Cambridge Assessment International Education

Example Responses – Paper 4

Cambridge IGCSE™ / IGCSE (9–1) Chemistry 0620 / 0971

For examination from 2023

Cambridge Pathway

Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge IGCSE / IGCSE (9-1) Chemistry 0620 / 0971.

This booklet contains responses to all questions from June 2023 Paper 42, 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

0620 / 0971 June 2023 Question Paper 42

0620 / 0971 June 2023 Mark Scheme 42

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

Question 1

1 A list of oxides, **A** to **H**, is shown.

A calcium oxide

B aluminium oxide

C silicon(IV) oxide

D sulfur dioxide

E carbon dioxide

F iron(III) oxide

G silver oxide

H carbon monoxide

Answer the following questions about the oxides, **A** to **H**.
Each letter may be used once, more than once or not at all.

State which of the oxides, **A** to **H**:

(a) is responsible for acid rain

D .... [1]

(b) has a giant covalent structure

C .... [1]

(c) is a reducing agent in the blast furnace

H .... [1]

(d) is the main constituent of bauxite

B .... [1]

(e) is the main impurity in iron ore

C .... [1]

(f) can be reduced by heating with copper.

G .... [1]

Examiner comment

- Although 6 out of 6 was seldom seen, most candidates scored well overall with parts **(a)**, **(b)** and **(d)** usually being correct.
- Parts **(c)** and **(f)** proved more difficult and part **(e)** was the hardest with only some candidates getting this question correct because the majority assumed iron(III) oxide to be the main impurity of iron ore.
- Many candidates opted to give the name of the oxide which, although a little time consuming for candidates, was acceptable.

Question 2

2 Fluorine, chlorine and bromine are in Group VII of the Periodic Table.

(a) State the name given to Group VII elements.

halogens [1]

Examiner comment

Many candidates gave incorrect versions of the name and, naturally, 'halides' was often seen.

(b) Explain why Group VII elements have similar chemical properties.

Group VII elements have the same properties was because they have the same number of outer shell electrons [1]

Examiner comment

Many candidates omitted the word 'number' and wrote 'same electrons in the outermost shell', but they were not awarded marks for this.

(c) Complete Table 2.1 to show the colour and state at r.t.p. of some Group VII elements.

Table 2.1

element	colour	state at r.t.p.
fluorine	pale yellow	gas
chlorine	pale yellow-green	gas
bromine	red-brown	liquid

[3]

Examiner comment

- Less successful candidates assumed bromine to be orange, probably because of confusion with bromine water.
- The colours and states of the halogens are now given in the syllabus and although some leeway in the descriptions were allowed, chlorine was expected to be 'pale yellow-green' in colour and bromine to be 'red-brown':

(d) Bromine has two naturally occurring isotopes, ^{79}Br and ^{81}Br.

(i) State the term given to the numbers 79 and 81 in these isotopes of bromine.

nucleon number .... [1]

Examiner comment

- Candidates need to be aware that 'nucle**on** number' is not the same as 'nucle**ar** number'.
- The correct term 'nucleon number' or its alternative, 'mass number', was fairly well known.

(ii) Complete Table 2.2 to show the number of protons, neutrons and electrons in the atom and ion of bromine shown.

Table 2.2

	^{79}Br	$^{81}Br^{-}$
protons	35	35
neutrons	44	46
electrons	35	36

[3]

Examiner comment

Occasionally the neutron row was seen as 79 and 81 and the electron row as 35 and 34, on the incorrect assumption that a Br^{-} ion has one less electron than a Br atom. The majority of successful candidates were awarded 3 marks.

(iii) Table 2.3 shows the relative abundances of the two naturally occurring isotopes of bromine.

Table 2.3

isotope	^{79}Br	^{81}Br
relative abundance	55%	45%

Calculate the relative atomic mass of bromine to **one** decimal place.

