KUO CHUAN PRESBYTERIAN SECONDARY SCHOOL

2024 PRELIMINARY EXAMINATION
Secondary 4 Express

NAME	
CLASS	
REG. NO	

CHEMISTRY

6092 / 02

Paper 2

22 August 2024

Setter: Ms Koh Li Eng

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use a 2B pencil for any diagrams, graphs or rough working.
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 24.

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

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

This document consists of **23** printed page and **1** blank page.

[Turn Over

Section A

Answer **all** questions.

1 Fig. 1.1 shows part of the Periodic Table with some elements.

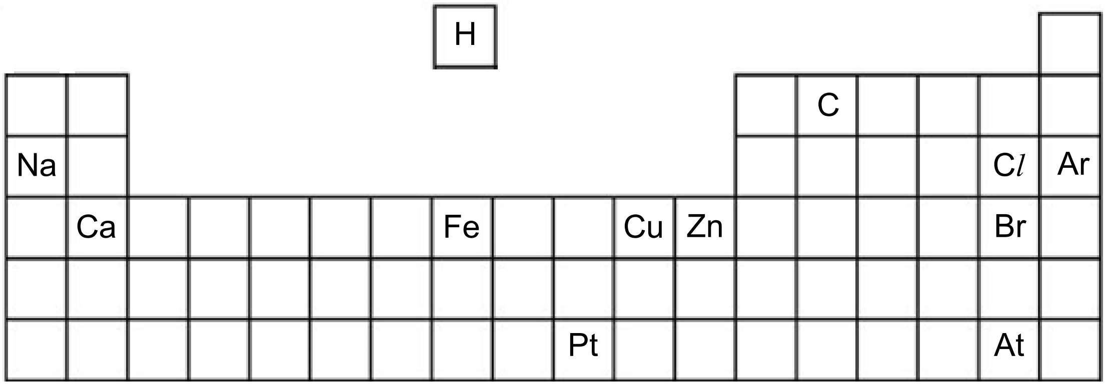


Fig. 1.1

Use the symbols of the elements from Fig. 1.1 to answer the questions.

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

(a) Which element is inert?

.... [1]

(b) Which elements have an atomic mass of 40?

.... [1]

(c) Which elements exist as a black solid?

.... [1]

(d) Which element forms a carbonate that is the most thermally stable?

.... [1]

(e) Which elements are used to make brass?

.... [1]

(f) Which elements can be used as electrodes in the electrolysis of water?

.... [1]

[Total: 6]

2 Complete the table to name the most appropriate separation technique that can be used to obtain the substance underlined in the mixture.

mixture	separation technique
ammonium chloride + sodium chloride	
water + lead(II) sulfate	
methanol + glucose solution	

[3]

[Total: 3]

3 An experiment was carried out to investigate the rate of reaction between magnesium and dilute nitric acid using the apparatus shown in Fig. 3.1.

