	Class	Index Number
Candidate Name ______________________		

ST ANDREW'S SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022
SECONDARY 4 EXPRESS

CHEMISTRY
PAPER 2 **6092/2**

Monday **22 August 2022** **1 hour 45 minutes**

INSTRUCTIONS TO CANDIDATES

Do not open this question paper until you are told to do so.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class in the spaces provided on the question paper.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions in the spaces provided, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

Electronic calculators may be used. You may lose marks if you do not show your working or if you do not use appropriate units.

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 the last page.

FOR EXAMINER'S USE
/ 80

This question paper consists of 25 printed pages.

Error Analysis

DO NOT ATTEMPT THIS PART DURING THE EXAM/TEST.

IT IS TO BE COMPLETED AFTER THE EXAM/TEST, AFTER YOU HAVE DONE CORRECTIONS FOR YOUR PAPER.

Name:_____( ) Date: _____

Exam: CT1/Mid-Year/CT2/Final/Prelim

Everyone, not just the fastest and most competent, is capable of high achievement. Care, perseverance and craftsmanship are what count.

Mistakes are not a sign of weakness. Mistakes help me learn. Consistent effort and effective strategies are the main determinant of success

A) 3 things I have learnt from this paper.

1.)_____

_____

2.)_____

_____

3.)_____

_____

B) 2 common mistakes I made in this paper.

1.)_____

_____

2.)_____

_____

C) Confession:

I could have done better if _____

_____

_____

Mistakes are not a sign of weakness. Mistakes help me learn. Consistent effort and effective strategies are the main determinant of success.

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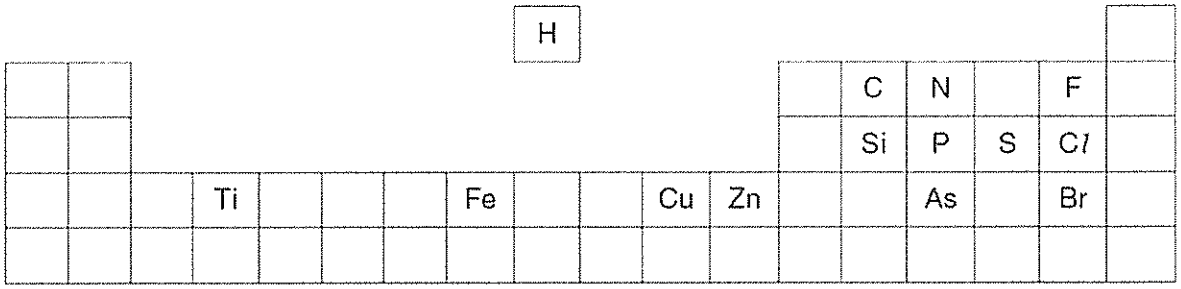
Section A

Answer **all** questions in the spaces provided.
The total mark for this section is 50.

A1 The diagram shows part of the Periodic Table.



Answer the following questions using only the elements shown in the diagram. Each element can be used once, more than once, or not at all.

Identify an element that

(a) is in period 3 and has seven electrons in its outer shell.

.....[1]

(b) forms an ion of -3 charge with three fully filled electron shells.

.....[1]

(c) can form both positive and negative ions.

.....[1]

(d) is a liquid at room temperature.

.....[1]

(e) forms an amphoteric oxide.

.....[1]

(f) forms an aqueous chloride that reacts with aqueous ammonia to give a reddish-brown precipitate.

.....[1]

[Total: 6]

A2 Sodium chloride can be found in rock salt, which occurs naturally as white crystals.

Fig. 2.1 outlines the steps used to determine the percentage of sodium chloride present in a sample of rock salt of mass 2.5 g.

