Cambridge Assessment International Education

Example Responses – Paper 2

Cambridge O Level
Chemistry 5070

For examination from 2023

Cambridge Pathway

Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge O Level Chemistry 5070.

This booklet contains responses to all questions from June 2023 Paper 22, which have been written by a Cambridge examiner. Responses are accompanied by a brief commentary highlighting common errors and misconceptions where they are relevant.

The question papers and mark schemes are available to download from the School Support Hub

5070 June 2023 Question Paper 22

5070 June 2023 Mark Scheme 22

Past exam resources and other teaching and learning resources are available from the School Support Hub

Question 1

1 Choose from the following oxides to answer the questions.

CO
CO_2
CaO
CuO
Fe_2O_3
H_2O
SO_2
SiO_2
ZnO

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

State which oxide:

(a) is neutral

H_2O [1]

(b) reacts with calcium oxide to form slag in the blast furnace

SiO_2 [1]

(c) reacts with warm dilute hydrochloric acid to give a blue coloured solution

CuO [1]

(d) is amphoteric

ZnO [1]

(e) contains an ion with an oxidation number of +3

Fe_2O_3 [1]

(f) decolourises acidified aqueous potassium manganate(VII).

SO_2 [1]

[Total: 6]

Examiner comment

Candidates very rarely gave two answers or used the name of the oxide rather than its formula. A common misconception was to confuse the formulae for silicon(IV) oxide and sulfur dioxide in their answers for **(b)** and **(f)**.

Question 2

2 Group VII includes the elements fluorine, chlorine, bromine and iodine.

(a) Chlorine is a green gas at room temperature and pressure.

State the appearance of iodine at room temperature and pressure.

iodine is a dark-grey solid ..... [2]

Examiner comment

A very common misconception was that iodine was a liquid and was brown in colour. Some candidates also stated that iodine was purple. The description for iodine given in the syllabus was rarely seen.

(b) Chlorine reacts with aqueous potassium iodide in a displacement reaction.

$$Cl_2(aq) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(aq)$$

(i) Explain, in terms of electrons, why chlorine is an oxidising agent in this reaction.

chlorine gains electrons from the iodide ions .....

..... [1]

(ii) State the oxidation number of iodine in I_2.

0 ..... [1]

Examiner comment

Oxidation numbers of -1 and -2 were often given with some candidates not appreciating that chlorine is an element and so the oxidation number is 0.

(iii) Describe what is observed during the displacement reaction.

the colourless solution turns brown ..... [1]

Examiner comment

A very common misconception was to explain why a displacement reaction took place rather than giving the observation that a brown solution was obtained.

(c) The rate of diffusion of fluorine gas is greater than that of chlorine gas under the same conditions of temperature and pressure.

(i) State what is meant by the term diffusion.

this is the net movement of particles from a high concentration to a low concentration of particles

..... [1]

(ii) Explain why the rate of diffusion of fluorine is greater than that of chlorine under the same conditions.

a molecule of fluorine has a lower mass than a molecule of chlorine

..... [1]

Examiner comment

Some candidates referred to fluorine being more reactive, rather than focusing on comparing the masses of a fluorine molecule and a chlorine molecule. Another misconception was to refer to the atomic mass of fluorine and of chorine, and not appreciating that it was fluorine molecules of chlorine molecules that were present.

(iii) The rate of diffusion of fluorine increases as the temperature increases.

Suggest why using ideas about kinetic particle theory.

fluorine molecules move faster and have more kinetic energy

..... [1]

[Total: 8]

Question 3

3 This question is about the preparation of salts.

(a) Zinc nitrate is a soluble salt.

It is prepared by the reaction of an insoluble carbonate with a dilute acid.

The equation for this reaction is shown.

$$ZnCO_3(s) + 2HNO_3(aq) \rightarrow Zn(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

A sample of 4.50 g of zinc carbonate is added to 50.0 cm^3 of 1.30 mol / dm^3 nitric acid.