79 x 0.55 + 81 x 0.45 = 79.9

relative atomic mass = ..79.9.................... [2]

Examiner comment

- A common error was to add the two isotopic masses together and divide by 2, e.g. 79 + 81 = 160 160 ÷ 2 = 80.0
- Candidates are getting better at these calculations and many are realising that the first mark is gained by multiplying the particle masses by their relative abundances and deriving a total value.

(e) Chlorine displaces bromine from aqueous potassium bromide but does **not** displace fluorine from aqueous sodium fluoride.

(i) Write the symbol equation for the reaction between chlorine and aqueous potassium bromide.

$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ [2]

Examiner comment

Some candidates assumed that potassium chloride had the formula KCl2 or that bromine (and / or chlorine) existed as monoatomic substances, e.g. 2Cl + 2KBr → 2KCl + 2Br.

(ii) State why chlorine does **not** displace fluorine from aqueous sodium fluoride.

chlorine is less reactive than fluorine [1]

Examiner comment

The most common error was to compare reactivity of the ions, so answers such as 'chloride is less reactive than fluoride' were not awarded any marks.

(f) Aqueous silver nitrate is a colourless solution containing $Ag^+(aq)$ ions.

(i) Describe what is seen when aqueous silver nitrate is added to aqueous sodium chloride.

white precipitate [1]

Examiner comment

Some incorrectly inserted effervescence as a further observation so were not awarded the mark.

(ii) Write the ionic equation for the reaction between aqueous silver nitrate and aqueous sodium chloride.

Include state symbols.

$Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)}$ [3]

Examiner comment

Many candidates omitted the state symbols, wrote full symbol equations without any ions or wrote AgCl as ions, e.g. $Ag^{+}Cl^{-}$.

Question 3

3 Over 200 million tonnes of sulfuric acid are manufactured every year.

(a) State the name of the process used to manufacture sulfuric acid.

Contact process .... [1]

Examiner comment

The common error was 'Haber process'.

(b) Part of the manufacture of sulfuric acid involves converting sulfur dioxide to sulfur trioxide.

(i) Describe **two** methods by which sulfur dioxide is obtained.

1 burning sulfur

2 roasting sulfur ores

[2]

Examiner comment

- Neither source was well known. The most frequently seen incorrect responses were 'burning sulfur in oxygen' and 'burning fossil fuels'.
- This question relied upon knowledge of the new syllabus. The correct answer came from section **6.3.9** of the syllabus which states: 'state the sources of the sulfur dioxide (burning sulfur or roasting sulfide ores) and oxygen (air) in the Contact process.'

The conversion of sulfur dioxide to sulfur trioxide is a reversible reaction which can reach equilibrium.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(ii) State **two** features of an equilibrium.

1 rate of forward reaction is equal to the rate of the reverse reaction

2 concentrations of reactants and products are constant

[2]

Examiner comment

- In cases where the first mark was not awarded, candidates tended to give incorrect answers such as 'the forward reaction is equal to the reverse reaction' (with no mention of rate) or 'the rates of forward and reverse reactions are constant' ('constant' is not the same as 'equal').
- Where the second mark was not awarded, candidates tended to give incorrect answers such as 'concentrations reactants and products are the same' ('same' is not equivalent to 'constant'), but 'concentrations remain the same' would have been awarded a mark.

(iii) State the typical conditions and name the catalyst used in the conversion of sulfur dioxide to sulfur trioxide.

temperature 450 °C

pressure 200 kPa

catalyst vanadium(V) oxide

[3]

Examiner comment

The most common error was seen when candidates converted 2 atm pressure into kPa and incorrectly gave 0.2 or 20,000.

(iv) Complete Table 3.1 to show the effect, if any, when the following changes are applied to the conversion of sulfur dioxide to sulfur trioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The forward reaction is exothermic.

Only use the words **increases**, **decreases** or **no change**.

Table 3.1

change	effect on the rate of the forward reaction	effect on the concentration of SO_3(g) at equilibrium
temperature decreases	decreases	increase
pressure increases	increase	increase
no catalyst	decreases	no change

[4]

Examiner comment

Some candidates incorrectly thought that the effect of temperature decrease would decrease SO_3 concentration, frequently seen as 'decrease' in the table.

