Name and Index Number: ( )	Class:

SENG KANG SECONDARY SCHOOL
2024 PRELIMINARY EXAMINATION

CHEMISTRY **6092/02**

Secondary 4 Express **21 August 2024**

Paper 2 **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.

[Turn over

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]

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]

(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.

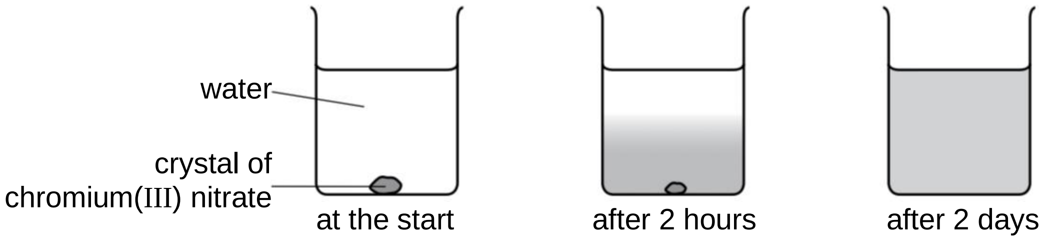


Fig. 2.2

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]

3 **(a)** Iodine reacts with chlorine to form iodine monochloride, I*Cl*.

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*	?

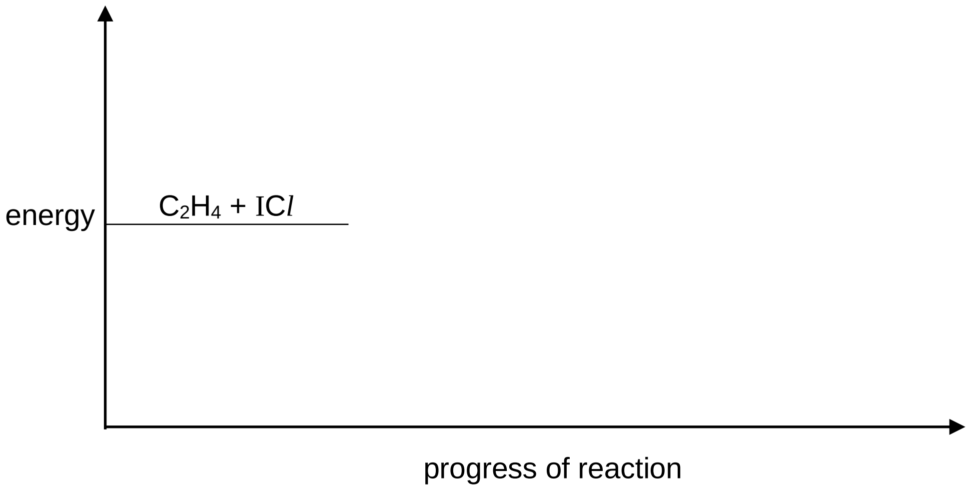
Calculate the bond energy of I—C*l*.

bond energy of I—C*l* = …………………….... [2]

(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]

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]

(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]

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]

(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

(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.