$$Mg\ (s) + 2HNO_3\ (aq) \rightarrow Mg(NO_3)_2\ (aq) + H_2\ (g)$$

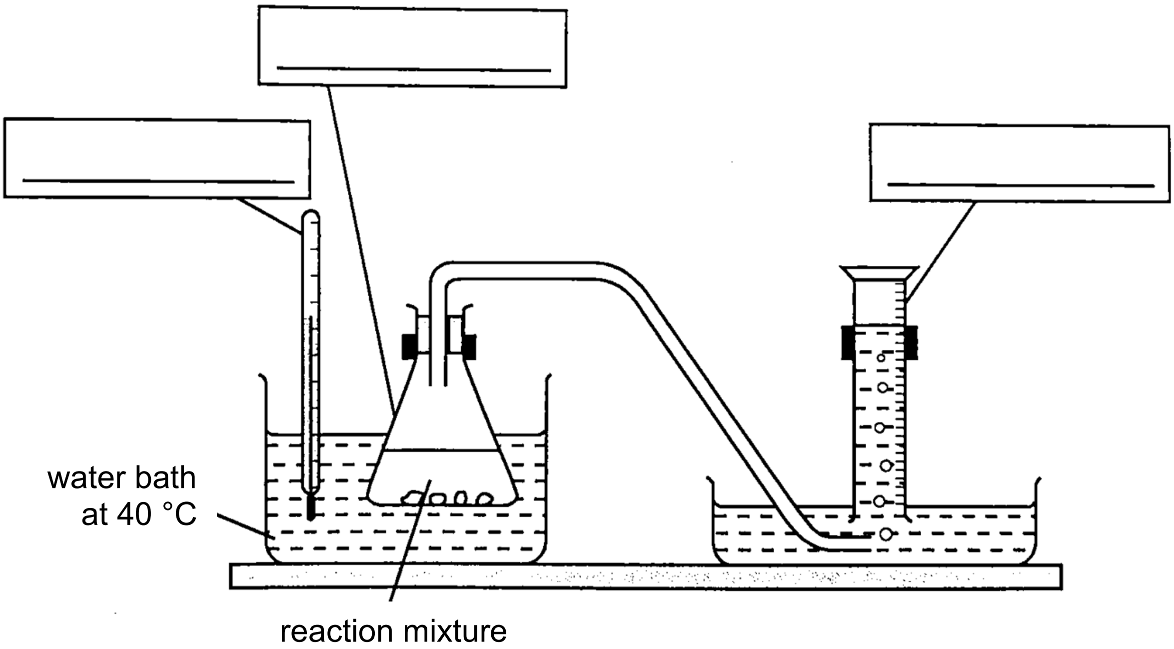


Fig. 3.1

(a) Complete Fig. 3.1 by filling in the empty boxes to identify the apparatus. [2]

(b) 2.0 g of magnesium was added to 100 cm^3 of 1.5 mol/dm^3 of dilute nitric acid.

Show that magnesium is used in excess in this reaction.

[3]

[Total: 5]

4 The relative abundance of isotopes can be determined experimentally using a technique called mass spectrometry. Fig. 4.1 shows the mass spectrum of copper isotopes and their respective natural abundance.

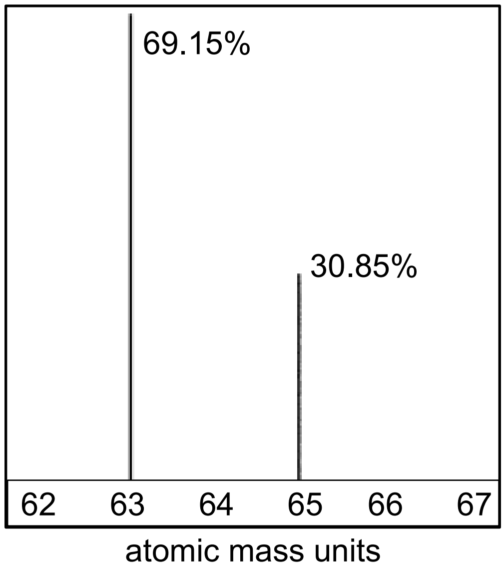


Fig. 4.1

(a) Based on the information, calculate the relative atomic mass of copper. Show your workings clearly and give your answer to the nearest whole number.

[2]

(b) Copper is a typical transition element with many of its compounds having colours. An example is copper(II) chloride solution, $CuCl_2$, which is green-blue in colour.

(i) Complete Fig. 4.2 with the expected observations when $CuCl_2$ undergoes the different reactions.