(v) Explain in terms of collision theory why reducing the temperature decreases the rate of the forward reaction.

The kinetic energy of particles decreases and as the frequency of collisions between particles decreases. A lower proportion of particles have energy greater than or equal to the activation energy.

[3]

Examiner comment

- These marking points increased in difficulty with M1 being the easiest. Very few candidates did not achieve this mark. The most common incorrect response to M1 was to write 'kinetic energy decreases' with no reference to particles losing this energy.
- Most candidates were awarded M2 by writing the equally acceptable phrase 'less collisions per unit time'. Common errors to M2 included writing 'less collisions' without reference to their frequency, or 'decreased chance of collisions'.
- M3 proved to be the most difficult mark, as candidates missed out the key element of there being a lower proportion of particles having energy greater than activation. Consequently, common incorrect answers included 'particles have energy lower than activation energy' which suggests all particles have energy lower than activation energy and 'many particles have energy lower than activation energy' giving no idea of proportion. Another incorrect answer for M3 was to state that 'activation energy is lowered'.

(c) Sulfuric acid contains SO_4^{2-} ions.

The oxidation number of O atoms in SO_4^{2-} ions is –2.

Determine the oxidation number of S atoms in SO_4^{2-} ions. Show your working.

$S + (4 \times -2) = -2 \therefore S = +6$

oxidation number = +6 [2]

Examiner comment

- The most common error was to omit the '+' in '+6'. Oxidation numbers are integers which need a sign in front of them.
- Other errors included not taking account of the 4 oxygen atoms in sulfate group, $O_4 = -2$, and $S + -2 = -2 \therefore S = 0$; not taking account of the overall charge of the ion being – 2 and assuming it to be 0, so $S + -8 = 0, \therefore S = +8$; and errors with subtraction of negative numbers, e.g. $S = -2 - (-2 \times 4)$ often became $S = -2 - 8 \therefore S = -10$ rather than $S = -2 - (-8)$.

Question 4

4 Solid sodium hydroxide is a base which dissolves to form an aqueous solution, NaOH(aq).

(a) State what is meant by the term base.

proton acceptor .... [1]

Examiner comment

All other comments about pH greater than 7 contains OH^- ions etc were ignored.

(b) State the term given to a base which dissolves to form an aqueous solution.

alkali .... [1]

Examiner comment

The most common error was ‘alkaline’.

(c) State the colour of thymolphthalein in NaOH(aq).

blue .... [1]

Examiner comment

The most common error was ‘colourless’, presumably as a consequence of confusing ‘thymolphthalein’ with ‘phenolphthalein’.

(d) Complete the word equation for the reaction of NaOH(aq) with ammonium chloride.

sodium hydroxide + ammonium chloride → sodium chloride + water + ammonia

[3]

Examiner comment

The most common incorrect responses were ‘salt’ instead of ‘sodium chloride’, ‘hydrogen’ instead of ‘water’ and ‘ammonium’ instead of ‘ammonia’.

(e) Some metal oxides react with NaOH(aq).

(i) State the term given to metal oxides which react with bases such as NaOH(aq).

amphoteric .... [1]

Examiner comment

Common incorrect answers were 'basic' or 'acidic'.

(ii) Name a metal oxide which reacts with NaOH(aq).

aluminium oxide. .... [1]

Examiner comment

The most common incorrect answer was 'potassium oxide'. The correct names of amphoteric oxides from the syllabus were either 'aluminium oxide' or 'zinc oxide'. The names of other amphoteric oxides were accepted.

(f) Ethanoic acid, CH_3COOH, is a weak acid.

(i) Complete the dot-and-cross diagram in Fig. 4.1 of a molecule of ethanoic acid.

