

3 Relative atomic masses are compared to $\frac{1}{12}$ of the mass of one atom of ^{12}C.

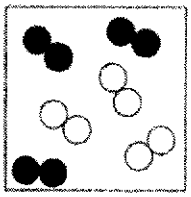
A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

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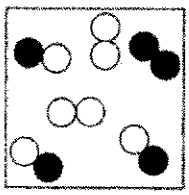
10 Hydrogen reacts with bromine to form hydrogen bromide.

Which diagram represents a reaction between hydrogen and bromine that is **not** yet completed?

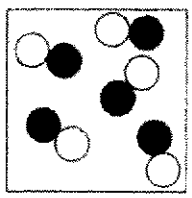
A



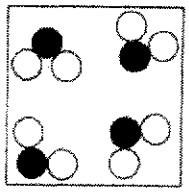
B



C



D



11 Three compounds are listed.

copper(II) nitrate, $Cu(NO_3)_2$

zinc sulfate, $ZnSO_4$

sodium thiosulfate, $Na_2S_2O_3$

Which row shows the element that is present in the greatest percentage by mass in each compound?

[relative formula masses, M_r: $Cu(NO_3)_2$, 188; $ZnSO_4$, 161; $Na_2S_2O_3$, 158]

	copper(II) nitrate	zinc sulfate	sodium thiosulfate
A	copper	oxygen	oxygen
B	copper	oxygen	sulfur
C	oxygen	zinc	sodium
D	oxygen	zinc	sulfur

12 Compound T is the only substance formed when 500 cm^3 of ammonia reacts with 250 cm^3 of carbon dioxide. All measurements are at room temperature and pressure.

What is the formula of T?

A $(NH_2)_2CO$ **B** $(NH_4)_2CO_3$ **C** NH_2COONH_4 **D** NH_4COONH_4

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13 The equation shows the production of iron from its ore, iron(III) oxide.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

80 tonnes of iron(III) oxide produces 50 tonnes of iron.

What is the percentage yield?

A 45% **B** 63% **C** 68% **D** 89%

14 Which statement about hydrochloric acid is correct?

A Hydrochloric acid is formed when hydrogen chloride gas dissolves in water.

B Hydrochloric acid reacts with magnesium to form magnesium chloride and water.

C When hydrochloric acid is added to acidified silver nitrate, yellow precipitate is observed.

D When hydrochloric acid is warmed with aqueous ammonium chloride, ammonia gas is evolved.

15 An excess of substance E is added to the acid that is spilled onto the laboratory bench. The solution produced as a result is neutral.

What is substance E?

A aqueous ammonia

B aqueous sodium hydroxide

C calcium carbonate powder

D water

16 Compound G is a gas at room temperature. G dissolves in water to give a solution with a pH of 4.

Which statement about compound G is correct?

A An aqueous solution of G will not conduct electricity.

B Atoms of a metallic element are present in G.

C Atoms of hydrogen are present in G.

D G is ionically bonded.

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17 The table shows the pH values of four substances that can be consumed by humans.

substance	pH value
P	6.6
Q	3.1
R	10.4
S	7.8

Which statement about these substances is correct?

A P is alkaline.

B Q has the lowest concentration of hydrogen ions.

C R can neutralise excess stomach acid.

D S has a pH value closest to neutral.

18 The addition of calcium hydroxide to soil reduces its acidity but also reduces the efficiency of fertilisers.

Which two equations explain this?

1 $Ca(OH)_2(s) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$

2 $Ca(OH)_2(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + 2H_2O(l)$

3 $Ca(OH)_2(s) + 2NH_4NO_3(aq) \rightarrow Ca(NO_3)_2(aq) + 2NH_3(g) + 2H_2O(l)$

4 $Ca(OH)_2(s) + Cu^{2+}(aq) \rightarrow Cu(OH)_2(s) + Ca^{2+}(aq)$

A 1 and 2 only **B** 1 and 4 only **C** 2 and 3 only **D** 3 and 4 only

19 A pure sample of a salt is obtained by filtration followed by evaporation of the filtrate.

Which pair of reagents would produce the salt?

A aqueous silver nitrate and hydrochloric acid

B aqueous sodium hydroxide and hydrochloric acid

C excess copper(II) oxide and hydrochloric acid

D platinum and hydrochloric acid

20 A solution of sodium carbonate is added to tap water. A white precipitate forms.

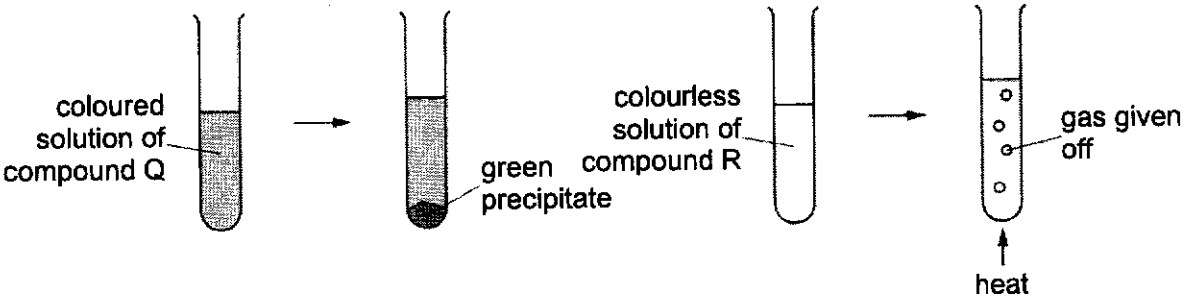
Which ion present in the tap water causes the precipitate to form?

A chloride **B** magnesium **C** potassium **D** sulfate

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21 Aqueous sodium hydroxide is used to identify the ions present in aqueous solutions of compounds Q and R.

The results are shown.



before addition of aqueous sodium hydroxide	after addition of a few drops of aqueous sodium hydroxide	before addition of aqueous sodium hydroxide	after addition of aqueous sodium hydroxide

Which row is correct?

	ion in compound Q	ion in compound R
A	Fe^{2+}	NH_4^+
B	Fe^{2+}	NO_3^-
C	Fe^{3+}	NH_4^+
D	Fe^{3+}	NO_3^-

22 Which reagent and observation describes the test for an oxidising agent?

	reagent	colour change
A	acidified aqueous potassium manganate(VII)	colourless to purple
B	acidified aqueous potassium manganate(VII)	purple to colourless
C	aqueous potassium iodide	brown to colourless
D	aqueous potassium iodide	colourless to brown

23 Aqueous copper(II) sulfate is electrolysed with copper electrodes.

What is the equation for the reaction occurring at the anode?

A $Cu \rightarrow Cu^{2+} + 2e^-$

B $Cu^{2+} + 2e^- \rightarrow Cu$

C $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

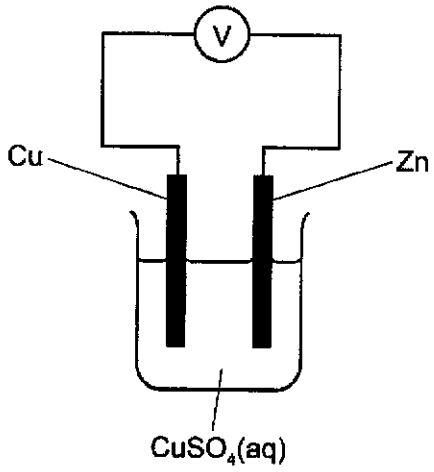
D $2SO_4^{2-} + 2H_2O \rightarrow 2H_2SO_4 + O_2 + 4e^-$

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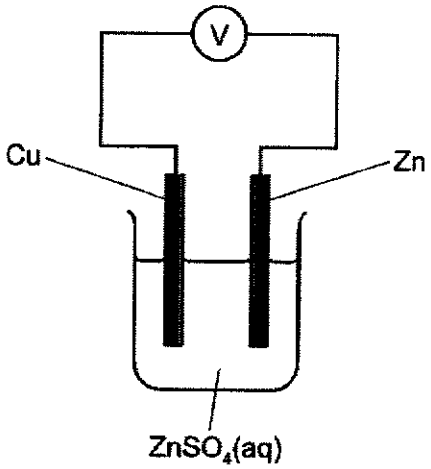
24 Students proposed four cells to produce electricity in a school laboratory.