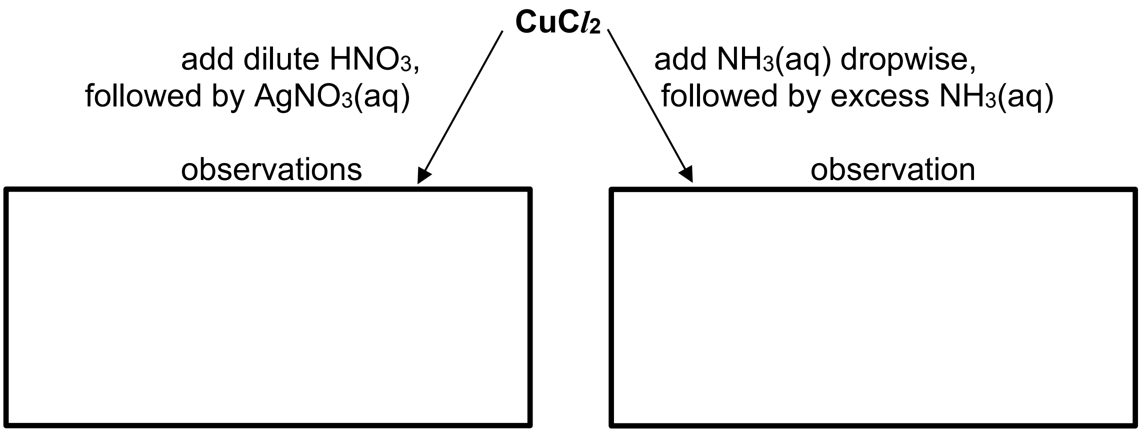


Fig. 4.2

[3]

(ii) Name the type of reaction that occurred between $CuCl_2$ and $AgNO_3$.

.... [1]

(iii) Under suitable conditions, $CuCl_2$ can be converted into a compound **X** which is pale green in colour. The composition of **X** by mass is Cu, 21.5%, F, 38.7%, K, 39.8%.

Use the information to work out the empirical formula of compound **X**.
Show your working clearly.

[3]

[Total: 9]

5 Fig. 5.1 shows two set–ups that a student used to investigate the difference in the reactions between an electrolytic cell and a simple cell.

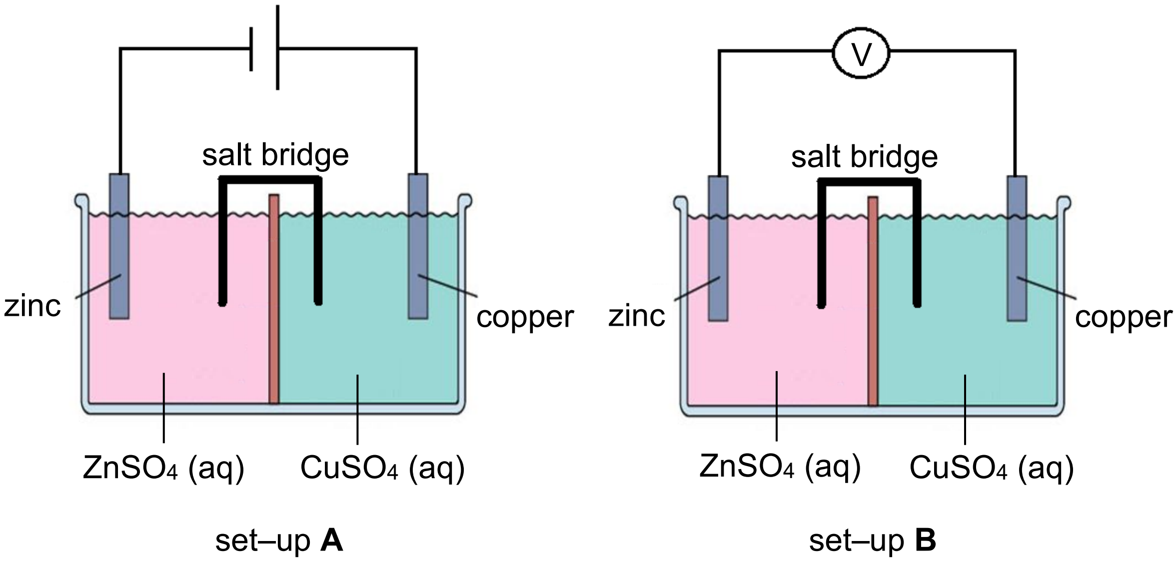


Fig. 5.1

(a) Draw arrows in Fig. 5.1 to show the flow of electrons on both set-ups clearly. [1]

(b) It was observed that the zinc electrodes of both set-ups change in size.

(i) State and explain the expected changes in sizes of the zinc electrodes in both set-ups.

Your answer should:

- describe the expected change in size in each set-up
- explain why each change occurs
- give half-equations for each change.

....

....

....

....

....

....

....

.... [5]

(ii) Describe two differences, other than the change in size of the zinc electrode, in the observations between the two set-ups.

....

....

....

.... [2]

(c) The student would like to prepare more zinc sulfate and copper(II) sulfate for the experiments.