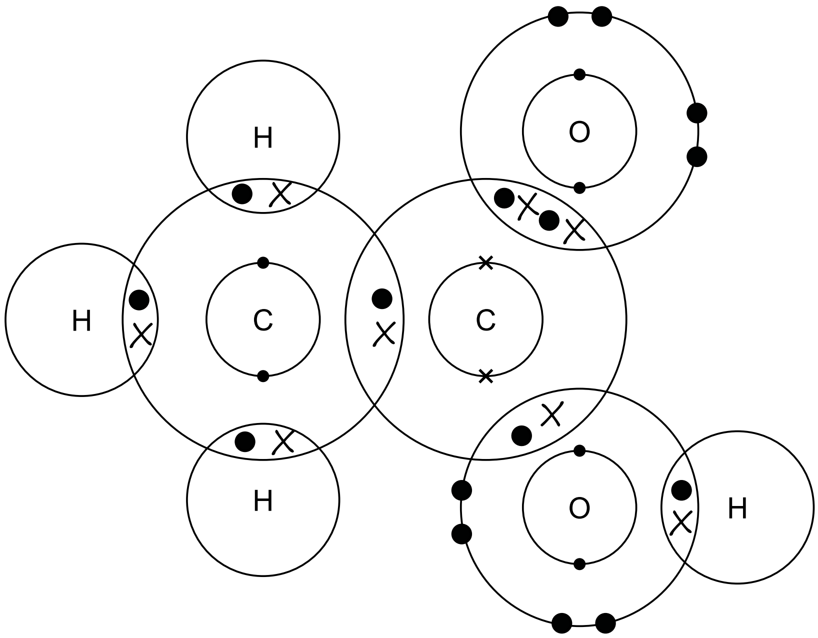


Fig. 4.1

[3]

Examiner comment

- Many candidates who were not awarded M1 used two identical symbols for a dot and cross pair of electrons, e.g. two dots or two crosses, or placed two pairs of electrons, i.e. a double bond, between the carbon atoms.
- Where M2 was not awarded, candidates used a single dot and cross for the C=O double bond.
- For those candidates who were awarded M1 and M2, the main errors in M3 were to miss out the 4 non-bonding electrons on each O atom, or to give an ‘extra’ non-bonding electron on the H atoms.

(ii) Suggest the pH of dilute ethanoic acid.

4 .... [1]

Examiner comment

- Common errors included giving any pH numbers outside this range, or stated ‘pH below 7’ as this would also include pH 1 and pH 2.
- The correct answer was any pH number within the range 3≤ pH <7.

(iii) Complete the symbol equation to show the dissociation of ethanoic acid.

CH_3COOH *$\rightleftharpoons CH_3COO^- + H^+$* .... [3]

Examiner comment

- Most candidates were awarded a mark for ‘H^+’.
- Where candidates were not awarded a mark, it was because they used a non-reversible arrow and not ⇌.

(iv) Write the ionic equation for the reaction when an acid neutralises a soluble base.

$H^+ + OH^- \rightarrow H_2O$ .... [1]

(g) In a titration, 25.0 cm^3 of 0.0800 mol / dm^3 aqueous potassium hydroxide, KOH(aq), is neutralised by 20.0 cm^3 of dilute sulfuric acid, H_2SO_4(aq).

$$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

Calculate the concentration of H_2SO_4, in g / dm^3 using the following steps.

- Calculate the number of moles of KOH used.

$\frac{0.0800 \times 25}{1000}$

0.002 .... mol

- Determine the number of moles of H_2SO_4 which react with the KOH.

$\frac{0.002}{2}$

0.001 .... mol

- Calculate the concentration of H_2SO_4 in mol / dm^3.

$\frac{0.01 \times 1000}{20}$

0.05 .... mol / dm^3

- Calculate the concentration of H_2SO_4 in g / dm^3.