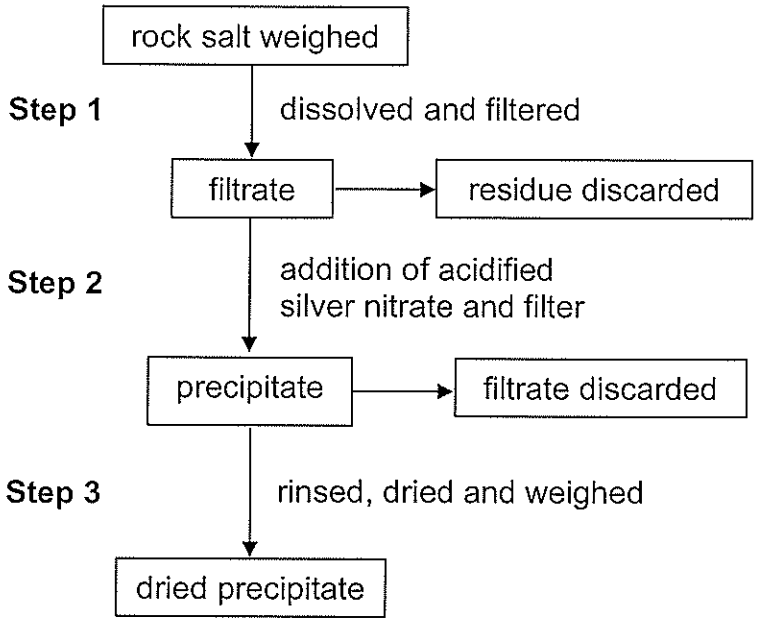


Fig. 2.1

(a) Write the ionic equation, with state symbols, for the formation of the precipitate in **Step 2**.

.....[2]

(b) Explain why the silver nitrate added in **Step 2** must be acidified before use.

.....

.....[1]

(c) Suggest another reagent that can be used in **Step 2** instead of silver nitrate.

.....[1]

(d) At the end of the experiment, the mass of the dried precipitate was found to be 5.74 g. Calculate the percentage of sodium chloride present in this sample of rock salt.

[2]

(e) Suggest another method to show that the rock salt sample is impure.

.....

.....[1]

[Total: 7]

A3 Fig. 3.1 shows a set-up of a simple cell.

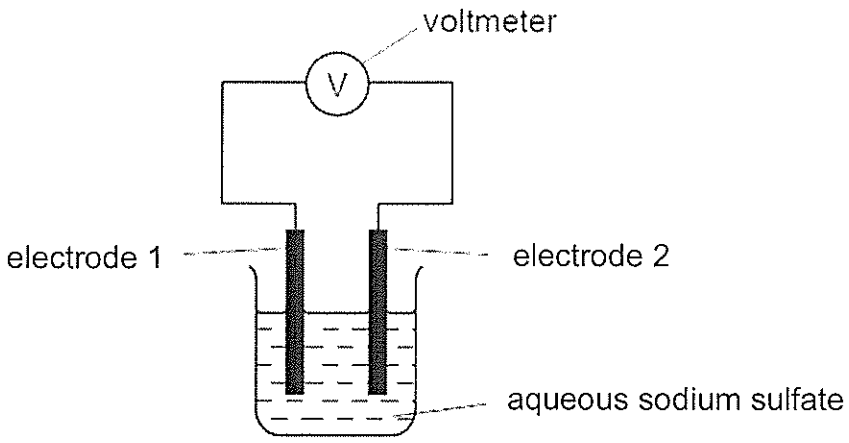


Fig. 3.1

The results from the simple cell, using the metals tin, cadmium, zinc and copper, are shown in Table 3.1.

Table 3.1

cell	electrode 1	electrode 2	voltage / V
1	copper	cadmium	0.74
2	tin	copper	-0.48
3	copper	zinc	1.10

(a) List the four metals in order of increasing reactivity.

.....[1]

(b) Hence, deduce the expected voltage for cell **4** shown below.

cell	electrode 1	electrode 2	voltage / V
4	tin	cadmium	

[1]

(c) With reference to cell **3**,

(i) write the half-equations for the reactions taking place at each electrode.

electrode 1:

electrode 2:

[2]

(ii) hence, describe the expected observations in the cell after some time.

.....

.....

.....[2]

[Total: 6]

A4 The Contact Process is an industrial process used to manufacture sulfuric acid. It is carried out in four stages.

Stage 1: $S\,(s) + O_2\,(g) \rightarrow SO_2\,(g)$

Stage 2: $2SO_2\,(s) + O_2\,(g) \rightleftharpoons SO_3\,(g)$ $\Delta H = -197$ kJ/mol

Stage 3: $SO_3\,(g) + H_2SO_4\,(l) \rightarrow H_2S_2O_7\,(l)$

Stage 4: $H_2S_2O_7\,(l) + H_2O\,(l) \rightarrow 2H_2SO_4\,(aq)$

(a) Draw an energy profile diagram for the reaction taking place in **Stage 2** of the Contact Process. Label the enthalpy change and activation energy clearly on your diagram.