Which cell would produce the largest voltage in a safe way?

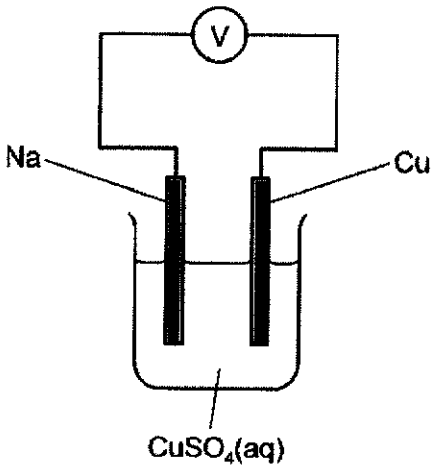
A



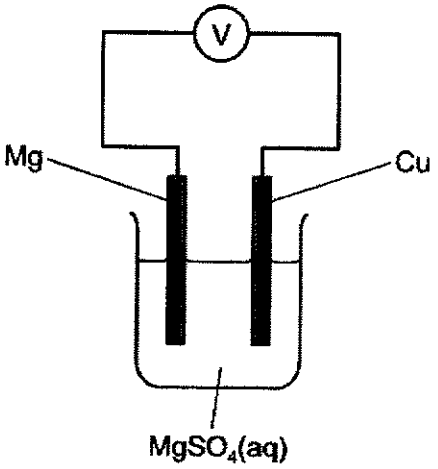
B



C



D



25 Many properties of an element and its compounds can be predicted from the position of the element in the Periodic Table.

What property could **not** be predicted in this way?

A its metallic or non-metallic properties

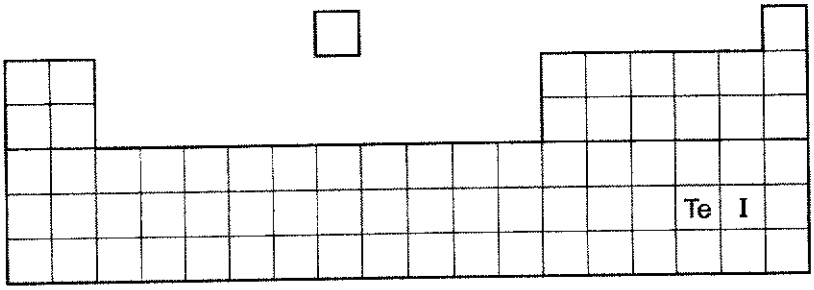
B the acidic or basic nature of its oxide

C the formula of its oxide

D the number of isotopes it has

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26 Iodine, I, has a lower relative atomic mass than tellurium, Te, but is placed after it in the Periodic Table.



Which statement explains why iodine is placed after tellurium in the Periodic Table?

A Iodine has fewer neutrons than tellurium.

B Iodine has fewer protons than tellurium.

C Iodine has more neutrons than tellurium.

D Iodine has more protons than tellurium.

27 Elements in Group 1 of the Periodic Table react with water.

Which row describes the products made in the reaction and the trend in reactivity of the elements?

	products	trend in reactivity
A	metal hydroxide and hydrogen	less reactive down the group
B	metal hydroxide and hydrogen	more reactive down the group
C	metal oxide and hydrogen	less reactive down the group
D	metal oxide and hydrogen	more reactive down the group

28 Which statement about the Group 17 halogens is correct?

A Bromine consists of Br_2 molecules at room temperature and pressure.

B Iodine will displace bromine from aqueous potassium bromide.

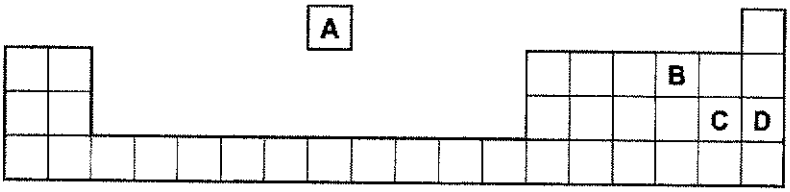
C The halogens become darker in colour as the relative molecular mass decreases.

D The halogens become more volatile as the relative molecular mass increases.

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29 Part of the Periodic Table is shown.

Which substance is an unreactive gas found in the atmosphere?



30 Which statement about corrosion of metals is correct?

A A barrier method is needed to prevent the corrosion of stainless steel.

B Iron corrodes to produce hydrated iron(I) oxide.

C Sacrificial protection uses a less reactive metal attached to the metal object that is being protected.

D When corrosion occurs, the metal loses electrons to become positive ions.

31 Some metals and the compounds in their ores are shown.

metal	Al	Ca	Pb	Na	Fe	Mg
compound in ore	Al_2O_3	$CaCO_3$	PbS	NaCl	Fe_2O_3	$MgCO_3$

Which type of reaction occurs in the extraction of each metal from its ore?

A electrolysis

B precipitation

C reduction

D thermal decomposition

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32 Two reactions are done.

Reaction 1: Hydrated cobalt(II) chloride is heated. It changes colour.

Reaction 2: Water is added to the product of reaction 1. It becomes hotter. The original colour is produced.

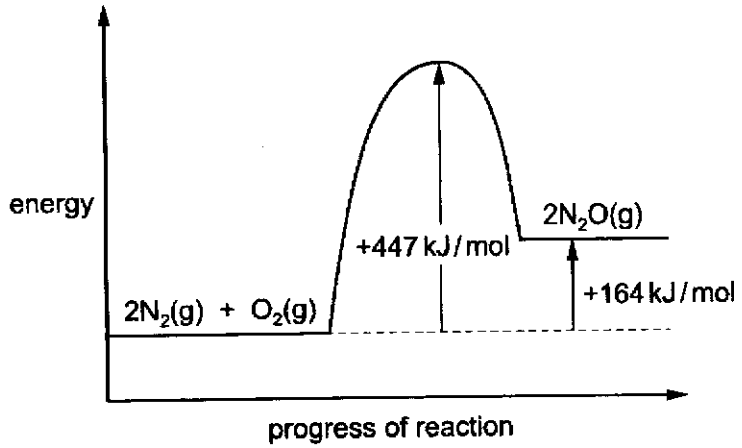
Which types of reaction have occurred in reactions 1 and 2?

	endothermic	exothermic	neutralisation	reversible
A	✓	✓	✓	✓
B	✓	✓	✓	×
C	✓	✓	×	✓
D	✓	×	×	✓

33 Under certain conditions, nitrogen reacts with oxygen to form N_2O.

$$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$$

The reaction pathway diagram is shown.



What is the activation energy of the reverse reaction?

A −447 kJ/mol **B** −283 kJ/mol **C** +141.5 kJ/mol **D** +283 kJ/mol

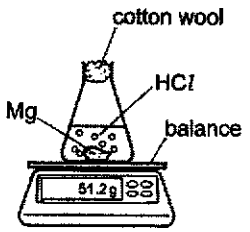
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34 A student plans to investigate how the rate of the reaction changes when hydrochloric acid and magnesium react.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

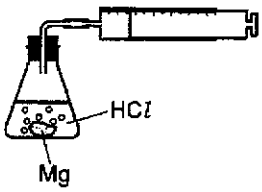
Three methods are described.