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

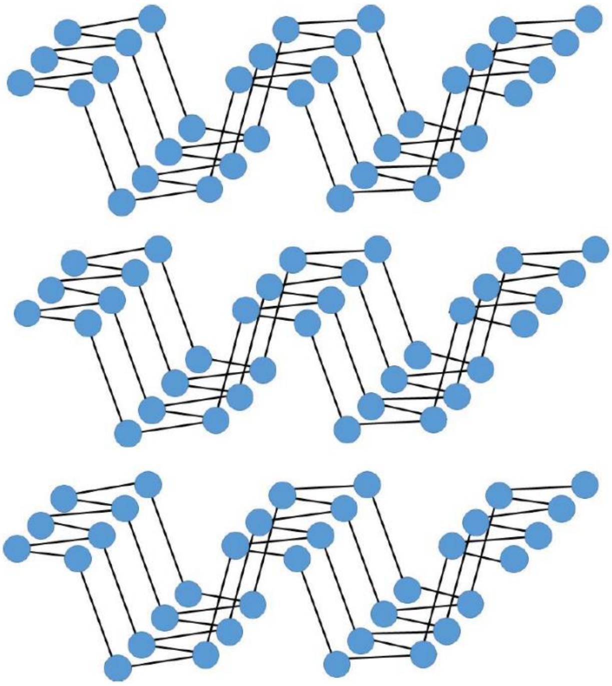
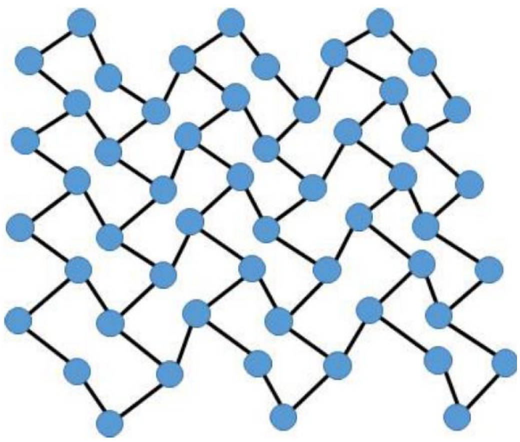
……………………………………………………………………………………….. [3]

[Total: 11]

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

(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.

………………………………………………………………………………..

………………………………………………………………………………..

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………………………………………………………………………………..

………………………………………………………………………………..

………………………………………………………………………………..

………………………………………………………………………………..

……………………………………………………………………………….. [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]

7 Biodiesel Fuel

The Manufacture of Biodiesel

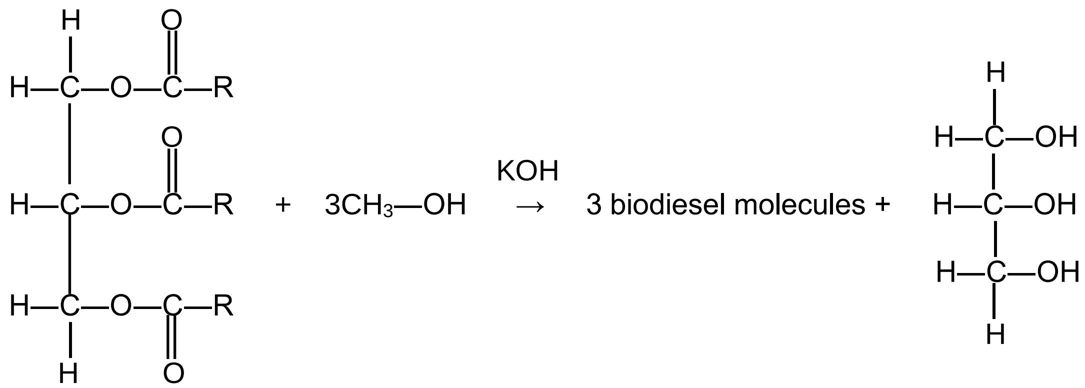
Biodiesel is a renewable, biodegradable fuel manufactured from vegetable oils, animal fats, or waste cooking oils, where their physical characteristics are closer to those of petroleum diesel fuels. In fact, waste vegetable oil is the main raw material used for biodiesel production in the United States.

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

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.