[3]

(b) In terms of oxidation states, explain whether or not the reaction in **Stage 3** of the Contact process is a redox reaction.

.....

.....

.....[2]

(c) Write the overall chemical equation for the reactions in **Stage 3** and **Stage 4**.

.....[1]

(d) Explain why it is important that the product in **Stage 1** does not escape into the atmosphere.

.....

.....[1]

(e) The overall percentage yield for the Contact Process is approximately 30%. Based on the information provided, suggest why this is so.

.....

.....[1]

[Total: 8]

A5 Table 5.1 shows the bond energies of some hydrogen halides.

Table 5.1

bond	bond energy (kJ/mol)
H–F	562
H–Cl	431
H–Br	366
H–I	299

(a) Suggest which hydrogen halide will result in the acid with the lowest pH when dissolved in water. Explain your answer.

.....

.....

.....

.....

.....

.....[3]

(b) Predict the bond energy of hydrogen astatide. ..... kJ/mol [1]

(c) Hydrogen bromide can be produced by reacting hydrogen and bromine gas in the following reaction:

$$H_2\,(g) + Br_2\,(g) \rightarrow 2HBr\,(g)$$

Table 5.2 shows the bond energies of some bonds.

Table 5.2

bond	H–H	Br–Br
bond energy (kJ/mol)	432	193

(i) Calculate the enthalpy change of this reaction.

[2]

(ii) Hence, state and explain whether this is an exothermic or endothermic reaction.

.....

.....

.....[2]

[Total: 8]

A6 Chlorofluorocarbons (CFCs) are widely used in refrigerants, aerosol products and as solvents. Fig. 6.1 shows some common CFCs and their industrial names.

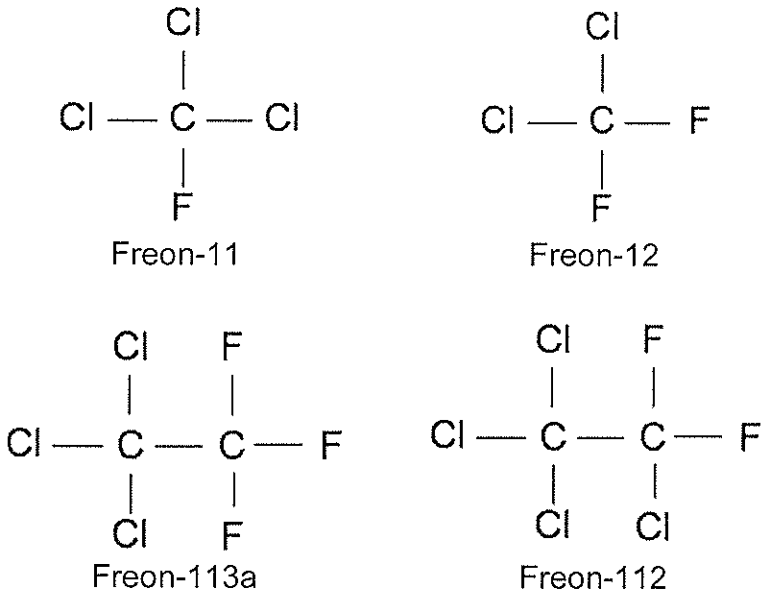


Fig. 6.1

(a) In terms of mass composition, a CFC is found to consist of 12% carbon, 19% fluorine, with the remainder being chlorine.

Determine the empirical formula of this CFC and use the information provided in Fig. 6.1 to identify this CFC.

empirical formula: .....

identity of CFC: .....

[2]

(b) A student claims that Freon-113a can also be synthesised from ethene.

Do you agree? Explain your answer.

.....

.....

.....[2]

(c) Freon-113a has a melting point of 14 °C and a boiling point of 46 °C.

(i) Describe the arrangement of Freon-113a particles at room temperature and pressure.

.....

.....[1]

(ii) Explain briefly how the melting and boiling point of Freon-112 will differ from Freon-113a.

.....

.....

.....[2]

(d) The use of CFCs has been banned in the world under the Montreal Protocol.

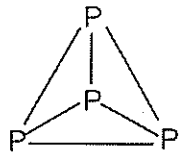
State the reason why this is the case.

.....

