O

ANDERSON SECONDARY SCHOOL
Preliminary Examination 2024
Secondary Four Express

CANDIDATE NAME:

CLASS: /

INDEX NUMBER:

CHEMISTRY **6092/02**

Paper 2

15 Aug 2024

1 hour 45 minutes

0800 – 0945h

Candidates answer in the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

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

Section 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.
A copy of the Periodic Table is printed on page 26.

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

Section A	70
Section B	10
Total	80

This document consists of **25** printed pages and **1** blank page.

Setter: Mr Edmund Tan

Section A

Answer **all** questions.

1 **(a)** Use the list of substances to answer the questions.

You may use each substance once, more than once or not at all.

argon
carbon
carbon dioxide
chlorine
iron
iron(II) chloride
oxygen
neon

(i) Which **two** substances are diatomic gases at room temperature?

………………………………………………………………………………….. [1]

(ii) Which substance is a compound that contains a transition element?

………………………………………………………………………………….. [1]

(iii) Which substance provide an inert environment in light bulbs?

………………………………………………………………………………….. [1]

(iv) Which **two** substances form acidic oxides?

………………………………………………………………………………….. [1]

(v) Which **two** substances produce a solid when added to aqueous silver nitrate?

………………………………………………………………………………….. [1]

(b) Table 1.1 describes three processes.

Complete Table 1.1 by filling in the missing information.

Table 1.1

description of process	name of process
conversion of polyunsaturated fats to saturated fats	
formation of an organic compound by the reaction of alcohols and carboxylic acids	
mixing dilute hydrochloric acid and aqueous sodium hydroxide	

[3]

[Total: 8]

2 Mothballs, often used to repel moths and insects, gradually disappear over time when placed in a closed cupboard. A student places some mothballs in a closed cupboard and records its mass over several days. The following data was collected.

day	mass of mothballs/ g
0	5.0
2	4.6
4	4.2
6	3.8
8	3.4

During the experiment, no liquid or solution was found in the cupboard. A pungent gas was produced and can be detected whenever the cupboard doors are opened.

(a) Describe and explain the trend observed in the mass of the mothball over time.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(b) Explain how the concept of diffusion contributes to the observation of pungent smell.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

[Total: 4]

3 Sustainable aviation fuels (SAFs) are being developed to reduce the carbon footprint of air travel. One method involves collecting used cooking oil from restaurants, processing it to remove impurities such as water and blending it with jet fuel. Fig. 3.1 shows the flow chart outlining the production process of SAFs.

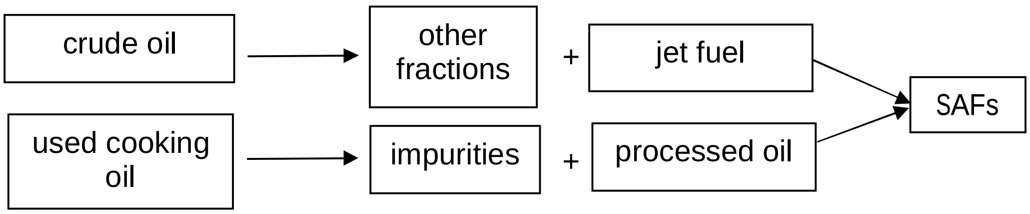

Fig 3.1

(a) **(i)** Name the separation process to obtain jet fuel from crude oil.

………………………………………………………………………………….. [1]

(ii) Explain how the named process in **(a)(i)** is used to separate different components of crude oil, including the fraction used as jet fuel.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

………………………………………………………………………………….. [2]

(b) Describe how a separating funnel can be used to separate processed oil from impurities in used cooking oil.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(c) Biofuels, like sugarcane-based bioethanol, are alternative energy sources to fossil fuels.
Burning of bioethanol releases similar products as burning ethanol.

Discuss the concept of the carbon cycle and explain why the burning of bioethanol might **not** be always considered as carbon neutral.