(i) Show by calculation that the zinc carbonate is in excess.

moles of $ZnCO_3$ used = 4.50 / 125 = 0.036

moles of HNO_3 needed to react = 0.036 × 2 = 0.072

moles of HNO_3 used = 50.0 ÷ 1000 × 1.30 = 0.065

not enough HNO_3 present because 0.065 is less than 0.072

so too much $ZnCO_3$

[3]

Examiner comment

A variety of approaches were used to answer this question and the example response shows just one of these approaches. Some candidates used a similar approach. They calculated the moles of nitric acid present and then calculated the number of moles of zinc carbonate that could react with this amount. These candidates then calculated the mass of this amount of zinc carbonate and showed it was less than the moles of zinc carbonate present. The most common misconception was to confuse zinc carbonate and nitric acid, so they then used the incorrect molar masses. Less successful answers involved just isolated calculations with no written explanations about their significance.

(ii) Once the reaction has finished the mixture is filtered.

State why the mixture is filtered.

the excess zinc carbonate is removed from the reaction mixture

..... [1]

(iii) Describe how to make pure, dry zinc nitrate crystals from an aqueous solution of zinc nitrate.

Heat the aqueous zinc nitrate until a saturated solution is obtained. Cool the saturated solution so crystals form and filter these off the crystals. Wash the crystals with water and dry between layers of filter paper.

..... [3]

Examiner comment

A common misconception was to start with the zinc carbonate and the dilute nitric acid and to include the filtering referred to in **(ii)**. Candidates often included some of the steps needed to prepare the pure dry crystals and missed one step out completely or only included one aspect of the particular step. Typically, candidates forgot to cool the mixture before filtering off the crystals or did not wash the crystals before drying them.

(b) Lead chloride is an insoluble salt.

It is prepared using a precipitation reaction.

Name **two** aqueous solutions that react together to give a precipitate of lead chloride.

sodium chloride and lead nitrate [1]

Examiner comment

Many candidates did not include a soluble lead compound and often gave examples more suited to acid and base method, such as lead hydroxide and dilute hydrochloric acid. Many candidates did not appreciate that lead nitrate is the only common lead salt soluble in water and so, for example, used insoluble lead sulfate.

(c) Ammonium sulfate is a soluble salt.

It is prepared by the reaction of an alkali and an acid.

Name the alkali and the acid used.

alkali aqueous ammonia

acid dilute sulfuric acid

[1]

[Total: 9]

Question 4

4 This question is about compounds that contain magnesium and nitrogen.

(a) The formula for a nitride ion can be written as $^{15}_{7}N^{3-}$.

Complete Table 4.1 to show the number of particles in this nitride ion.

Table 4.1

particle	number of particles
electron	10
neutron	8
proton	7

[3]

(b) State why the formula for a magnesium ion is Mg^{2+} rather than Mg^{+} or Mg^{3+}.

when magnesium atoms lose two electrons they obtain a stable full outer shell of electrons [1]

Examiner comment

Candidates found **(b)** very demanding and often did not mention anything about the electronic configuration of a magnesium ion. Answers that mentioned it is in Group II and so lose two electrons were not considered to be of sufficient detail. The most successful answers referred to Mg^{2+} having a stable electronic configuration, because it has a full outer shell of electrons.

(c) The formula for a nitride ion is N^{3-}.

Deduce the formula for magnesium nitride.

Mg_3N_2 [1]

(d) Magnesium nitrate, $Mg(NO_3)_2$, is an ionic compound.

Predict **two** physical properties of magnesium nitrate.

1 it has a high melting point

2 it dissolves in water

[2]

(e) Calculate the percentage by mass of nitrogen in magnesium nitrate.

Give your answer to **two** significant figures.

M_r of magnesium nitrate is $24 + 2(14 + 48) = 148$

percentage of nitrogen = $\left(\frac{24}{148}\right) \times 100 = 18.919$

percentage by mass .....19..... [2]

Examiner comment

A common misconception was to have $\left(\frac{28}{100}\right)$ x 100, where the candidates had used the molar mass of magnesium nitride. Other candidates did not give an answer to two significant figures.

Question 5

5 Carbon reacts with steam to make carbon monoxide and hydrogen.

This reaction is reversible. The forward reaction absorbs thermal energy.

$$C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$$

(a) An equilibrium mixture is formed when the reversible reaction happens in a closed system.