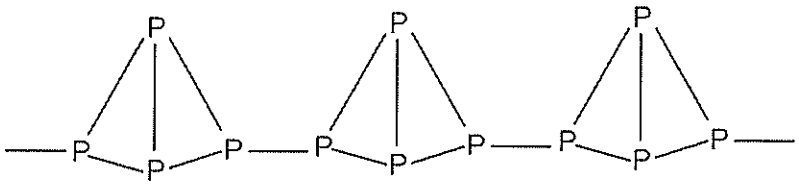
.....[1]

[Total: 8]

A7 Phosphorus exists as several different forms that have different physical properties. The most common forms are white phosphorus, P_4 and red phosphorus, which is a macromolecule. The structures of white and red phosphorus are shown below.



white phosphorus, P_4



red phosphorus, P_n

(a) Describe one similarity in the structures of white and red phosphorus.

.....

.....[1]

(b) The melting point of white phosphorus, P_4, is 44 °C while the melting point of red phosphorus, P_n, is 590 °C.

In terms of bonding and structure, explain why red phosphorus has a higher melting point than white phosphorus.

.....

.....

.....

.....

.....

.....[4]

(c) Red phosphorus is commonly used as the striking surface of matchboxes.

The match head contains potassium chlorate ($KClO_3$) which is easily ignited by friction on the striking surface.

State, with sufficient description, the types of bonds that are present in potassium chlorate.

.....

.....

.....[2]

[Total: 7]

Section B

Answer all **three** questions this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Contact lenses are used by many people on a daily basis and are made of polymers. Over decades, contact lenses have been refined by scientists to be more comfortable for their users. There are two main types of contact lenses – rigid and soft contact lenses.

Rigid Contact Lens

Rigid contact lenses are made of poly(hydroxyethyl methacrylate), also known as PHEMA. The structure of PHEMA is shown in Fig. 8.1.

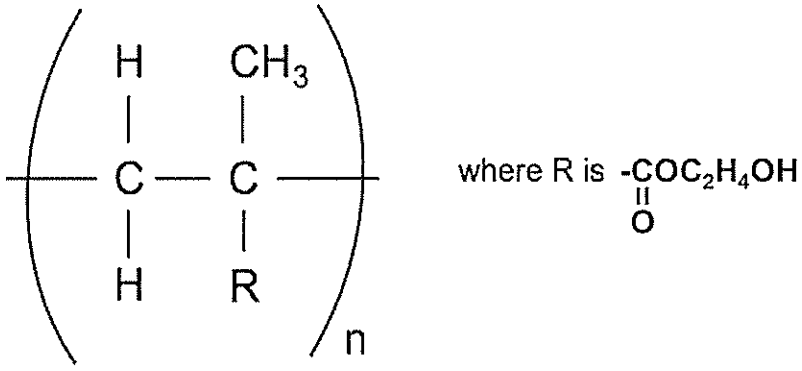


Fig. 8.1

PHEMA is a **linear polymer** because it consists of a long string of carbon-carbon bonds as shown in Fig. 8.2.

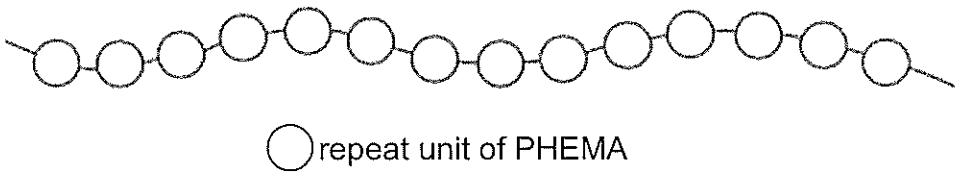


Fig. 8.2

However, users find rigid contact lenses uncomfortable or unhealthy for long term use as PHEMA causes the eyes to dry out.

Soft Contact Lens

Soft contact lenses are more commonly used these days due to their high oxygen-permeability and water-absorbency. These lenses are based on hydrogels, which are networks of cross-linked polymer chains that are highly water-absorbent.

A **cross-linked polymer** makes use of a cross-linking monomer to link long-chain polymers such as PHEMA. Fig. 8.3 shows the structure of a cross-linking monomer. Fig. 8.4 shows how cross-linking monomers link the long-chain linear polymer, PHEMA, to form a cross-linked polymer.