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…………………………………………………………………………………………

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

(d) The equation describes the combustion of ethanol.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

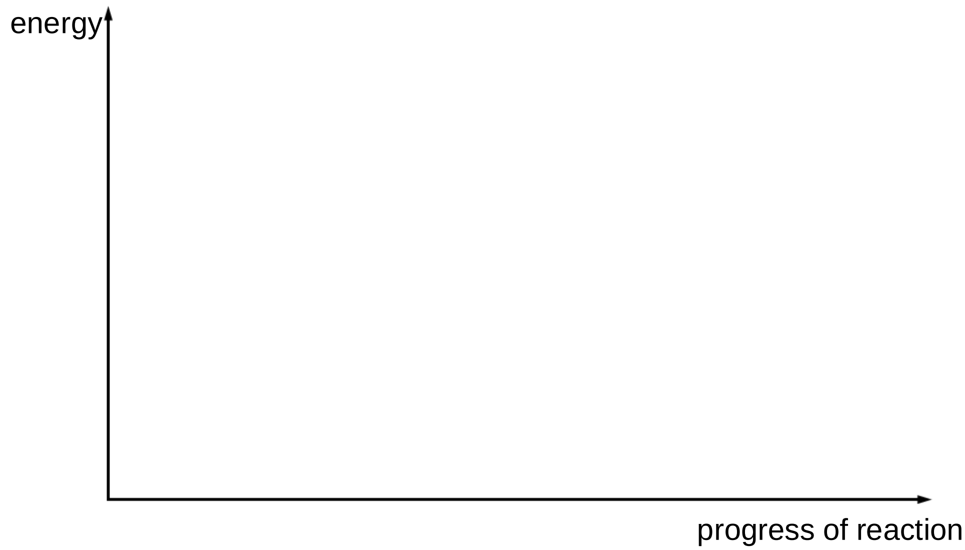
Use the information to calculate the enthalpy change for this reaction.

bond	bond energy kJ/mol	bond	bond energy kJ/mol
C−C	350	C=C	610
C−O	358	O=O	496
C−H	410	C=O	799
O−H	460		

enthalpy change = ……………………… kJ [2]

(e) Complete the energy profile diagram for the combustion of ethanol.

Your diagram should include
- the formulae of reactants and products,
- the enthalpy change of reaction, and
- the activation energy.



[3]

[Total: 13]

4 Glutamic acid, an amino acid, is naturally present in the body and in many foods.

(a) Glutamic acid is a compound that contains 40.8% carbon, 6.1% hydrogen, 9.5% nitrogen and 43.6% oxygen by mass.

Determine the empirical formula of glutamic acid.
Show your working clearly.

[2]

(b) Monosodium glutamate, commonly known as MSG is the sodium salt of glutamic acid.

Deduce the charge on the glutamate ion.

……………………………………………………………………………………. [1]

(c) When amino acids undergo condensation polymerisation, they form a macromolecule.

Fig. 4.1 shows the repeat unit of a macromolecule formed by condensation polymerisation.

The repeat unit contains five different elements, C, O, N, H and X.

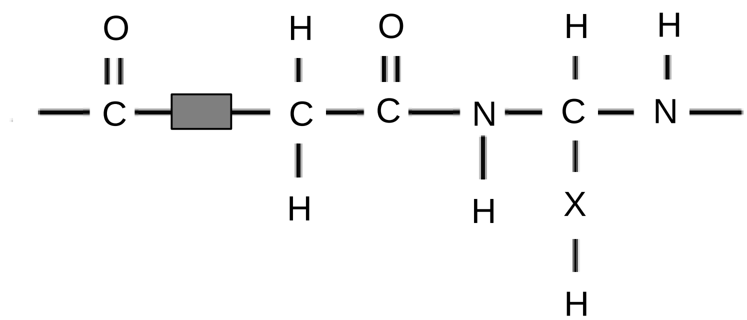


Fig. 4.1

(i) Name the type of linkage found in the repeat unit.

…………………………………………………………………………….. [1]

(ii) Draw the full structural formula of the **two** monomers.

[2]

(iii) Using ideas of valency, suggest an element that could be **X**.

…………………………………………………………………………….. [1]

(d) State the functional group that a molecule must have to undergo addition polymersiation.