Complete the table below to identify the starting reagents needed.
Include state symbols.

salt	**formulae of starting reagents used**
$ZnSO_4$ (s)	**(1)** .... **(2)** H_2SO_4 (aq)
$CuSO_4$ (s)	**(1)** .... **(2)** H_2SO_4 (aq)

[2]

[Total: 10]

6 In the Haber process, nitrogen and hydrogen are reacted together to form ammonia.

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

(a) Describe the arrangement and movement of ammonia particles at room temperature and pressure.

....

.... [1]

Table 6.1 shows some bond energies of the covalent bonds of nitrogen and hydrogen atoms.

Table 6.1

bond	**bond energy in kJ/mol**
N–N	160
N=N	418
N≡N	941
N–H	391
H–H	436

(b) Based on information given in Table 6.1, describe and explain the trend of bond energy between nitrogen atoms.

....

....

....

....

.... [2]

(c) **(i)** Using the data given in Table 6.1, calculate the overall enthalpy change for the forward reaction of the Haber process.

Show your working.

[3]

(ii) Hence, state the energy change for the backward reaction where 2 moles of ammonia decomposes.

.... [1]

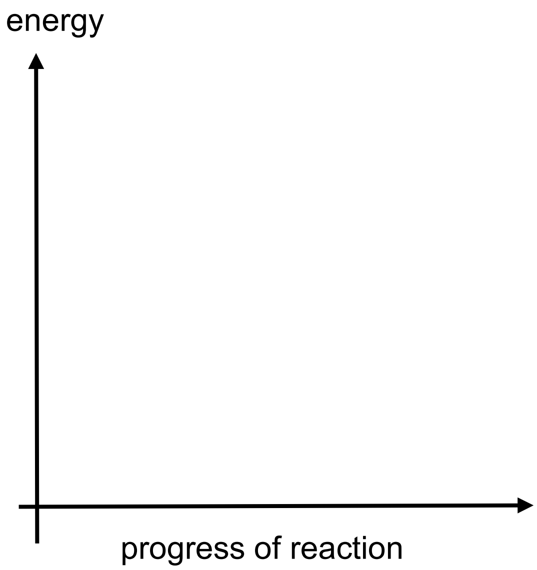
[Total: 7]

7 A study has been done on the cracking of poly(propene), $(C_3H_6)_n$, as a possible alternative to solving plastic waste. It is an endothermic reaction which requires nano materials as catalyst. The products are mainly $C_7 – C_{10}$ hydrocarbons.

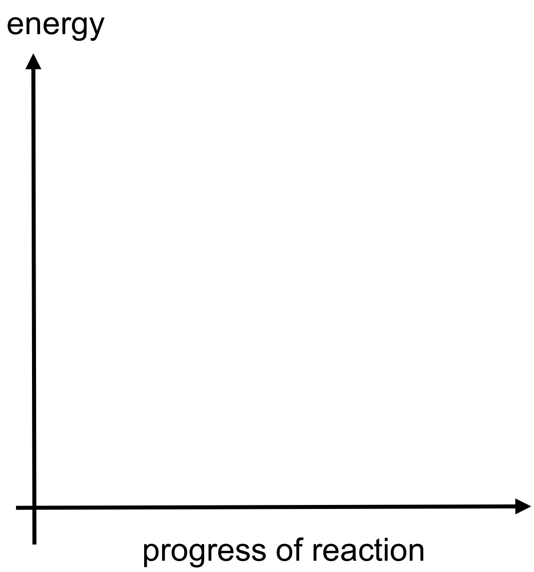
(a) Draw the energy profile diagrams to show the effect of the catalyst on the energy changes in the cracking of poly(propene).

Your diagrams should show:

- the reactants and products of the reaction
- the activation energy of the reaction
- the enthalpy change of the reaction, △H



reaction without catalyst



reaction with catalyst

[3]

(b) **(i)** Draw the structure of the repeating unit of poly(propene) and give the empirical formula of poly(propene).

[2]

(ii) Using its empirical formula from (b)(i), construct a balanced chemical equation for the complete combustion of poly(propene).

.... [1]

(iii) Hence, calculate the volume of carbon dioxide produced when 5 kg of poly(propene) is completely burned in air.