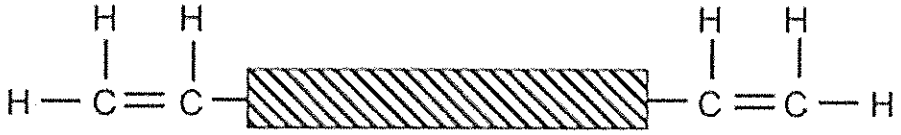


Fig. 8.3

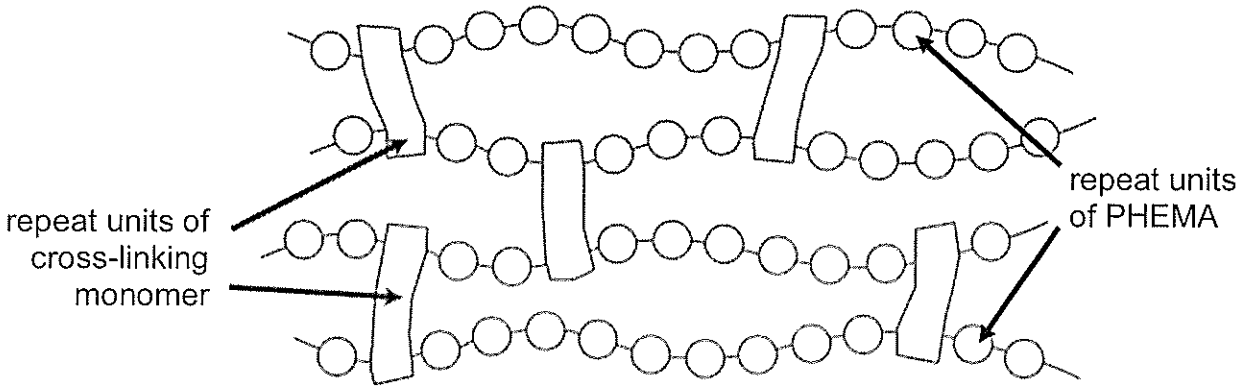


Fig. 8.4

References:
https://pslc.ws/potm/contacts.htm
https://www.compoundchem.com/2015/10/13/contactlenses/

(a) **(i)** Draw the full structural formula of the monomer of PHEMA. All bonds need to be clearly displayed.

[2]

(ii) Identify any two functional groups present in the monomer.

.....

.....[2]

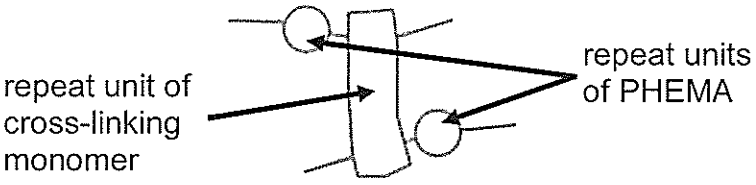
(iii) Determine if PHEMA is an addition or condensation polymer. Explain your answer.

.....

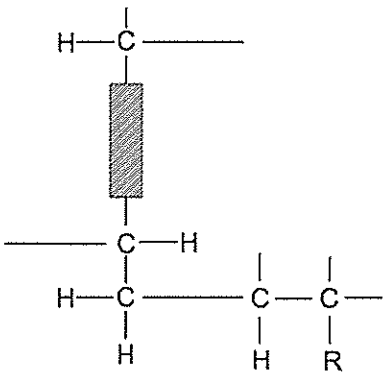
.....

.....[2]

(b) A segment of the cross-linked polymer is shown below.



Complete the partially drawn structure of this segment in the space below. You can use Fig. 8.1 and 8.3 to help you.



[2]

(c) Use the information given about the properties of soft contact lenses to predict whether polyethene can be used to make these lenses. Explain your answer.

.....

.....[1]

(d) In an addition reaction, 77 g of the cross-linking monomer (M_r = 154) is reacted with excess iodine.

Calculate the mass of iodine required to completely react with the cross-linking monomer.

[3]

[Total: 12]

B9 Diesel is a fraction of petroleum which is mainly used as a fuel for diesel-powered vehicles. Biodiesel is an alternative to petroleum-based diesel using renewable resources such as oils derived from plants.

Fig. 9.1 shows the average percentage change in exhaust emissions from vehicles using different mixtures of petroleum-based diesel and biodiesel.