…………………………………………………………………………….. [1]

[Total : 8]

5 **(a)** Lead is extracted by heating its oxide with hydrogen. The equation for the extraction is shown.

$$PbO + H_2 \rightarrow Pb + H_2O$$

Fig 5.1 shows the apparatus used for this extraction process.

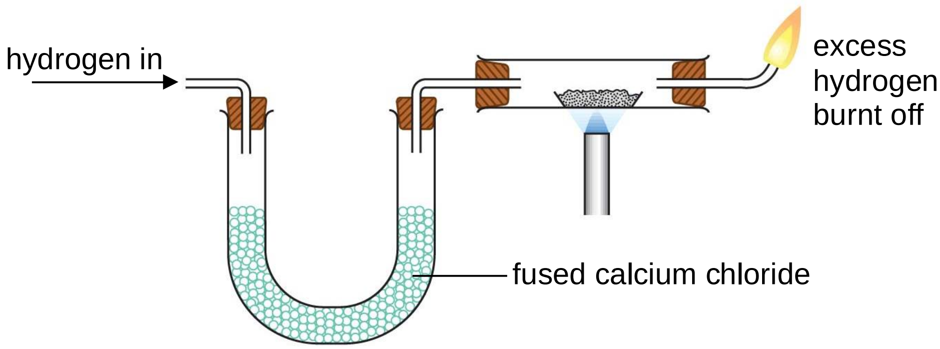


Fig 5.1

(i) Is hydrogen acting as the oxidising agent or reducing agent?

Explain your answer using the loss or gain of oxygen.

……………………………………………………………………………………..

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

(ii) “Aluminium can be extracted from its oxide using the same method.”

Do you agree? Explain your answer.

……………………………………………………………………………………..

……………………………………………………………………………………..

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

(iii) After the heating has stopped, the flow of hydrogen gas must maintain until the solid has completely cooled to room temperature.

Explain why is this necessary.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

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

(b) **(i)** A disproportionation reaction is a reaction in which the same element is both oxidised and reduced, forming two separate products.
An example of a disproportionation reaction is shown.

$$4H_3PO_3 \rightarrow 3H_3PO_4 + PH_3$$

Explain, in terms of oxidation states, why the reaction is a disproportionation reaction.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………….. [2]

(ii) Comproportionation reactions also involve the oxidation and reduction of the same element.

An example of a comproportionation reaction involving sulfur is shown.

$$2H_2S + SO_2 \rightarrow 3S + 2H_2O$$

Use information in **(b)(i)** and **(ii)** to suggest how comproportionation reactions generally differ from disproportionation reactions.

……………………………………………………………………………………..

…………………………………………………………………………….. [1]

[Total: 7]

6 **(a)** The ‘iodine clock’ reaction is an experiment used to investigate rates of reaction.

In a series of experiments, aqueous potassium iodide was mixed with a fixed volume of starch and iron(III) salt solutions. The mixing produces iodine, which turns blue-black in the presence of starch.

The condition of each experiment varies, and these conditions affects the time taken for the solution to turn blue-black.

Table 6.1 shows the conditions and results for a series of experiments.

Table 6.1

experiment	volume of aqueous potassium iodide / cm^3	volume of distilled water / cm^3	temperature / °C	catalyst added	time taken for blue-black colour to appear/s
1	3.0	7.0	20	none	50
2	6.0	4.0	20	none	27
3	6.0	4.0	20	silver	26
4	6.0	4.0	20	copper	20
5	6.0	4.0	40	none	15

(i) Explain how a catalyst affects reaction rates.

………………………………………………………………………………………..

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

(ii) Using information in Table 6.1, compare the effectiveness of copper and silver as catalysts on the rate of reaction.

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

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

(b) (i) Use ideas about collisions between particles, and with reference to values in Table 6.1, explain why changing the concentration and temperature affect the time taken for the blue-black colour to appear.

……………………………………………………………………………………..

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……………………………………………………………………………………..

…………………………………………………………………………………….. [4]

(ii) Explain the importance of starch in the experiments.

……………………………………………………………………………………..

……………………………………………………………………………………..

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

[Total: 9]

7 Sulfur dioxide, SO_2, is one of six pollutants that are closely tracked and monitored in the world. Emission sources include industries such as refineries and power stations, as well as motor vehicles and other sources.