[2]

(c) Poly(propene) is a main form of plastic waste because of its wide variety of applications such as water pipes.

Suggest an advantage and a disadvantage of using poly(propene) instead of iron to make water pipes.

....

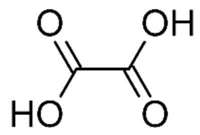
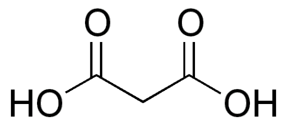
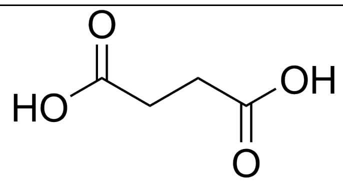
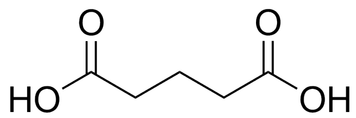
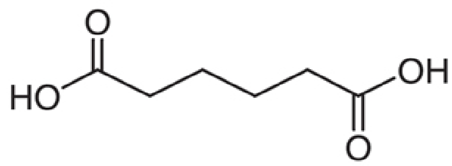
....

....

.... [2]

[Total: 10]

8 The table shows some information of the homologous series of a class of organic compounds called dicarboxylic acids.

name	**condensed formula**	***skeletal formula**
ethanedioic acid	HOOCCOOH	
propanedioic acid	$HOOCCH_2COOH$	
		
pentanedioic acid	$HOOC(CH_2)_3COOH$	
hexanedioic acid	$HOOC(CH_2)_4COOH$	

**In skeletal formulae, the carbon atoms are implied to be located at the corners and ends of line segment rather than being indicated by the atomic symbol C. Hydrogen atoms attached are also not indicated but understood to be present accordingly.*

(a) **(i)** Fill in the table to show the name and condensed formula of the dicarboxylic acid missing in the homologous series. [1]

(ii) What is the general formula of the members in this homologous series?

.... [1]

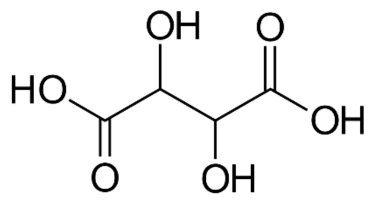
(b) A student claims that dicarboxylic acids are able to undergo condensation polymerisation on its own to form polyesters.

Explain whether you agree with claim.

....

.... [1]

(c) Tartaric acid is a substituted dicarboxylic acid which is found in unripe grapes, making it taste sour. It is a weak, dibasic acid and undergoes neutralisation with potassium hydroxide. The skeletal formula of tartartic acid is shown below.



(i) Explain the term weak acid and circle the acidic hydrogens on the skeletal formula of tartaric acid.

....

....

.... [2]

(ii) State another physical and chemical property that tartaric acid will exhibit.

physical property: ....

....

chemical property: ....

.... [2]

(iii) Suggest two differences in the structural formula between tartaric acid and butanoic acid, C_3H_7COOH.

....

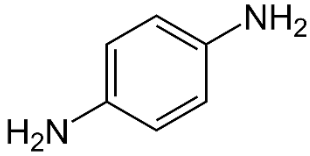
....

....

.... [2]

(iv) Tartaric acid can undergo condensation polymerisation reaction with 1, 4-phenylene-diamine to form a polyamide.

The skeletal formula of 1, 4-phenylene-diamine is shown below.



Draw the structure of the polyamide, showing one repeat unit.

[1]

[Total: 10]

9 A student investigated the rate of reaction in a series of experiments for the following reaction.

$$2ClO_2\,(aq) + 2OH^-\,(aq) \rightarrow ClO_3^-\,(aq) + ClO_2^-\,(aq) + H_2O\,(l)$$

The initial rate of this reaction was determined using different concentrations of the reactants as shown in the following experiments. Table 9.1 shows his results.

Table 9.1

experiment	**concentration of ClO_2 (mol/dm³)**	**concentration of OH^- (mol/dm³)**	**initial rate of reaction (mol/dm³ s)**
1	0.02	0.03	0.00276
2	0.02	0.06	0.00552
3	0.04	0.03	0.01104
4	0.04	0.03	0.00552
5	0.04	0.06	0.02208

From the data in Table 9.1, changes in the concentration of each reactant affect the rate of reaction differently. Knowing how the rate is affected by the concentration of each reactant will allow us to predict the rate of reaction.