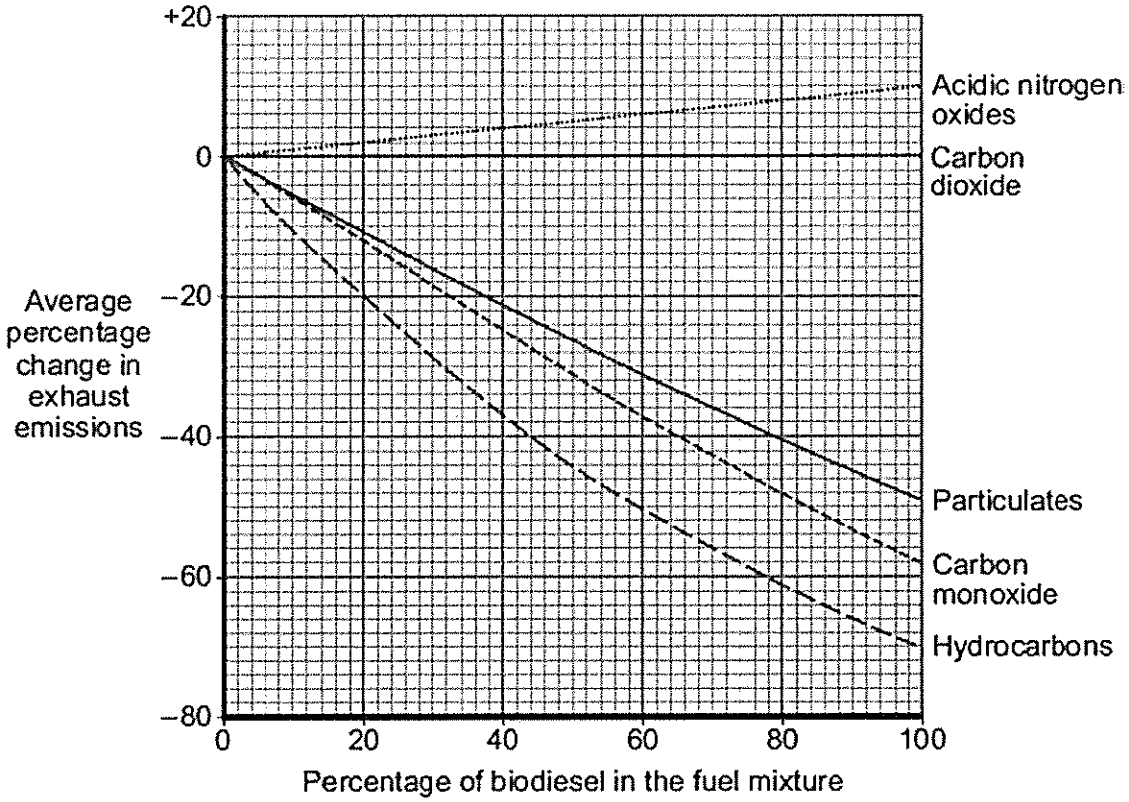


Fig. 9.1

(a) (i) With reference to Fig. 9.1, describe how the average percentage changes in the exhaust emissions of acidic nitrogen oxides and carbon monoxide vary as the percentage of biodiesel in the fuel mixture increases.

.....

.....

.....

.....

.....[2]

(ii) Hence, state a positive effect to human health by increasing the percentage of biofuel in the fuel mixture.

.....

.....

.....[1]

(b) Attaining 'carbon neutrality' has been the aim of many research agencies around the world to reduce carbon emissions. 'Carbon neutrality' refers to processes that result in net-zero carbon emissions.

Biodiesel derived from plants is one such alternative that achieves 'carbon neutrality' as plants make use of carbon dioxide during photosynthesis.

Based on the description above, explain how 'carbon neutrality' is achieved with the use of biodiesel.

.....

.....

.....

.....[2]

(c) Diesel contains an alkane of 12 carbon atoms, which undergoes catalytic cracking to form a mixture of two hydrocarbons. One of the products has a chemical formula of C_4H_8.

(i) Write the equation for the catalytic cracking of diesel.

.....[1]

(ii) Draw the full structural formulae of two isomers of C_4H_8.

[2]

[Total:8]

EITHER

B10 Metal **X** is found in Group II of the Periodic Table. A student placed 0.30 g of metal **X** into two separate conical flasks containing hydrochloric acid of different volumes and concentrations. The volume of hydrogen gas was measured at regular intervals at room temperature and pressure.

Table 10.1 shows the volumes and concentrations of hydrochloric acid used in each experiment, and Fig. 10.2 shows the results obtained.