1



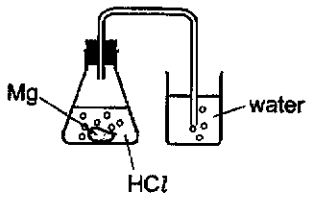
Record the mass of the flask and contents every 30 seconds for 5 minutes.

2



Measure and record the volume of gas in the syringe after 30 seconds.

3



Count and record the total number of bubbles of gas in the water every 30 seconds for 5 minutes.

Which methods could be used to measure how the rate of reaction changes?

A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

35 In which reaction is the pressure **least** likely to affect the rate of reaction?

A $C(s) + CO_2(g) \rightarrow 2CO(g)$

B $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

C $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

D $2SO_2(g) + O_2(g) \rightarrow 2SO_2(g)$

36 Hydrogen is used as a reactant both in the Haber process and in its addition to alkenes.

Which row is correct?

	catalyst in the Haber process	product of addition of hydrogen to an alkene
A	iron	alcohol
B	iron	alkane
C	nickel	alcohol
D	nickel	alkane

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37 In the fractional distillation of petroleum, different fractions are obtained at the top and bottom of the fractionating column.

Which properties does the fraction obtained at the top of the fractionating column have, compared with the fraction obtained at the bottom?

1 higher viscosity

2 lower boiling point

3 lower volatility

4 shorter chain length

A 1 and 2 only **B** 1 and 3 only **C** 2 and 4 only **D** 3 and 4 only

38 Which statement about organic compounds is correct?

A Each molecule of propan-1-ol has one –OH group and each molecule of propan-2-ol has two –OH groups.

B Octane and decane are in a homologous series with the general formula C_nH_{2n}.

C The ester butyl butanoate has eight carbon atoms in each molecule.

D The structure of the functional group in a carboxylic acid is –C–O–O–H.

39 A chlorine atom can replace a hydrogen atom in a molecule of butane, $CH_3CH_2CH_2CH_3$, to form chlorobutane.

How many different structural isomers of chlorobutane can be formed?

A 1 **B** 2 **C** 3 **D** 4

40 Different strategies to reduce the effects of environmental issues have been suggested.

Which row is correct?

	strategy to reduce the effects of climate change	strategy to reduce the effects of acid rain
A	reduction in livestock farming	planting trees
B	reduction in livestock farming	using low-sulfur fuels
C	reduction in use of renewable energy	planting trees
D	reduction in use of renewable energy	using low-sulfur fuels

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}

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Name and Index Number: ( )	Class:

SENG KANG SECONDARY SCHOOL
2024 PRELIMINARY EXAMINATION

CHEMISTRY

Secondary 4 Express

Paper 2

6092/02

21 August 2024

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your index number and name 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, highlighters, glue or correction fluid.

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

Section B
Answer any **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.
A copy of the Periodic Table is printed on page 22.

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

For Examiner's use	
Section A	**/ 70**
1	/ 6
2	/ 12
3	/ 9
4	/ 12
5	/ 11
6	/ 8
7	/ 12
Section B	**/ 10**
8	/ 10
9	/ 10
Total	**/ 80**
Total %	**/ 100**

Parent's / Guardian's Signature: .....

This document consists of **22** printed pages.

Do not turn over the page until you are told to do so.

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Section A [70 marks]

Answer **all** the questions in this section in the spaces provided.

1 Choose from the list of compounds to answer these questions.

aluminium nitrate

ammonia

calcium hydroxide

carbon dioxide

ethanol

methane

sulfur dioxide

sulfuric acid

water

Each compound may be used once, more than once or not at all.

Identify the compound that:

(a) is a common solvent for chromatography in the laboratory,

..... [1]

(b) is used to test for the presence of carbon dioxide,

..... [1]

(c) decolourises acidified aqueous potassium manganate(VII),

..... [1]

(d) gives white precipitate which dissolves in excess aqueous sodium hydroxide,

..... [1]

(e) is a product of Haber Process,

..... [1]

(f) is a waste gas from digestion in animals.

..... [1]

[Total: 6]

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2 This question is about metals and some metal compounds.

(a) Chromium is a transition metal.

Sodium is an element in Group 1 of the Periodic Table.

State **two** physical properties of chromium that are different to those of sodium.

1. .....

2. ..... [2]

(b) The symbols for two isotopes of chromium are shown.

$^{52}_{24}Cr$ $^{53}_{24}Cr$

Complete Table 2.1 to show the number of subatomic particles in these two isotopes of chromium.

Table 2.1

	$^{52}_{24}Cr$	$^{53}_{24}Cr$
number of electrons		
number of neutrons		
number of protons		

[2]

(c) Chromium(III) oxide is reduced by carbon, under high temperature, to produce chromium and carbon dioxide.

(i) Construct a balanced chemical equation for this reaction. State symbols are **not** required.

..... [1]

(ii) Chromium(III) oxide is classified as an amphoteric oxide but carbon dioxide is classified as an acidic oxide.

Explain the meaning of the terms *amphoteric* and *acidic* as applied to these oxides. Include one equation in your explanation.

.....

.....

.....

..... [2]

[Turn over

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(d) A coloured crystal of chromium(III) nitrate is placed at the bottom of a beaker containing water.

Colour spreads throughout the water overtime. Fig. 2.2 shows the spread of colour after two days.

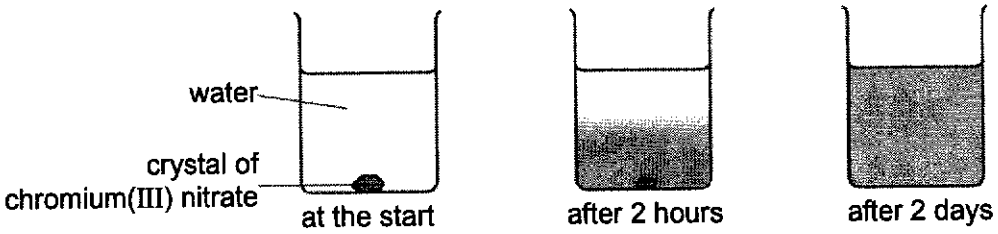


Fig. 2.2

Explain these observations.

.....

.....

.....

.....

.....

..... [3]

(e) Table 2.3 shows the observations made when four different metals are heated in oxygen.

Table 2.3

metal	observations
lanthanum	forms a layer of oxide rapidly on the surface but does not burn
mercury	does not form a layer of oxide on the surface
nickel	forms a layer of oxide slowly on the surface but does not burn
sodium	burns rapidly

Using the information in Table 2.3 to suggest the order of reactivity of these metals.

most reactive ....., ..., ..., ... least reactive [2]

[Total: 12]

[Turn over

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3 **(a)** Iodine reacts with chlorine to form iodine monochloride, IC*l*.

Draw a 'dot and cross' diagram for a molecule of iodine monochloride. Show outer electrons only.

[1]

Iodine monochloride is a useful reagent in organic synthesis.

(b) Iodine monochloride reacts in a similar way to bromine. It can undergo addition reaction with ethene. This reaction gives an enthalpy change of −94 kJ/mol.

(i) Draw the displayed formula of the product of this reaction.

[1]

(ii) Table 3.1 shows some of the bond energies.