(i) Explain why the reversible reaction must be in a closed system for an equilibrium mixture to be formed.

a closed system stops the gaseous reactant and products from escaping [1]

Examiner comment

A common misconception was to refer to keeping the conditions constant, rather than focusing on keeping all the reactants and products within the system.

(ii) Predict what happens to the **position of equilibrium** when the temperature is decreased and the pressure remains constant.

Explain your answer.

prediction moves to the reactant side of the equation

explanation backward reaction is exothermic so thermal energy is released to minimise the temperature decrease

[2]

Examiner comment

Some candidates muddled up left and right. It was better for candidates to refer to either the reactant or the product-side instead of left- or right-hand side.

(ii) Predict what happens to the **position of equilibrium** when the temperature is decreased and the pressure remains constant.

Explain your answer.

prediction moves to the product side of the equation

explanation there are more gaseous moles of products than gaseous moles of reactants – this minimises the decrease in pressure

[2]

Examiner comment

Some candidates stated that the position of equilibrium did not move because the number of moles of reactant was the same as the number of moles of the product. This answer did not take into account that when the pressure was changed, the important factor was the number of moles of gaseous reactants and number of moles of gaseous products, and this was different.

(b) Predict what happens to the **rate of the backward reaction** when the temperature is decreased and the pressure remains constant.

Explain your answer.

prediction the rate decreases

explanation the molecules move slower and the kinetic energy of the molecules decreases so that the collisions are less successful

[2]

Examiner comment

Candidates often did not appreciate that the factors that affect rate of reaction applied to both the forward and backward reaction in a reversible reaction. The change in the rates of reaction were not affected by any shift in the position of equilibrium. As the temperature decreases, the molecules move slower and have less kinetic energy so there are fewer successful collisions. In this answer, as in **(d)**, candidates could refer to particles instead of molecules and this was often a safer approach since in this way there was no incorrect reference to an incorrect type of particle.

(b) Predict what happens to the **rate of the backward reaction** when the temperature is decreased and the pressure remains constant.

Explain your answer.

prediction the rate increases

explanation There are more particles per unit volume. The collision frequency increases since the molecules are now more crowded.

[2]

Examiner comment

As in **(c)**, candidates did not appreciate that the factors that affected rate of reaction applied to both the forward and the backward reaction in a reversible reaction. The most successful answers referred to molecules being closer to one another, or that the number of molecules per unit volume increased. As a result, the collision frequency between molecules increased. Candidates needed to appreciate that it is the collision frequency that is important for changes in pressure, not just the number of collisions.

Question 6

6 This question is about the energy changes that take place during chemical reactions.

(a) Nitrogen reacts with oxygen to make nitrogen monoxide.

The reaction is endothermic.

$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$

Draw, on the axes provided in Fig. 6.1, the reaction pathway diagram for this reaction.

Include labels for the:

- axes
- reactants
- product
- enthalpy change of reaction, ΔH
- activation energy, E_a.