Table 10.1

experiment	mass of metal **X** used (g)	volume of HCl (cm^3)	concentration of HCl used (mol/dm^3)	volume of H_2 collected (cm^3)
1	0.30	80	1.0	300
2	0.30	50	2.0	300

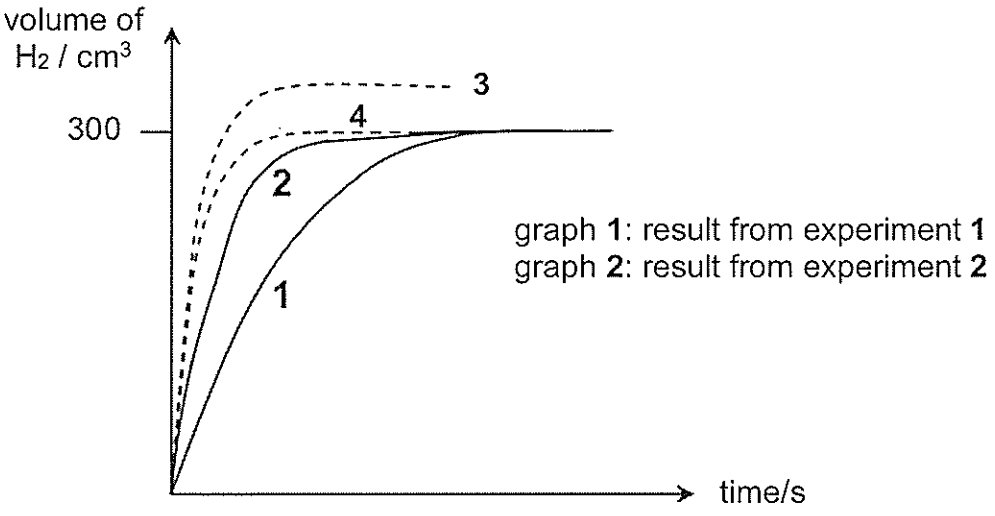


Fig. 10.2

(a) (i) By calculations or otherwise, explain why metal **X** is the limiting reagent in the two experiments using the information provided above.

.....

.....

.....[2]

(ii) Hence, use calculations to determine the identity of metal **X**.

identity of metal **X** .....[3]

(b) Explain, in terms of reacting particles, the difference between the shapes of the graphs **1** and **2**.

.....

.....

.....

.....[2]

(c) (i) Experiment **2** was repeated, with an additional 0.1 g of calcium. The result is shown in graph **3**. Explain the results obtained in this experiment.

.....

.....

.....

.....[2]

(ii) Experiment **2** was carried out again, this time with an additional 0.1 g copper. The result is shown in graph **4**. Suggest how copper affects the results obtained in this experiment.

.....

.....[1]

[Total: 10]

OR

B10 In an experiment to find out how two pollutant gases, carbon monoxide and sulfur dioxide affect the rate at which metals corrode, strips of three different metals were left in contact with each pollutant gas in 'moist air'. 'Moist air' refers to air with higher levels of humidity or water vapour.

After two weeks, the appearance of each metal strip was recorded as shown in Table 10.2.

Table 10.2

metal	moist air	moist air polluted with	
		carbon monoxide	sulfur dioxide
aluminium	remains shiny	remains shiny	remains shiny
copper	small patch of black and green solid	small patch of black and green solid	large patches of black and blue solid
iron	small patch of red-brown solid	small patch of red-brown solid	large patches of red-brown solid

(a) Explain why sulfur dioxide corrodes the copper and iron more quickly than carbon monoxide.

.....

.....

.....

.....[2]

(b) Aluminium is a more reactive metal compared to copper and iron. However, it remains shiny even in the presence of sulfur dioxide. Explain why this happens.

.....

.....[1]

(c) **(i)** State the identity of the red-brown solid on iron.

.....[1]

(ii) Describe and explain how the results for the iron metal would differ if a piece of magnesium was attached to it in moist air polluted with sulfur dioxide.

.....

.....

.....

.....

.....[2]

(d) It is observed that black and green solids are both observed on the copper strips in moist air and in moist air polluted with carbon monoxide.

When both solids are added to sulfuric acid, the solids dissolve to form a blue solution. It is observed that the green solid effervesce in sulfuric acid, but the black solid does not.

(i) Determine the identities of the black and green solids.

.....

.....[2]

(ii) Discuss why similar results are observed for copper in both moist air and in moist air polluted with carbon monoxide.

.....

.....

.....

.....[2]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							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 –		114 Fl flerovium –		116 Lv livermorium –		

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 berkellum –	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.).