Table 3.1

bond	bond energy / (kJ/mol)
C—C	348
C=C	614
C—C*l*	328
C—H	413
C—I	240
I—C*l*	?

Calculate the bond energy of I—C*l*.

bond energy of I—C*l* = ... [2]

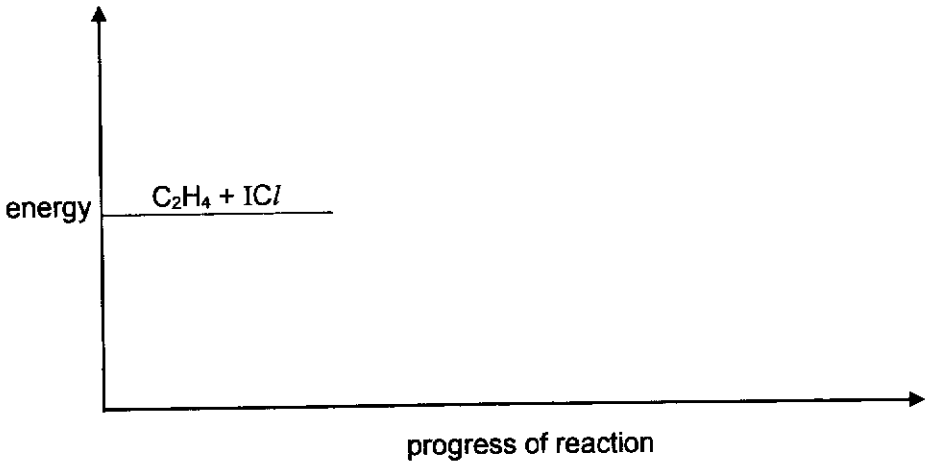
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(iii) Complete the energy profile diagram in Fig. 3.2 for this reaction.

The energy profile diagram should include:

- the chemical formula of the product,
- labels to show the activation energy and the enthalpy change of reaction.



[3]

Fig. 3.2

(c) Iodine monochloride also reacts in a similar way to chlorine.

Iodine monochloride reacts with ethane in the presence of ultraviolet light.

(i) State the type of reaction that takes place.

..... [1]

(ii) Construct a chemical equation for the reaction between iodine monochloride and ethane.

..... [1]

[Total: 9]

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4 A sample of clean, dry air contains 0.0400% carbon dioxide by volume.

(a) Calculate the number of molecules of carbon dioxide in 480 dm^3 of clean, dry air at room temperature and pressure.

number of molecules = ... [2]

(b) Complete combustion of fuels such as petrol makes carbon dioxide.

The percentage by mass of the elements present in petrol is given in Table 4.1.

Table 4.1

element	percentage by mass
carbon	85.7
hydrogen	14.3

(i) Calculate the empirical formula of petrol.

[2]

(ii) The molecular mass of petrol is 128.25.

Hence, calculate the molecular formula of petrol.

[1]

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(iii) If 1 kg of petrol is burnt completely, calculate the volume of carbon dioxide produced.

volume of carbon dioxide produced = ... [3]

(c) Higher levels of atmospheric carbon dioxide can lead to increased global warming.

(i) State **one** adverse effect of global warming.

.....

..... [1]

(ii) Describe how the presence of gases such as carbon dioxide in the atmosphere causes global warming.

.....

.....

.....

..... [2]

(d) Carbon dioxide is removed from the atmosphere by photosynthesis.

Construct a chemical equation for photosynthesis.

..... [1]

[Total: 12]

[Turn over

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5 By understanding the rate of reaction, we can find out how fast products are made and what causes reactions to slow down. Methods are then developed to improve production at the manufacturing industries.

This question is about two experiments on rate of reaction.

(a) In this experiment, peroxodisulfate ions, $S_2O_8^{2-}$, react with iodide ions in aqueous solution.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

(i) Explain whether peroxodisulfate ions are acting as an oxidising agent or reducing agent.

State how the equation shows this.

.....

..... [1]

(ii) Table 5.1 shows how the relative rate of this reaction changes when different concentrations of peroxodisulfate ions and iodide ions are used.

Table 5.1

experiment	concentration of $S_2O_8^{2-}$ in mol/dm^3	concentration of I^- in mol/dm^3	relative rate of reaction
1	0.008	0.02	1.7
2	0.016	0.02	3.3
3	0.032	0.02	6.8
4	0.008	0.04	3.4
5	0.008	0.08	6.9

Using the information in Table 5.1, describe how increasing the concentration of each of these ions affects the relative rate of reaction.

peroxodisulfate ions .....

.....

.....

iodide ions .....

.....

..... [2]

[Turn over

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(iii) Iron(III) ions, Fe^{3+}, catalyse this reaction.

Explain how catalysts increase the rate of reaction.

.....

.....

..... [2]

(b) Halogenoalkanes undergo hydrolysis to form an alcohol and a halide ion in the presence of water. In this process, the hydroxyl (−OH) group substitutes for the halogen, X, as shown in the equation.

$$RX + H_2O \rightarrow ROH + HX$$

key:

R: alkane group

To study the rate of reaction between a halogenoalkane and water, the following procedure is carried out:

Step 1: Dissolve 10 cm^3 of aqueous silver nitrate in 10 cm^3 of ethanol.

Step 2: Warm the mixture to 60 °C.

Step 3: A few drops of the halogenoalkane are added to the silver nitrate-ethanol mixture.

Step 4: The time taken for a precipitate to form is recorded in Table 6.2.

As the hydrogen halide forms, it dissolves in the water to produce H^+ and X^- ions. The ions then react with the silver ions in the solution, giving a precipitate. The appearance of the precipitate depends upon the halide ion generated in the reaction.

$$Ag^+(aq) + X^-(aq) \rightarrow AgX(s)$$

Table 5.2 shows the results obtained.

Table 5.2

experiment	halogenoalkane	number of drops of halogenoalkane	time / min
1	chlorobutane	4	6.0
2	bromobutane	8	3.0
3	fluorobutane	4	80.0
4	iodobutane	4	0.1

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(i) Using the data in Table 5.2, explain why a longer time is needed to give a precipitate in experiment 1 than experiment 2.

.....

.....

..... [2]

(ii) Describe the relationship between the rate of reaction of halogenoalkanes and water with the reactivity of halogens.

.....

..... [1]

(iii) Use ideas about collisions between particles to explain why the time taken to give precipitate increases when the experiments were repeated at 30 °C.

.....

.....

.....

.....

.....

..... [3]

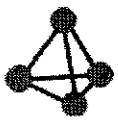
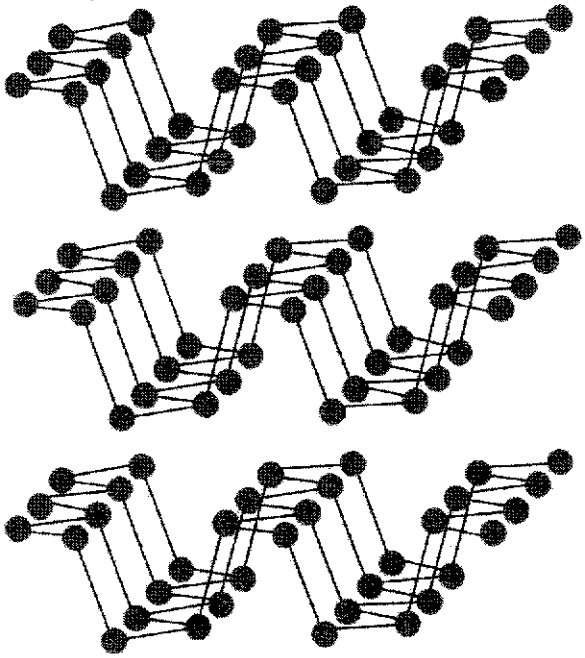
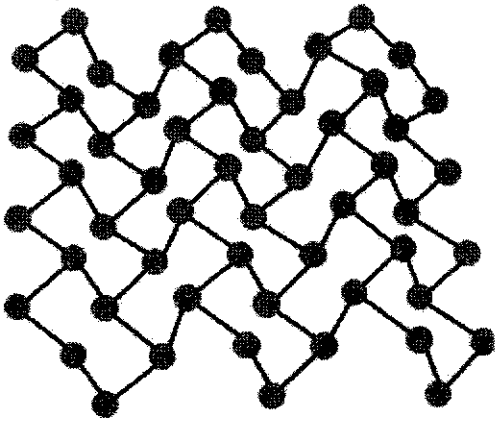
[Total: 11]

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6 Phosphorus is a mineral that makes up 1% of a person's total body weight. Most of the phosphorus in the body is found in our bones and teeth.