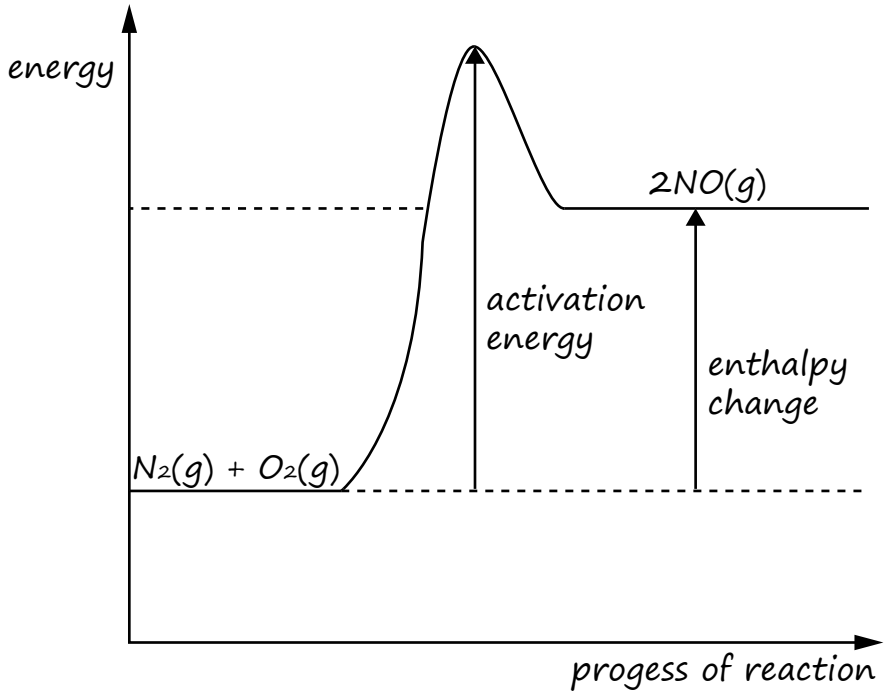


Fig. 6.1

[5]

Examiner comment

The most common errors involved candidates using the incorrect labels for the axes, for example using 'rate' and 'time'. Another error was to use 'energy change' or 'enthalpy change' for the y-axis. Using the word 'change' in the label made energy and enthalpy incorrect. Candidates needed to be very careful when drawing the exact position of the enthalpy change and the activation energy. The lines needed to be vertical with an arrowhead to indicate the correct direction of the energy change. In addition, the activation energy needed to start at the reactant level and go to the top of the activation energy hump. The enthalpy change needed to clearly show the difference in enthalpy between the reactant and the product. It was best to use construction lines (dotted lines) to indicate the energy levels of the reactants and products in the reaction pathway diagram.

(b) Hydrogen reacts with bromine to make hydrogen bromide.

$$H—H + Br—Br \rightarrow 2H—Br$$

Calculate the enthalpy change of this reaction.

Use the bond energies in Table 6.1.

Table 6.1

bond	bond energy in kJ/mol
H—H	436
Br—Br	193
H—Br	366

the bonds broken are H—H and Br—Br

+436 + 193 = + 629 kJ mol^{-1}

the bonds made are 2 lots of H—Br

2 x (−366) = −732 kJ mol^{-1}

+629 +(−732) = −103 kJ mol^{-1}

enthalpy change of reaction ..... −103 ..... kJ/mol [3]

[Total: 8]

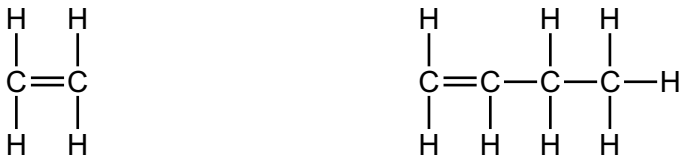
Examiner comment

Some candidates did not show the positive and negative signs to indicate if the enthalpy changes were endothermic or exothermic. This was particularly important where the final answer must clearly indicate the sign as well as the magnitude of the enthalpy change. It was also important to show the steps in the calculation since this allowed error carried forward marks to be awarded, even if the final answer was incorrect.

Question 7

7 Ethene, but-1-ene and but-2-ene are alkenes.

The displayed formulae of ethene and but-1-ene are shown in Fig. 7.1.



ethene but-1-ene

Fig. 7.1

(a) State the general formula of the homologous series of alkenes.

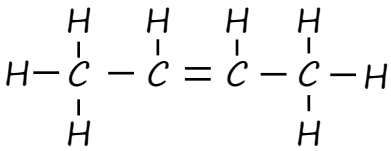
C_nH_{2n} [1]

(b) But-1-ene and but-2-ene are structural isomers.

(i) State the meaning of the term structural isomers.

these are compounds with the same molecular formula but different structural formulas [1]

(ii) Draw the displayed formula for but-2-ene.



[1]

(c) But-1-ene is an unsaturated hydrocarbon.

(i) State why but-1-ene is an unsaturated compound.

it has a molecule with a carbon-carbon double bond

..... [1]

(ii) State why but-1-ene is a hydrocarbon.

it has a molecule with only two elements hydrogen and carbon

..... [1]

(d) But-1-ene reacts with steam in the presence of a catalyst and reacts with bromine.

(i) Draw the structural formula of the product of the reaction with steam in the presence of a catalyst.

$CH_3CH_2CHOHCH_3$

[1]

Examiner comment

A common misconception was that candidates gave a structure that retained the carbon-carbon double bond as well as having an –OH bond in the molecule. Some candidates showed a C—H—O bond rather than the correct C—O—H bond.