The mass of SO_2 emissions over three decades is shown in Fig. 7.1.

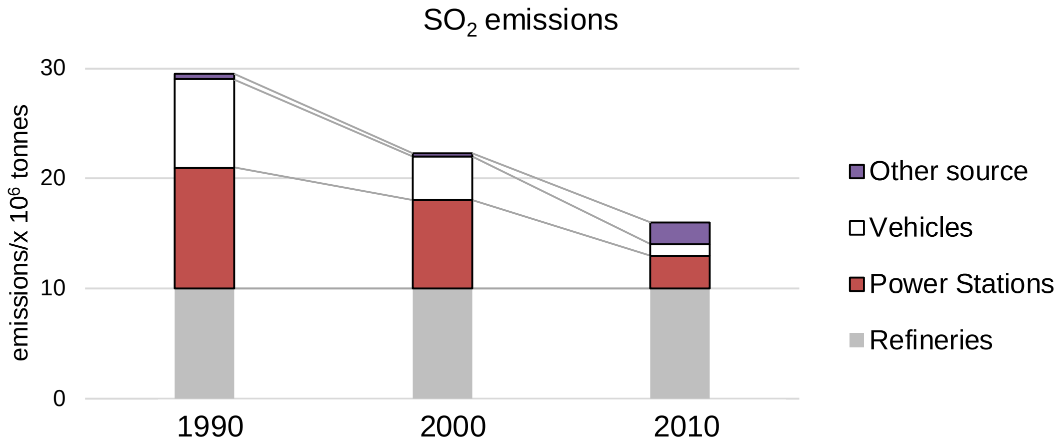


Fig. 7.1

(a) **(i)** Name the "other source".

…………………………………………………………………………… [1]

(ii) Using Fig. 7.1, describe the trend in sulfur dioxide emissions for vehicles, power stations and refineries over three decades.

……………………………………………………………………………..

……………………………………………………………………………..

…………………………………………………………………………… [1]

(b) Desulfurisation is a common method used to reduce SO_2 emissions in the industry. An example of a desulfurisation system, "wet scrubbing" in shown in Fig. 7.2.

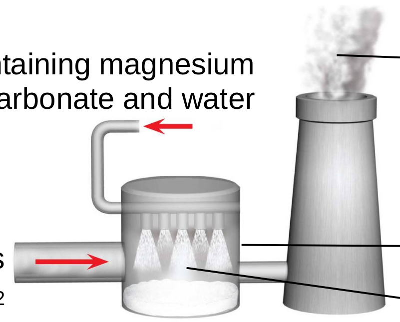


Fig. 7.2

In the wet scrubbing system, waste gas containing SO_2 is passed into the chamber. In the chamber, a slurry of magnesium carbonate and water is sprayed from the top.
The reaction produces a gas and magnesium sulfite which falls to the bottom of the chamber to be removed.

Complete the equation for the reaction that takes place during desulfurisation.

SO_2 (g) + [2]

(c) To increase the efficiency of SO_2 removal, a packed bed scrubber that contains beads can be installed in the chamber as shown in Fig. 7.3.

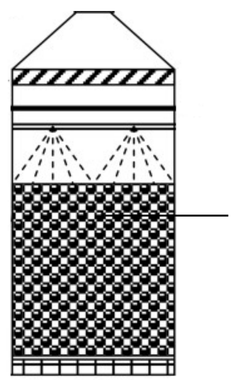


Fig. 7.3

(ii) Explain why installing the packed bed scrubber in the chamber is more efficient at removing SO_2.

………………………………………………………………………………………

……………………………………………………………………………………… [1]

(iii) Explain why it is **not** feasible to install desulfurisation systems on vehicles.

……………………………………………………………………………….

………………………………………………………………………………. [1]

(c) In the desulfurisation of refinery exhaust gases, calcium carbonate can be used in place of magnesium carbonate in the wet scrubbing process. The prices of both substances are shown in Table 7.4

Table 7.4

substance	cost per kg/$
calcium carbonate	0.11
magnesium carbonate	0.14

Using information from this question, determine which substance will be **more cost efficient** for a refinery that emits 1280 kg of SO_2 per hour.
Show clear calculations in your answer.
You may assume that both carbonates have the same efficiency in removing SO_2.