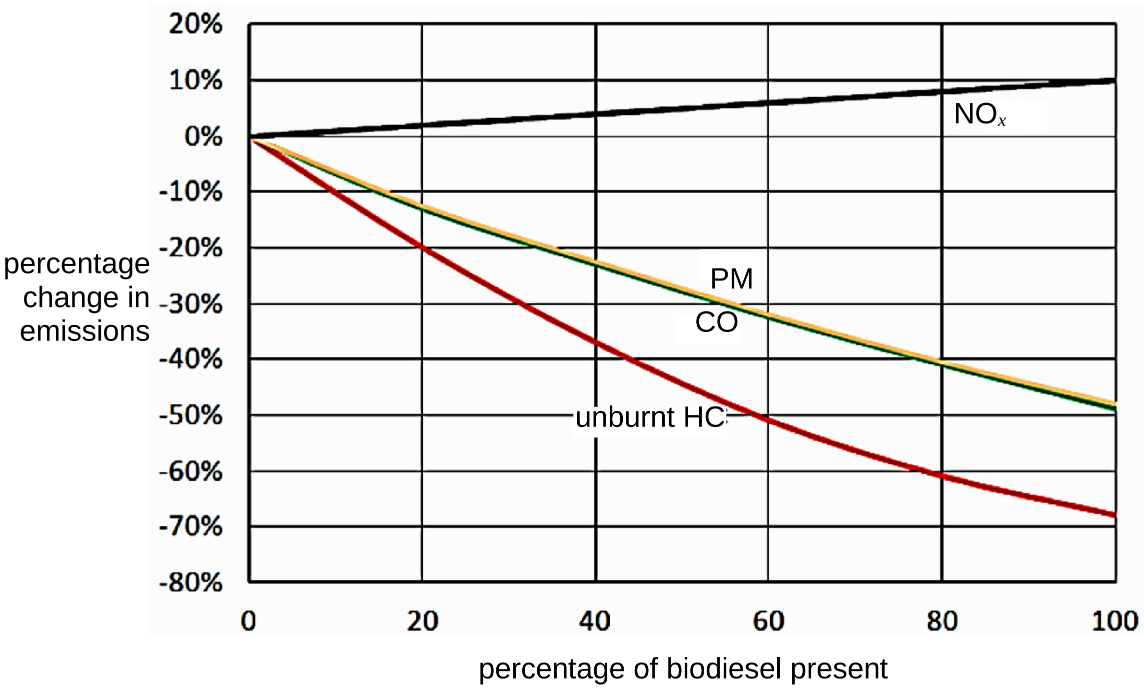


Fig. 7.2

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*

(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]

(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]

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.

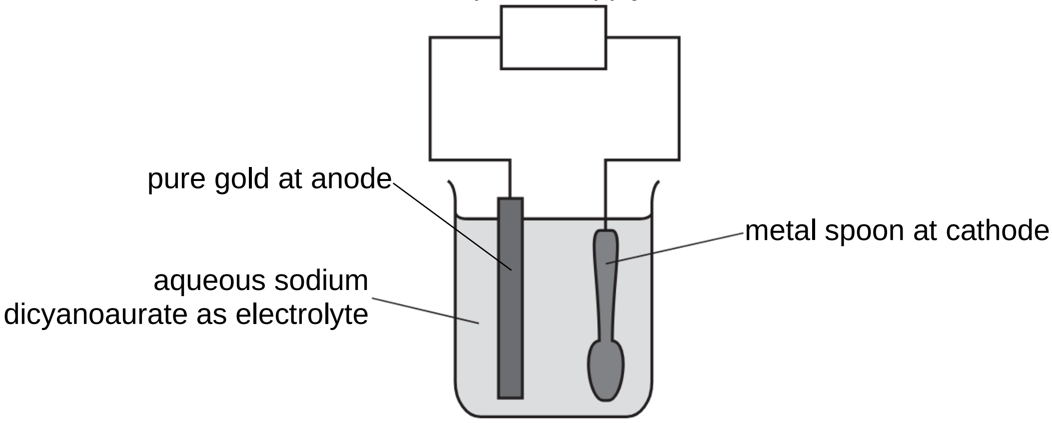


Fig. 8.1

(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

(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]

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.

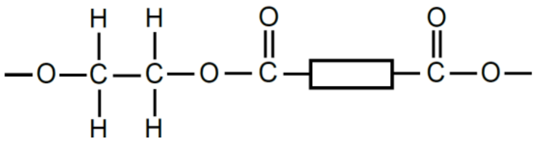


Fig. 9.1

(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

(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 ~

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

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 –

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