(ii) Draw the structural formula of the product of the reaction with bromine.

$CH_3CH_2CHBrCH_2Br$

[1]

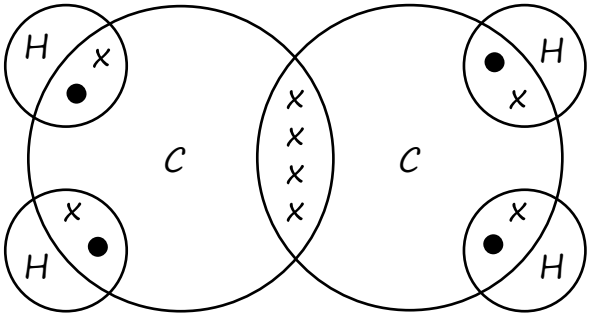
Examiner comment

Many candidates gave structures that retained the double bond and / or the hydroxyl group from the previous question. Some candidates put both bromine atoms on the same carbon atom, $CHBr_2CH_2CH_2CH_3$ and others on incorrect carbon atoms, $CH_2BrCH_2CH_2CH_2Br$.

(e) Ethene is a covalent substance.

(i) Draw a dot-and-cross diagram to show the bonding in a molecule of ethene.

Include only the outer shell electrons of each atom.



[2]

Examiner comment

Some candidates included lone pairs on the carbon atoms, where in this example there were no lone pairs. Other candidates included at least one extra electron on the hydrogen atoms shown.

(ii) Explain why ethene has a low melting point.

the intermolecular force between ethene molecules is very weak and easily broken [1]

[Total: 10]

Examiner comment

Some candidates referred to covalent bonds breaking, or implied it was the presence of covalent bonds that was important in terms of the low melting point of ethane. References to either a 'giant structure' or 'weak covalent bonds' were incorrect. The most successful answers referred to 'weak intermolecular forces'. Answers such as 'weak forces between molecules' were also correct.

Question 8

8 This question is about electrolysis.

(a) The table shows some information about the electrolysis of three different electrolytes using graphite electrodes.

Complete Table 8.1 with the names of the products at each electrode.

Table 8.1

electrolyte	product at anode	product at cathode
concentrated aqueous potassium iodide	iodine	hydrogen
dilute sulfuric acid	oxygen	hydrogen
molten lead(II) bromide	bromine	lead

[3]

Examiner comment

Candidates made a variety of different errors and rarely got all the answers correct. Some errors were as a result of giving incorrect formulas when the question asked for the names of products. If the command word stated 'name', then writing the name was the best answer. If the command word 'identify' was used, then either the name or formula could be given, but if both were written then the formula and name needed to be correct. Some candidates gave the names of the ions that reacted at the electrodes, e.g. bromide, but these were not the products. Candidates had to appreciate that in a concentrated halide solution, the halogen was produced at the anode. Other candidates did not understand that the anions in the solution reacted at the anode and the cations at the cathode. As a result, although all the products were correct, they were put into the incorrect columns.

(b) Give **two** reasons why graphite is a suitable material from which to make electrodes.

1 graphite has very good electrical conductivity

2 graphite is inert and does not react with electrolytes

[2]

(c) Aluminium is manufactured by the electrolysis of aluminium oxide dissolved in molten cryolite.

At the anode, oxide ions react to make oxygen molecules.

Construct the ionic half-equation for this electrode reaction.

$2O^{2-} \rightarrow O_2 + 4e^-$ [1]

[Total: 6]

Examiner comment

The most common misconception was not to balance the equation in terms of atoms, or to put the electrons on the incorrect side of the equation. Another misconception was to write the formation of oxygen from hydroxide ions, even though the electrolyte was molten aluminium oxide. Candidates needed to remember that in the equation, both charge and atoms had to be balanced.

Question 9

9 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.

One mole of any gas contains 6.02×10^{23} molecules.

volume of CO_2 in air = $480 \times 0.04 \div 100 = 0.192$ (dm^3)

amount of CO_2 in air = $0.192/24 = 0.008$ (mol)

number of molecules = $0.008 \times 6.02 \times 10^{23}$

number of molecules 4.816×10^{21} [3]

Examiner comment

This was a new part of the Cambridge O Level syllabus. Candidates were often able to calculate the moles of carbon dioxide, but then did not know what to do with the Avogadro constant. The order in which the steps were done did not matter so it was acceptable to work out moles first, then do the percentage calculation and finally the number of molecules.