We can classify the reactions into the following two types as shown in Table 9.2.

Table 9.2

type of reaction	**characteristic**	**example**
First order reaction with respect to reactant **A**	The rate of reaction is proportional to the concentration of **A**.	If you double the concentration of **A**, the rate doubles. If you increase the concentration of **A** by a factor of 4, the rate goes up 4 times.
Second order reaction with respect to reactant **A**	The rate of reaction is proportional to the square of the concentration of **A**.	If you double the concentration of **A**, the rate would go up 4 times (2^2). If you tripled the concentration of **A**, the rate would increase 9 times (3^2).

(a) The student carried out four experiments using solutions at room temperature and one experiment using solutions at a lower temperature.

Which experiment was carried out at a lower temperature?

Explain your reasoning using information from Table 9.1.

....

....

....

.... [2]

(b) **(i)** Using information from Table 9.1, describe how the rate of reaction changes as the concentration of ClO_2 changes.

....

....

....

.... [2]

(ii) Hence, determine the order of reaction with respect to ClO_2.

.... [1]

(c) Determine the rate of reaction when the concentrations of both ClO_2 and OH^- are 0.01 mol/dm^3.

.... [1]

(d) Explain, in terms of collision between reacting particles, the effect of concentration on the rate of reaction.

....

....

....

.... [2]

(e) Oxides of chlorine, other than ClO_2, can also exist as Cl_2O.

Draw a 'dot-and-cross' diagram to show the bonding in Cl_2O.
Show outer electrons only.

[2]

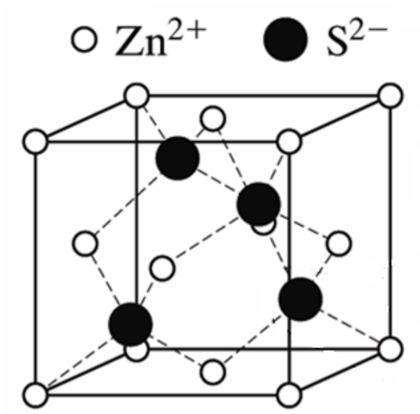
[Total: 10]

Section B

Answer **one** question from this section.

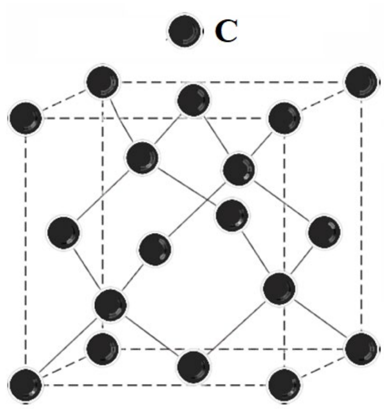
10 Sphalerite is the chief ore mineral of zinc containing zinc sulfide. It exists in crystalline form and is the most important mineral of zinc.

Fig. 10.1 and 10.2 shows the structures and melting points of zinc sulfide and diamond.



melting point: 1700 °C

Fig. 10.1



melting point: 3550 °C

Fig. 10.2

(a) State the type of structure zinc sulfide has.

.... [1]

(b) Explain why the melting points of the two substances differ from each other.

....

....

....

....

.... [2]

Zinc can be extracted from sphalerite via reduction by carbon in the blast furnace.

Sphalerite is first heated to produce zinc oxide.

$$2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$$

The zinc oxide is then heated in a blast furnace with carbon and hot air.

$$2C(s) + O_2(g) \rightarrow 2CO(g)$$

$$ZnO(s) + CO(g) \rightarrow Zn(g) + CO_2(g)$$

Zinc vapour and other waste gases are collected at the top of the furnace.

(c) Draw a 'dot-and-cross' diagram to show the bonding in zinc oxide.
Show outer electrons only.

[2]

(d) The three reactions occurring in the blast furnace are known as redox reactions.

With reference to any one of the reactions, explain why it is a redox reaction.

....

....

....

....

.... [2]

(e) The waste gases collected need to be treated before releasing into the environment.