Pure phosphorus exists as different allotropes. The structures and melting points of two such allotropes, white phosphorus and black phosphorus, are shown in the Table 6.1.

Table 6.1

name	structure	melting point / °C
white phosphorus		44
black phosphorus	part of the structure (side view):  part of the structure (top view): 	610

key:

● : phosphorus atom

[Turn over

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(a) With reference to Table 6.1, explain what is meant by the term *allotropes*.

.....

..... [1]

(b) Deduce the chemical formula of white phosphorus.

..... [1]

(c) **(i)** With reference to Table 6.1, deduce the structure of each allotrope of phosphorus.

white phosphorus .....

black phosphorus ..... [2]

(ii) With reference to the **bonding**, explain the difference in the melting points of the two allotropes of phosphorus.

.....

.....

.....

.....

.....

.....

.....

.....

..... [3]

(d) A single layer of black phosphorus can be obtained by using the scotch tape delamination method. This method involves the use of a scotch tape to peel off a single layer.

With reference to the **structure** of black phosphorus in Table 6.1, explain why a single layer of black phosphorus can be easily peeled off using the scotch tape.

.....

..... [1]

[Total: 8]

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7 Biodiesel Fuel

The Manufacture of Biodiesel

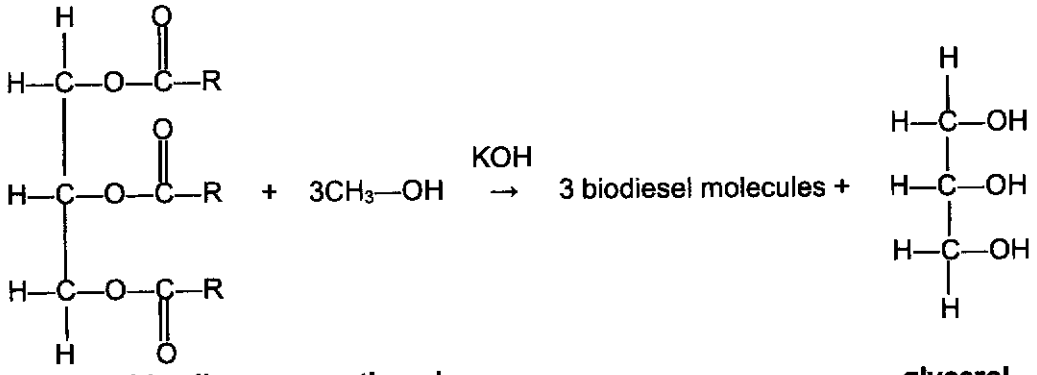
Biodiesel is a renewable, biodegradable fuel manufactured from vegetable oils, animal fats, or waste cooking oils, where their physical characteristics are closer to those of petroleum diesel fuels. In fact, waste vegetable oil is the main raw material used for biodiesel production in the United States.

Biodiesel fuel is manufactured by transesterification. In this process, the vegetable oil, which is a tri-ester with long hydrocarbon chains, reacts with methanol in the presence of potassium hydroxide as catalyst to produce the biodiesel and glycerol.

The diagram shows the structures of some of the molecules involved in the transesterification process.

key:

R: hydrocarbon chain



vegetable oil **methanol** **glycerol**

Waste vegetable oils, that were previously exposed to high temperatures during cooking, usually contain acids. The presence of acid in the waste vegetable oils makes it challenging to convert them into biodiesel, taking a longer time than waste vegetable oil without acid.

Comparison between Petroleum Diesel and Biodiesel

Table 7.1 compares some of the properties between petroleum diesel fuel and biodiesel.

Table 7.1

type of fuel	petroleum diesel	biodiesel
energy produced / kJ per g	approximately 43.0	approximately 37.8
biodegradability	non-biodegradable	biodegradable
production process	• takes millions of years to form • requires fossil fuel to be refined before it is useful	• presence of acid affects the rate of reaction • requires crops (e.g. corn) to be grown for fuel
probability of incomplete combustion	more likely	less likely

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The Use of Biodiesel as a Fuel in Diesel Engines

Biodiesel is usually blended with petroleum diesel since most diesel engines cannot run on pure biodiesel without some form of engine modification.

Fig. 7.2 shows the graph of percentage change in emissions of common pollutants such as nitrogen oxides (NO_x), particulate matter (PM), unburnt hydrocarbon (unburnt HC) and carbon monoxide (CO) from diesel engines, using varying proportions of biodiesel and petroleum diesel.

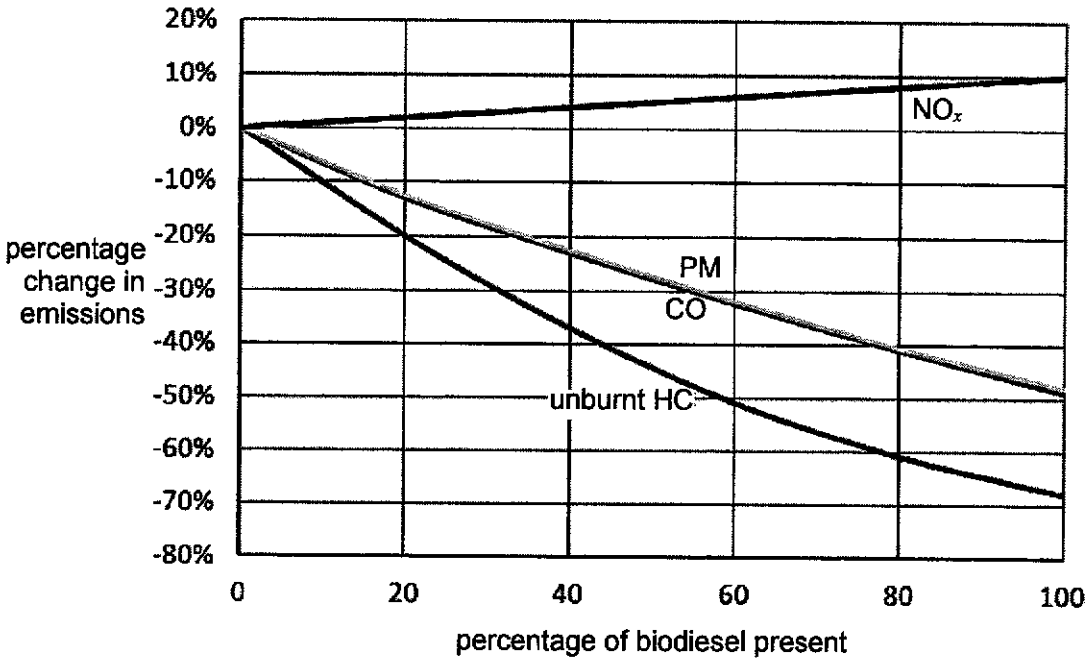


Fig. 7.2

Acknowledgement:

1) *GCE O Level Chemistry 2018 P2B Q9*
2) *Topi, D. Transforming waste vegetable oils to biodiesel, establishing of a waste oil management system in Albania. SN Appl. Sci. 2, 513 (2020)*
3) *http://www.dynamicscience.com.au/tester/solutions1/chemistry/organic/diesels.html*
4) *A Review of the Developed New Model Biodiesels and Their Effects on Engine Combustion and Emissions, Applied Sciences, 2018, 8, 2303*

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(a) **(i)** Suggest why vegetable oils are called *tri-esters*.