[3]

[Total: 9]

8 The formation of covalent bonds can be described as a force of attraction between the positive nucleus of an atom and the valence electron of another atom.

Electronegativity

Covalent bonds are also affected by the electronegativity of the connected atoms, which determines the chemical polarity of the bond. Two atoms of equal electronegativity will make non-polar covalent bonds. The overlapping of electron orbitals will result in the dumbbell-like shape for molecules with non-polar covalent bonds as shown in Fig 8.1.

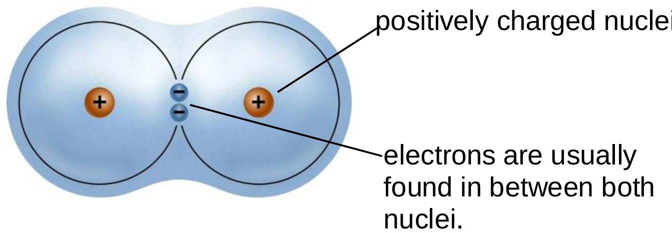


Fig 8.1

If the electronegativity difference is larger than 0.5, a polar covalent bond such as H−C*l* will be formed.
The unequal electronegativity between atoms causes a distortion in the shape and distribution of electron in the overlapping regions as shown in Fig 8.2.

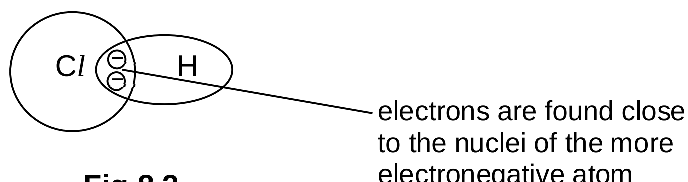


Fig 8.2

Due to the unequal distribution of electrons in the molecule, this creates a partial charge on each atom, where one is more 'positive' than the other.
The electronegativity of some elements is shown in Table 8.3.

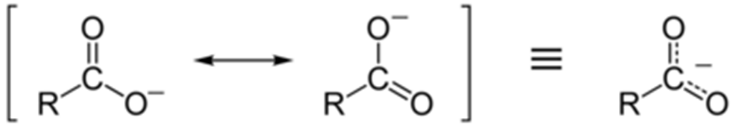
Table 8.3

element	electronegativity	element	electronegativity
hydrogen	2.20	sodium	0.93
carbon	2.55	fluorine	3.98
nitrogen	3.04	chlorine	3.16
oxygen	3.44	bromine	2.96

Effect of electronegativity on the stability of carboxylate anions
(resonance structure of carboxylate anions)
A molecule of carboxylic acid dissociates into a carboxylate anion and a hydrogen ion.

$$R-COOH \rightarrow RCOO^{-} \text{ and } H^{+}$$

Where **R** represents an organic group.



carboxylate anions resonance structure

The negative charge on the ion after dissociation of the H^+ ion is delocalised between the two electronegative oxygen atoms in a resonance structure. The stability of the resonance structure is dependent on the **R** group's ability to either, facilitate or hinder electron flow to the oxygen atoms.

If the **R** group is an electron-donating group, the negative charge on the resonance structure will be strengthened. The resonance structure would then strongly attract any nearby H^+ ions and form the acid molecule again.

If the **R** group is an electron-withdrawing group (containing electronegative atoms), the negative charge on the resonance structure will be weakened.

Dissociation constant of organic acids.

The dissociation constant of an organic acid indicates the extent to which it dissociates into ions. The larger the dissociation constant, the higher the extent of dissociation. The dissociation constant varies with different **R** groups. The names of the organic acid together with their dissociation constant values is shown in Table 8.4.