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

One of the hydrocarbons in gasoline has the molecular formula C_9H_{20}.

Construct the equation for the complete combustion of C_9H_{20}.

$C_9H_{20} + 14O_2 \rightarrow 9CO_2 + 10H_2O$ [1]

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

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

climate change [1]

Examiner comment

Candidates did not show a strong understanding of the greenhouse effect how carbon dioxide in the air causes global warming and there were two common misconceptions. The first related to carbon dioxide depleting the ozone layer. The second misconception involved thermal energy or infrared radiation from the sun being absorbed by carbon dioxide molecules rather than thermal energy from the Earth's surface.

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

carbon dioxide absorbs thermal energy coming from the Earth's surface and then emits it back into the atmosphere

..... [2]

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

State the word equation for photosynthesis.

carbon dioxide + water → glucose + water ..... [1]

[Total: 8]

Examiner comment

Some candidates tried to give a symbol equation rather than the word equation that was asked for. A correct symbol equation was accepted, but candidates who wrote symbol equations often made mistakes with formulae.

Question 10

10 Proteins and PET are polymers made by a reaction called condensation polymerisation.

(a) The diagram in Fig. 10.1 shows the structure of a section of a protein.

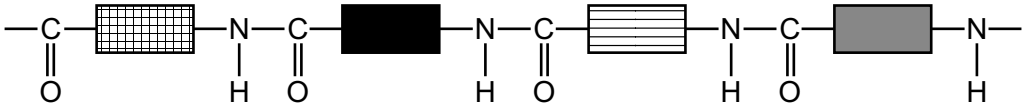
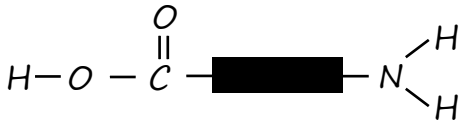


Fig. 10.1

(i) Draw the general structure of the amino acid monomers used to make proteins.



[1]

Examiner comment

Most candidates used the notation represented within the question, rather than the general structure using symbols and the R group notation giving a structure of $N_2NCHRCOOH$. This structure was an acceptable answer. Some candidates produced structures that were still linked together, such as a dipeptide.

(ii) Proteins are polyamides.

Name one **other** polyamide.

nylon ..... [1]

(b) PET is a polymer used to make plastic bottles.

The diagram in Fig. 10.2 shows the structure of PET.

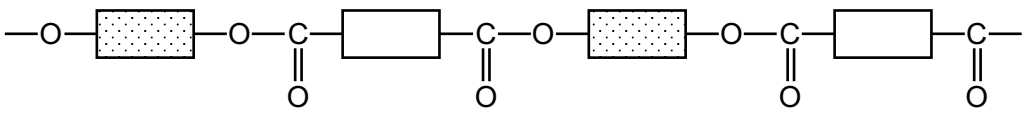


Fig. 10.2

(i) Name the linkage present in PET.

ester ..... [1]

(ii) Proteins and PET are both made by condensation polymerisation.

Describe the differences between condensation polymerisation and addition polymerisation.

In condensation polymerisation many monomers react to give the polymer and water. In addition polymerisation many unsaturated monomers react to produce only a polymer.

..... [2]

Examiner comment

Some candidates stated that addition polymerisation required water, whereas condensation polymerisation made water. Other errors included the idea that condensation required more than one monomer and addition polymerisation only one type of monomer. Similar misconceptions were expressed in terms of the monomers for condensation having two different functional groups.

(c) Describe **two** environmental challenges caused by the disposal of plastics such as PET.

1 *plastics have to be incinerated and this produces toxic gases such as carbon monoxide*

2 *plastics are non-biodegradable and are disposed of in land-fill sites that take up lots of space*

[2]

[Total: 7]

Cambridge Assessment International Education
The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA, United Kingdom
t: +44 1223 553554
e: info@cambridgeinternational.org www.cambridgeinternational.org