..... [1]

(ii) Deduce the structural formula of one biodiesel molecule that is produced during the transesterification process.

Use 'R' to represent the hydrocarbon chain.

[1]

(iii) Explain how and why 'the presence of acid in the waste vegetable oils will take a longer time for its conversion into biodiesel'.

.....

.....

.....

..... [2]

(b) **(i)** Currently, blends of 20% biodiesel with 80% petroleum diesel is ideal to be used in existing vehicles with no or little engine modification.

Using the data in Table 7.1, calculate the **total estimated** amount of energy produced in 1 kg of fuel in such mixture.

[2]

(ii) A scientist claims, "Biodiesel is a better source of fuel than petroleum diesel."

With reference to Table 7.1, give reasons to support his idea.

.....

.....

.....

..... [2]

[Turn over

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(c) **(i)** With reference to Fig. 7.2, identify the benefits of using 20% biodiesel.

.....

.....

.....

..... [2]

(ii) State and explain a possible effect of using 100% biodiesel on the environment.

.....

.....

.....

..... [2]

[Total: 12]

[Turn over

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Section B [10 marks]

Answer **one** question in this section in the spaces provided.

8 Electroplating is a process of using electrical current to deposit a thin layer of metal onto an electrically conductive object. Gold plating is one such example.

In the gold plating of a spoon, aqueous sodium dicyanoaurate, $NaAu(CN)_2$, is used as the electrolyte. The spoon is placed at the cathode and a piece of gold is used as the anode.

Fig. 8.1 shows the experimental set-up.

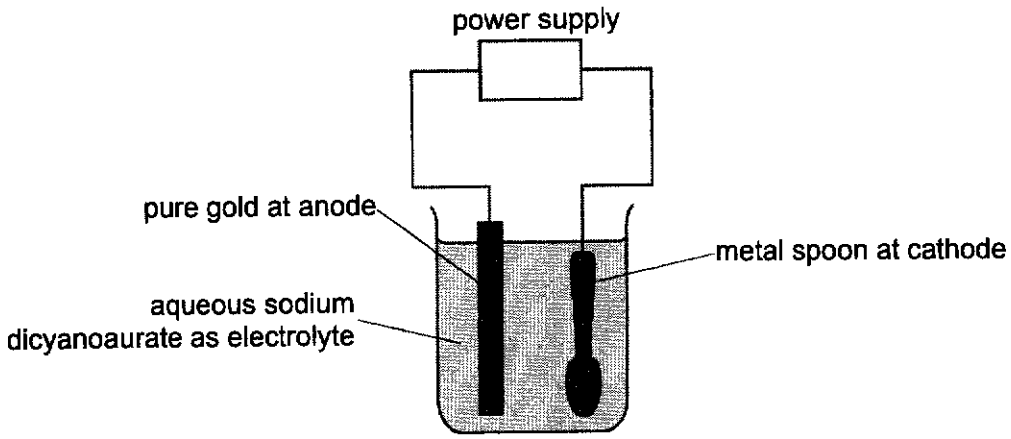


Fig. 8.1

(a) Sodium dicyanoaurate ionises in water to form sodium ions, gold ions and cyanide ions, CN^-.

State the oxidation state of each element in this electrolyte.

element	oxidation state in $NaAu(CN)_2$
carbon	
gold	
nitrogen	−3
sodium	

[2]

(b) **(i)** State the formulae of **all** the ions which are attracted to the cathode.

..... [1]

(ii) Gold is discharged at the cathode.

Write the half equation, with state symbols, for this reaction at the cathode.

..... [1]

[Turn over

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(iii) Explain why gold ions are discharged in preference over any other ions at the cathode.

.....

.....

.....

..... [2]

(c) Suggest whether the concentration of the electrolyte will change throughout the plating process. Explain your reasoning.

.....

.....

.....

..... [2]

(d) The experiment was repeated by replacing the gold electrode with graphite electrode, with all other factors remain constant.

State and explain what would happen at the cathode initially, and after a long period of time.

.....

.....

.....

..... [2]

[Total: 10]

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9 *Ideonella sakaiensis* is a type of bacteria found in cow stomachs that can break down polyethylene terephthalate (PET), a type of plastic commonly used to produce bottles.

Fig. 9.1 shows the structure of a section of PET.

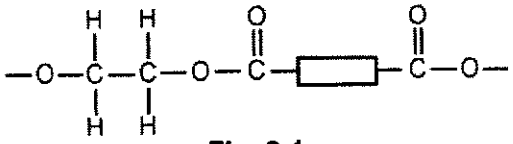


Fig. 9.1

(a) PETase, produced by the bacteria, breaks down PET to produce ethylene glycol and terephthalic acid.

(i) Draw the full structural formulae of the monomers that react to form PET.

ethylene glycol terephthalic acid [2]

(ii) Suggest the role of PETase in the breakdown of PET.

..... [1]

(b) Plastic products can be upcycled to form vanillin, which is a synthetic vanilla flavour, often used in beverages and pharmaceuticals.

Vanillin contains the aldehyde functional group.

Table 9.2 shows information about homologous series of aldehydes.

Table 9.2

name	number of carbon atoms	formula	solubility
methanal	1	HCHO	soluble
ethanal	2	CH_3CHO	soluble
propanal	3	C_2H_5CHO	partially soluble
	4		insoluble

[Turn over

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(i) Complete Table 9.2 to show the name and formula of the aldehyde that contains 4 carbon atoms. [2]

(ii) Deduce the general formula for aldehydes.

..... [1]

(iii) Using information in Table 9.2 and your knowledge of Organic Chemistry, suggest two factors that affect the solubility of organic compounds.

factor 1 .....

.....

factor 2 .....

..... [2]

(c) In 2018, a journal published that waxworms were able to eat and digest the poly(ethene) plastic. The saliva from waxworms can metabolise poly(ethene) into ethylene glycol.

(i) Deduce the name of the chemical reaction involved in the metabolism of poly(ethene) into ethylene glycol.

..... [1]

(ii) Explain how waxworms can help in the environmental problems posed by plastics.

.....