Describe one harmful effect on the environment and one harmful effect on humans if the waste gases are not treated.

....

....

....

....

.... [2]

(f) Briefly describe the method used to separate zinc from the rest of the waste gases.

....

.... [1]

[Total: 10]

11 Petrol and diesel vehicles are fitted with catalytic converter to reduce the amount of polluting substances emitted from the exhaust. For diesel engines, the catalytic converter may also include a particle filter to remove solid particles of carbon. Fig. 11.1 shows one design of diesel particle filter.

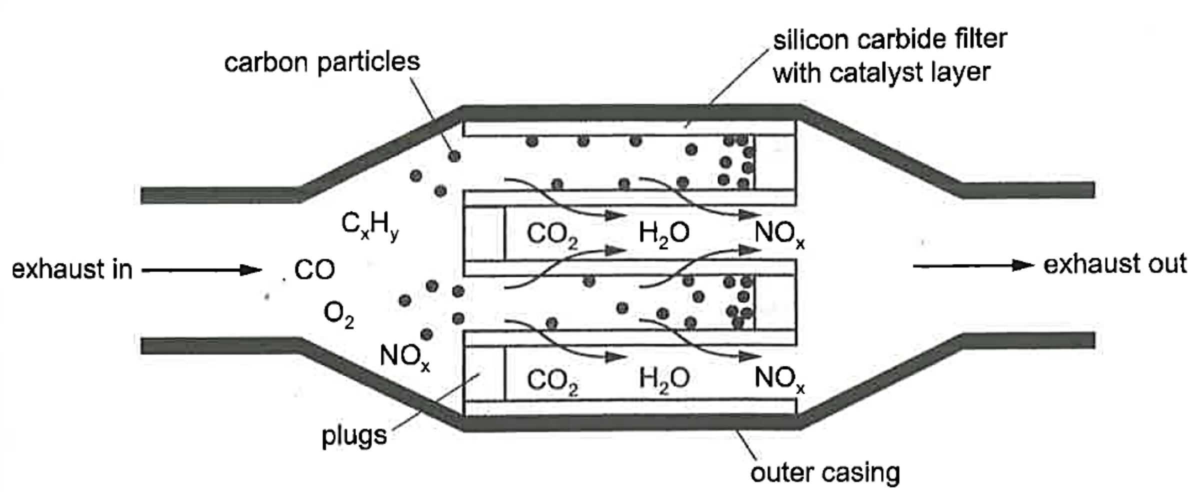


Fig. 11.1

The wall of the particle filter are made from silicon carbide, SiC. This is a hard solid that will **not** melt at the high temperature of the exhaust.

(a) Suggest how the structure and bonding of silicon carbide makes it resistant to melting, even at high temperature.

....

....

....

....

.... [3]

(b) The catalytic converters make use of catalysts to remove pollutants from the exhaust.

(i) State the catalysts involved in the catalytic converters.

.... [1]

(ii) Describe how the catalysts speed up the reactions for the removal of pollutants.

....

.... [1]

(c) **(i)** Using the information provided Fig. 11.1, write a balanced chemical equation of a redox reaction that occurs in the catalytic converter.

.... [1]

(ii) Identify the oxidising agent for the redox reaction for your answer in **(c)(i)**.

.... [1]

(d) Diesel engines may also be fitted with a second catalytic converter to remove the remaining oxides of nitrogen. This second converter uses ammonia as the reducing agent. One possible reaction, for the removal of nitrogen dioxide, is shown by the following **unbalanced** equation.

$$\ldots\ldots NH_3 + \ldots\ldots NO_2 \rightarrow \ldots\ldots N_2 + \ldots\ldots H_2O$$

(i) Balance the equation by filling in the blanks above. [1]

(ii) Nitrogen monoxide is also removed by the catalytic converter as it will damage the ozone layer if released into the atmosphere. The two-step reaction is as shown.

Step 1: $NO + O_3 \rightarrow NO_2 + O_2$

Step 2: $NO_2 + O_3 \rightarrow NO + 2O_2$

It was discovered that one nitrogen monoxide molecule can destroy thousands of ozone molecules.

Use the equations from steps 1 and 2 to explain why.

....

....

....

.... [2]

[Total: 10]

End of Paper

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