Table 8.4

R group	dissociation constant	name of acid
$-CH_3$	1.75×10^{-5}	ethanoic acid
$-CH_2CH_3$	1.34×10^{-5}	propanoic acid
$-CH_2Cl$	1.40×10^{-3}	chloroethanoic acid
$-CHCl_2$	4.50×10^{-2}	dichloroethanoic acid
$-CH_2Br$	1.30×10^{-3}	bromoethanoic acid
$-CH_2F$	2.60×10^{-3}	fluoroethanoic acid

Data retrieved from :
https://chem.libretexts.org/Ancillary_Materials/Reference/Reference_Tables/Equilibrium_Constants/E1%3A_Acid_Dissociation_Constants_at_25C

(a) **(i)** Complete the table for the missing information.

name of substance	chemical formula	type of covalent bond(s) present (tick one)		
		polar	non-polar	not applicable
hydrogen chloride	HCl	✓		
sodium fluoride				
	CH_4			
	O_3			

[3]

(ii) Using information from Table 8.3, describe the trend in electronegativity across period 2 and down group 17.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

………………………………………………………………………………….. [2]

(b) **(i)** What is the impact of electron-donating groups on the pH of the acid?

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

………………………………………………………………………………….. [2]

(ii) Draw a ‘dot-and-cross’ diagram to show the arrangement of electrons in a carboxylate ion. You may replace the R group with a hydrogen atom.

Show outer electrons only.

[2]

(c) **(i)** Using information from Table 8.4, draw the full structural formula of dichloroethanoic acid.

[1]

(ii) State the characteristics of a stronger organic acid.

Explain your answer in terms of electronegativity and quantitative data.

………………………………………………………………………………..

………………………………………………………………………………..

………………………………………………………………………………..

……………………………………………………………………………….. [2]

[Total: 12]

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Section B

Answer **one** question from this section.

9 Fig 9.1 shows the electrolysis of a solution containing Na^+ and Cl^- ions after x minutes.

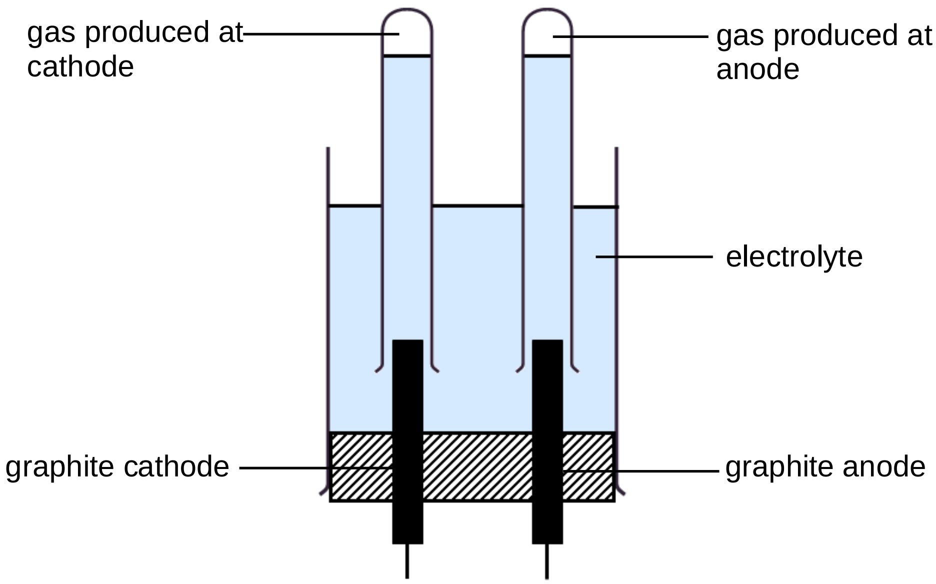


Fig 9.1

(a) Use information from the fig 9.1 to name the electrolyte.

…………………………………………………………………………………………[1]

(b) Write ionic equations for the reactions at the cathode and anode.

cathode ………………………………………………………………………………..