..... [1]

[Total: 10]

~ END OF PAPER ~

[Turn over

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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, $L = 6.02 \times 10^{23}\ mol^{-1}$

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MARK SCHEME for SKSS 2024 4E Chemistry Prelim Paper 1 & 2

PAPER 1 [40 marks]

1	2	3	4	5	6	7	8	9	10
D	C	B	B	A	B	B	D	C	B
11	12	13	14	15	16	17	18	19	20
D	C	C	A	C	C	C	C	C	B
21	22	23	24	25	26	27	28	29	30
A	D	A	D	D	D	B	A	D	D
31	32	33	34	35	36	37	38	39	40
C	D	D	B	C	B	C	C	D	B

PAPER 2
Section A [70 marks]

1 *[This question mainly assesses students' memory work.]*
[accept if correct chemical formula is written each time]
(a) ethanol/water **[1] [accept if both are written]** **(b)** calcium hydroxide **[1]** **(c)** sulfur dioxide **[1]**
(d) aluminium nitrate **[1]** **(e)** ammonia **[1]** **(f)** methane **[1]**

2 *[This question is similar to the Specimen Paper Q4]*
(a) **[1m for each correct answer; max. of 2m]**
*Any **TWO** of the following answers:*
- forms/gives coloured compounds
- higher density
- higher melting and boiling point

[reject: good catalyst, variable oxidation states as these are not physical properties]

(b) **[1m for all correct number of electrons and protons; 1m for all correct number of neutrons; max. of 2m]**

	$^{52}_{24}Cr$	$^{53}_{24}Cr$
number of electrons	**24**	**24**
number of neutrons	**28**	**29**
number of protons	**24**	**24**

(c) **(i)** $2Cr_2O_3(s) + 3C(s) \rightarrow 4Cr(s) + 3CO_2(g)$ **[1]**
[reject if the coefficients are not in the simplest form]

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MARK SCHEME for SKSS 2024 4E Chemistry Prelim Paper 1 & 2

[Note to marker: All state symbols must be written correctly to be awarded 1m if students choose to include in the balanced chemical equation.]

(ii) Amphoteric oxide can react with both acids and bases while acidic oxide can only react with bases. **[1]**

*Any **ONE** of the following equations:*

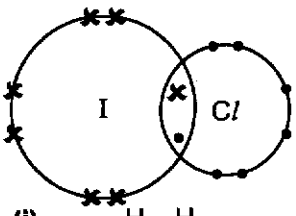
- $Cr_2O_3 + 6HCl \rightarrow 2CrCl_3 + 3H_2O$ ***OR*** with any other acids
- $CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$ ***OR*** with any other bases **[1]**

[Note to marker: It is **not** within the syllabus for students to write the chemical equation of chromium(III) oxide with a base as complex ions are formed.]

(d)
- crystal dissolves **[1]**
- *(idea of collision)* particles collide / particles bounce off each other **[1]**
- *(idea of diffusion)* particles move further apart / particles move/diffuse from higher concentration to lower concentration / movement of particles down a concentration gradient **[reject the word 'spread' to describe diffusion as this word is already seen in the question]** **[1]**

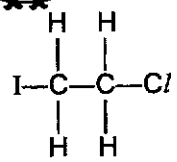
(e) **[1m for every 2 correct order of arrangement; max. of 2m]**
(most reactive) sodium, lanthanum, nickel, mercury (least reactive)

3 (a)



[1]

(b) (i)



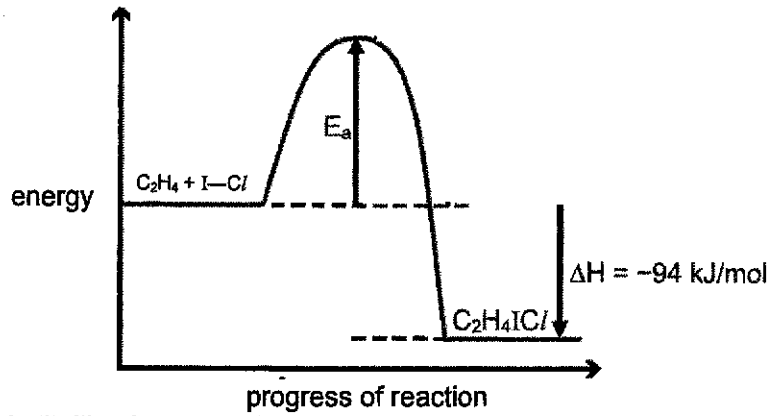
[1]

(ii) $\Delta H_{bond\ breaking} = 614 + 4(413) + ? = (2266 + ?)$ kJ
$\Delta H_{bond\ forming} = 240 + 4(413) + 348 + 328 = 2568$ kJ
$\Delta H_{bond\ breaking} - \Delta H_{bond\ forming} = -94$
$2266 + ? - 2568 = -94$ **[1m with correct working]**
$? =$ 208 kJ/mol **[1m with correct unit]**

(iii) *[This part of the question is similar to Specimen Paper, Q9(d)]*
[1m for showing energy of reactants is more than products; 1m for showing E_a and correctly labelled with single-headed arrow pointing in the correct direction (upwards); 1m for indicating correct chemical formula of product (allow ecf from (b)(i)); max. of 3m]

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(c) **(i)** Substituition **[accept minor spelling error]** **[1]**

(ii) $C_2H_6 + ICl \rightarrow C_2H_5Cl + HI$ **[1]**

4 **(a)** Volume of CO_2 present in clean, dry air = $\frac{0.04}{100} \times 480$
= 0.192 dm^3

No. of moles of $CO_2 = \frac{0.192}{24}$ = <u>0.008 mol.</u> **[1]**

No. of molecules of $CO_2 = 0.008 \times 6.02 \times 10^{23}$
$= 4.816 \times 10^{21}$ = = <u>4.82×10^{21} (3 s.f.)</u> **[1]**

(b) **(i)**

	C	H
mass / g	85.7	14.3
A_r	12	1
No. of mol	$\frac{85.7}{12} = 7.142$	$\frac{14.3}{1} = 14.3$
ratio	$\frac{7.142}{7.142} = 1$	$\frac{14.3}{7.142} = 2.00$

[1]

∴ empirical formula = CH_2

(ii) Relative molecular mass of CH_2 = 12 + 1 + 1 = 14

$n \times 14 = 128.25$

$n = 9.16 \approx 9$

∴ molecular formula = $(CH_2)_9 = C_9H_{18}$ **[1]**

(iii) Equation: $2C_9H_{18} + 27O_2 \rightarrow 18CO_2 + 18H_2O$ **[1]**

Note to marker: There are two solutions to this part of the question.

<u>*Solution 1*</u>	<u>*Solution 2*</u>
No. of moles of C_9H_{18} present $= \frac{1000}{(12\times9)+(1\times18)} = 7.9365$	No. of moles of C_9H_{18} present $= \frac{1000}{128.25} = 7.79727$ **[1]**
Mole ratio = C_9H_{18} : CO_2 = 2 : 18 =7.9365: 71.42857	Mole ratio = C_9H_{18} : CO_2 = 2 : 18 =7.79727: 70.175
Vol. of CO_2 = 71.42857 × 24 = 1710 dm^3 (3 s.f.)	Vol. of CO_2 = 70.175 × 24 = 1680 dm^3 (3 s.f.) **[1]**

(c) **(i)** *Any **ONE** of the following answers:*

- Desertification of fertile land would lead to the amount of food that can be produced globally to decrease. **[1]**

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- High temperatures from more frequent and severe heat waves can be fatal.
- Ocean warming can cause commercially-important fish population to be depleted.
- Melting of polar ice caps can cause sea levels to rise and permanently flood coastal areas.