M_r of H_2SO_4 $(1 \times 2) + 32 + (16 \times 4) = 98$

0.05×98

4.9 .... g / dm^3

[5]

Examiner comment

- Where the candidates' final answer was incorrect, successful candidates were awarded some marks by showing their working.
- Incorrect responses to M1 included using an incorrect concentration of KOH (usually 0.8 mol/dm^3) so M1 became 0.2 mol, not converting cm^3 to dm^3 (i.e. forgetting to divide by 1000) so M1 became 2 mol or using the *Mr* of KOH (56) instead of its concentration so M1 became 1.4 mol.
- The frequent incorrect response to M2 was multiplying M1 by 2 (instead of dividing).
- The most common error for M3 was dividing M1 by M2 (or vice versa).
- The most common errors in M4 and M5 were not stating the *Mr* of H_2SO_4 or writing down unexplained numbers or leaving sums unevaluated.
- M5 (and M4) were awarded if M5 was equivalent to M3 × 98, but M3 multiplied by an unexplained number resulted in 0 marks for M4 and M5.

Question 5

5 Propane and propene both react with chlorine.

(a) When a molecule of propane, C_3H_8, reacts with chlorine in the presence of ultraviolet light, one atom of hydrogen is replaced by one atom of chlorine.

(i) State the term given to reactions in which one atom in an alkane is replaced by another atom.

substitution [1]

Examiner comment

Common incorrect responses included 'displacement' or 'photochemical'.

(ii) State the purpose of ultraviolet light in this reaction.

to provide activation energy [1]

Examiner comment

Common incorrect responses were 'as a catalyst' or 'to supply energy' (which was too vague).

(iii) State the term given to any reaction which requires ultraviolet light.

photochemical [1]

Examiner comment

Common incorrect responses included 'substitution' or 'photosynthesis'.

(iv) Write the symbol equation for the reaction between propane and chlorine.

$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$ [2]

Examiner comment

Incorrect responses were mainly as a result of incorrect products, e.g.:

- $C_3H_8 + Cl_2 \rightarrow C_3H_6Cl_2 + H_2$
- $C_3H_8 + Cl_2 \rightarrow C_3H_6Cl_2$
- $C_3H_8 + Cl_2 \rightarrow C_3H_6 + 2HCl$.

(b) A molecule of propene, C_3H_6, is unsaturated and will react with chlorine at room temperature.

(i) State why propene is an unsaturated molecule.

the bonding in alkenes includes a double carbon-carbon bond .... [1]

Examiner comment

- Incorrect responses included many which did not emphasise that it was the carbon-carbon bonding which leads to unsaturation, e.g. 'it has a double bond', 'it has a carbon double bond' or 'not all bonds are single'. None of these vague statements were accepted as they could also apply to carboxylic acids which have a C=O double bond.
- Variations based upon the idea of carbon to carbon bonding not being single were allowed.

(ii) Give the structural formula of the product of this reaction.

$CH_3CHClCH_2Cl$ .... [1]

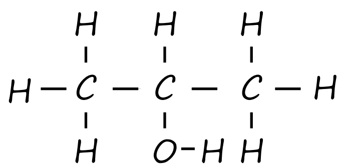
Examiner comment

The common error was to draw the structure formula of 1,3-dichloropropane, i.e. $CH_2ClCH_2CH_2Cl$.

(c) Propene undergoes addition reactions with steam.
There are two possible products, **A** and **B**.

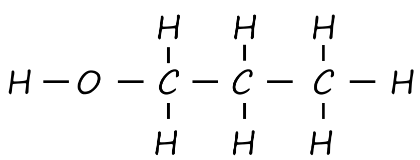
Draw the displayed formula and name each product **A**.

displayed formula of product



name of product **A** propan-2-ol ....

displayed formula of product **B**

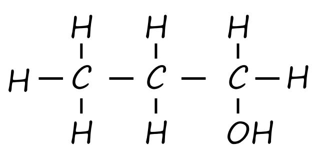


name of product **B** propan-1-ol ....