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

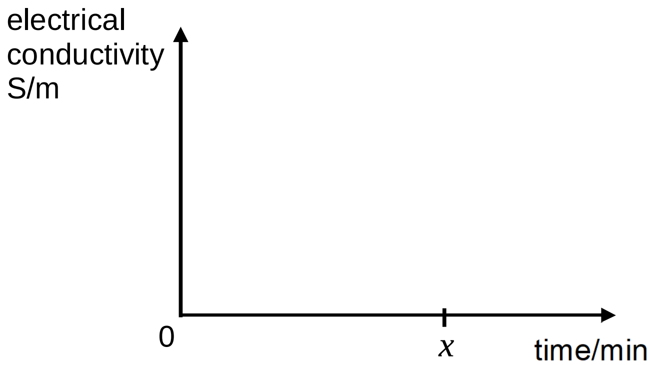
(c) Describe a positive test for the gas produced at the cathode.

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(d) A data logger can be used to monitor the electrical conductivity of the electrolyte over time.
The higher the concentration of ions in the electrolyte, the higher the electrical conductivity of the solution.

(i) Sketch the graph in the axes below to show how the electrical conductivity changes from 0 min to x min.



[1]

(ii) Explain the shape of your graph in **(d)(i)**.

…………………………………………………………………………………..

…………………………………………………………………………………..

………………………………………………………………………………… [2]

(e) The above electrolysis is repeated using platinum cathode and silver anode. Only the anode had a different observation.

(i) Explain why the same observation was recorded at both the graphite cathode and platinum cathode.

…………………………………………………………………………………..

………………………………………………………………………………… [1]

(ii) Describe and explain the observation at the silver anode.

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

………………………………………………………………………………… [2]

[Total : 10]

10 Fig 10.1 shows a setup where the bulb lights up, indicating a closed circuit. A gas is produced at one of the electrodes.

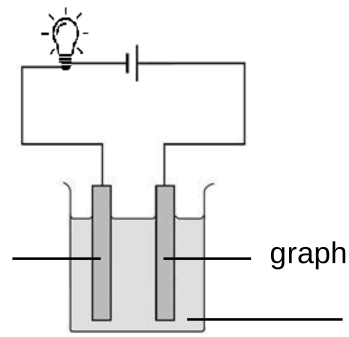


Fig 10.1

(a) Explain, in terms of bonding, how the graphite electrodes enable the setup to be a closed circuit.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(b) Name the product that forms at each electrode.

graphite electrode 1 ……………………………………………………………..…….

graphite electrode 2 ……………………………………………………………… [2]

(c) Describe a test for the gas produced.

test ………………………………………………………………………………….

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

(d) In another experiment, the light intensity of the bulb was measured when different electrodes, graphite, W, X, Y and Z were used.
Metal W is the most reactive metal out of the four unknown metals.

The results were recorded and shown in Table 10.2.

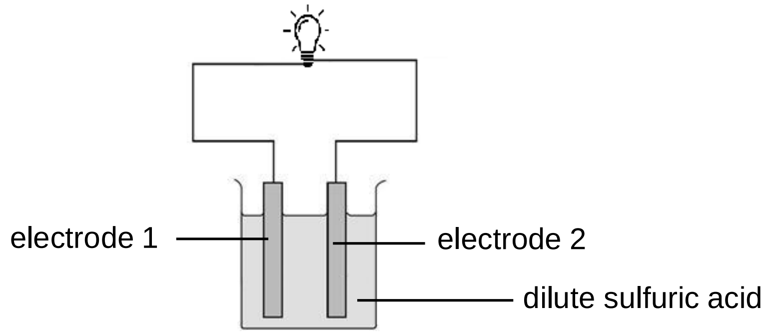


Table 10.2

experiment	electrode		light intensity/units
	1	2	
1	graphite	W	bulb did not light up
2	W	W	bulb did not light up
3	W	X	1.0
4	Y	X	0.3
5	Z	Y	0.1
6	Z	W	0.6

(i) Explain why the bulb did **not** light up for experiments 1 and 2.

……………………………………………………………………………………..

……………………………………………………………………………………..

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

(ii) Arrange the metals W, X, Y and Z in order of increasing reactivity.

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

(iii) When lead was used as an electrode, the bulb lights up briefly and stops after some time. Explain this observation.

……………………………………………………………………………………..

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

[Total: 10]

The Periodic Table of Elements

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

Group

1	2	3	4	5	6	7	8	9	10	11	12	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											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, $L = 6.02 \times 10^{23}\ mol^{-1}$.