[reject: cause climate change / melt ice caps / cause death]

(ii) Carbon dioxide, a greenhouse gas, traps heat within the Earth's atmosphere. **[1]**
This leads to the increase in the average temperature of the Earth's surface. **[1]**

(d) $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

5 (a) (i) Peroxodisulfate ions act as an oxidising agent. **[No mark is awarded unless explanation is correct.]**
It causes iodide ions to be oxidised to iodine due to an increase in oxidation state of iodine from −1 to 0. **[1]**

(ii) *[data analysis: inference]*
Peroxodisulfate ions: Comparing experiment 1 and 2 / 2 and 3, rate of reaction increases by twice/doubles when concentration of peroxodisulfate ions doubles with the same concentration of iodide ions at 0.02 mol/dm^3. **[1]**
Iodide ions: Comparing experiment 1 and 4 / 4 and 5, rate of reaction increases by twice/doubles when concentration of iodide ions doubles with the same concentration of peroxodisulfate ions at 0.008 mol/dm^3. **[1]**
[reject if the experiment numbers and concentrations are not quoted]

(iii) The presence of a catalyst provides an alternative pathway of lowering/decreasing activation energy, allowing more colliding particles to have energy greater than or equal to activation energy. **[1]**
This increases the frequency/rate of effective collisions and the rate of reaction. **[1]**

(b) (i) *[data analysis: inference and deduction, supported by scientific explanation]*
There are only 4 drops of halogenoalkanes used in experiment 1 as compared to 8 drops of halogenoalkanes used in experiment 2. **[1]**
[reject if number of drops is not quoted]
Lesser amount of reacting particles present per unit volume/in the same volume, resulting in lower frequency/rate of effective collisions hence slower rate of reaction. **[1]**

(ii) *[data analysis: describing trend]*
The more reactive the halogen, the slower the rate of reaction between a halogenoalkane and water. **[1]**
OR The less reactive the halogen, the faster the rate of reaction between a halogenoalkane and water.

(iii) At lower temperature, reactant particles have less kinetic energy and move slower. **[1]**
There are less reactant particles possessing energy that is greater than or equal to activation energy. **[1]**
This decreases the frequency/rate of effective collisions and the rate of reaction. **[1]**

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6 **(a)** Different forms of the same element of phosphorus with different structural arrangements of atoms. **[1]**
[reject if phosphorus is not stated]

(b) P_4 **[1]**

(c) **(i)** White phosphorus: simple molecular structure
Black phosphorus: giant (three dimensional) molecular structure

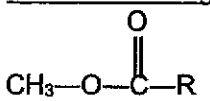
(ii) *[This part of the question requires students to memorise the correct scientific phrases to score.]*
[Marking point: 1m for stating the comparison of the melting points, that is low/lower VS high/higher m.p; 1m for stating the correct energy and type of force in white phosphorus; 1m for stating the correct energy and bond in black phosphorus; max. of 3m]
Little/Small amount of (thermal) energy is needed to overcome the weak intermolecular forces of attraction between the molecules of white phosphorus (in the simple molecular structure), hence has a low/lower melting point (of 44 °C).
Large/A lot of (thermal) energy is needed to break/overcome the strong, extensive covalent bonds between the phosphorus atoms (in the giant molecular structure), hence has a high/higher melting point (of 610 °C).

(d) *[Note: Students are to relate that the concept is similar to why graphite is soft.]*
Little/Small amount of energy is needed to overcome the weak forces of attraction between each layer **[1]**. Hence, the layers can be easily peeled off with the scotch tape delamination.

7 *[data-based question, reference from GCE O Level Chemistry 2018 P2B Q9]*

(a) **(i)** three ester linkages in one molecule / per molecule **[1]**

(ii)



[1]

(iii) Presence of acid in the waste vegetable oil will inactivate / make the catalyst ineffective / neutralise / remove KOH. **[1]**
This slows down / reduces / decreases the rate of reaction. **[1]**
Therefore, longer time is required for its conversion.

(b) **(i)** Amount of biodiesel present in 1kg of fuel = $\frac{20}{100} \times 1000 = 200g$
Amount of petroleum diesel present in 1kg of fuel = 800g **[1]**
Total estimated amount of energy produced = $(43 \times 800) + (37.8 \times 200)$
$= 34400 + 7560$
$=$ 41960 kJ **[1]**

(ii) Biodiesel is biodegradable when released into the environment (e.g. oil spill) and produces less carbon monoxide as it is less likely to be involved in incomplete combustion compared to petroleum diesel. **[1]**
Biodiesel requires crops (e.g. corn) to be grown for fuel which is an alternative renewable energy source while petroleum diesel requires fossil fuel to be refined, which is a non-renewable energy source. **[1]**

(c) **(i)** **[1m for stating all three pollutants; 1m for stating the % reduction]**
Usage of biodiesel reduces the emissions of unburnt hydrocarbon, particulate matter and carbon monoxide **[1]**
by about 46% in total compared to using petroleum diesel. **[1]**

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OR reduces emissions of unburnt hydrocarbon by 20%, carbon monoxide & PM by about 26% - 28%.
[reject if data is not quoted]

(ii) As more biodiesel is burnt, more nitrogen oxides are produced / increases production of NO_x by 10%. **[1]**
Nitrogen oxides is a cause of acid rain, which will damage metallic and limestone structures / nitrogen oxides react with sunlight and other pollutants to produce ozone which damage crops. **[1]**

Section B [10 marks]
[Note to marker: Only mark Q8 if student attempts both questions in this section.]

8 (a) **[1m for 2 correct answers; 2m for 3 correct answers]**

element	oxidation state in $NaAu(CN)_2$
carbon	**+2**
gold	**+1**
nitrogen	−3
sodium	**+1**

(b) **(i)** Na^+, Au^+ and H^+ **[reject: sodium ions, gold ions and hydrogen ions]** **[1]**

(ii) $Au^+(aq) + e^- \rightarrow Au(s)$ **[reject if correct state symbols are not included]** **[1]**
[allow ecf based on the oxidation state of Au in 8(a)]

(iii) Gold is the least reactive among the three cations attracted to the cathode ***OR*** Gold is less reactive than hydrogen and sodium. **[1]**
Hence, gold ions gain electrons more readily than sodium ions and hydrogen ions. **[1]**

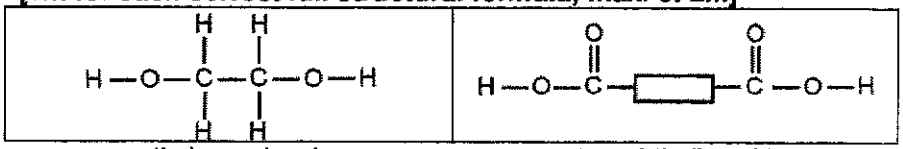
(c) No ***OR*** The concentration remains constant. **[No mark is awarded unless explanation is correct.]**
The gold ions that are discharged at the cathode came mainly from the gold anode. **[1]**
There is no net loss of gold ions from the electrolyte/ sodium dicyanoaurate. **[1]**

(d) Gold would be deposited at the cathode initially. Hydrogen gas would be evolved after a long time. **[1]**
Initially, the concentration of gold ions in the electrolyte decreases as they are preferentially discharged over sodium and hydrogen ions at the cathode. After a long time, hydrogen ions would then be discharged preferentially over sodium ions, forming hydrogen gas. **[1]**

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9 **(a)** **(i)** **[1m for each correct full structural formula; max. of 2m]**



ethylene glycol | terephthalic acid

(ii) Acts as catalyst ***OR*** A catalyst in the enzyme ***OR*** To increase the rate of reaction **[1]**

(b) **(i)** Butanal **[1]**; C_3H_7CHO **[1]**

(ii) $C_nH_{2n+1}CHO$ ***OR*** $C_{n-1}H_{2n-1}CHO$ **[1]**

(iii) **[1m for every correct factor; max. of 2m]**

- presence of oxygen in the organic compound
- length of carbon chain / number of carbon atoms / percentage by mass of carbon / relative molecular mass / molecular size

(c) **(i)** Oxidation **[accept minor spelling error]** **[1]**

(ii) Waxworms can remove <u>non-biodegradable plastic</u> from the environment, <u>reducing pollution</u>. **[1]**

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