[4]

Examiner comment

- The name of 'propan-1-ol' was frequently incorrectly written as 'propanol'.
- The common errors in drawing the displayed formulae was not showing every bond and frequently the –O–H bond was seen as –OH. See extract:



Question 6

6 Carboxylic acids can be converted to esters.

(a) Name the ester formed when butanoic acid, $CH_3CH_2CH_2COOH$, reacts with ethanol, CH_3CH_2OH.

ethyl butanoate .... [1]

Examiner comment

Some candidates named 'ethyl butanote' and 'butyl ethanoate'.

(b) Identify the other product formed in this reaction.

water .... [1]

Examiner comment

Some candidates gave 'hydrogen' or 'butyl ethanoate'.

(c) Deduce the empirical formula of the ester formed.

C_3H_6O .... [1]

Examiner comment

Some candidates gave the full molecular formula, $C_6H_{12}O_2$, or the structural formula.

(d) PET is a polyester. Part of the structure of PET is shown in Fig. 6.1.

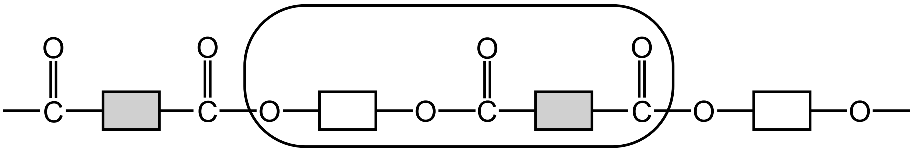


Fig. 6.1

(i) Circle **one** repeat unit of this polymer. [1]

Examiner comment

- The most common error made was to circle only part of the complete unit as below:

(d) PET is a polyester. Part of the structure of PET is shown in Fig. 6.1.

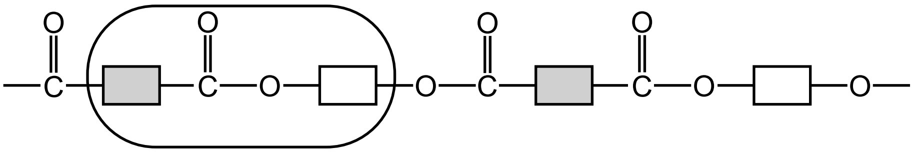


Fig. 6.1

- Another error was to circle an ester link as below:

(d) PET is a polyester. Part of the structure of PET is shown in Fig. 6.1.

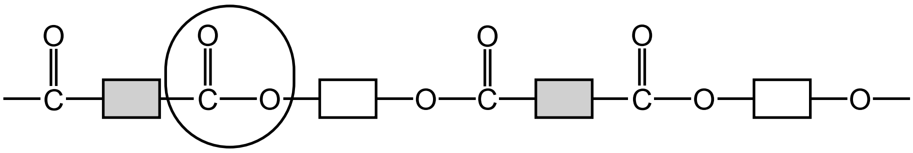
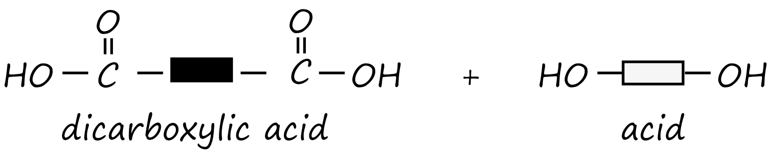


Fig. 6.1

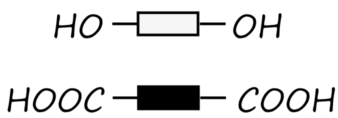
(ii) Draw the structures of the monomers which make up PET. Draw the functional groups using displayed formulae.



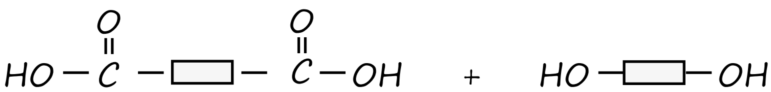
[2]

Examiner comment

- Some candidates did not display the dioic acid structure, as below:



- Alternatively, candidates displayed the dioic acid using an unshaded box, as below:



(iii) State the type of polymerisation used in making PET.

condensation .... [1]

Examiner comment

Many candidates incorrectly stated ‘addition’.

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