Cambridge Assessment International Education

# Cambridge IGCSE™

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| CANDIDATE NAME | | | | | | | | | |
| CENTRE NUMBER | | | | | | CANDIDATE NUMBER | | | | |

*6388004630*

**CHEMISTRY** **0620/43**

Paper 4 Theory (Extended) **October/November 2021**

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

**INSTRUCTIONS**

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

**INFORMATION**

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **16** pages. Any blank pages are indicated.

**1** A list of substances is shown.

**ammonia**
**bauxite**
**carbon dioxide**
**carbon monoxide**
**ethanol**
**hematite**
**oxygen**
**sodium chloride**
**sulfur dioxide**

Answer the questions using the list of substances.

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

State which substance is:

**(a)** an element ..... [1]

**(b)** an ore of aluminium ..... [1]

**(c)** a gas that causes acid rain ..... [1]

**(d)** used as a fuel ..... [1]

**(e)** an ionic compound ..... [1]

**(f)** produced in the Haber process ..... [1]

**(g)** a product of respiration ..... [1]

**(h)** a toxic product of the incomplete combustion of hydrocarbons

..... [1]

**(i)** a gas produced in the test for nitrate ions. ..... [1]

[Total: 9]

**2** This question is about electrolysis.

**(a)** State the meaning of the term *electrolyte*.

.....

..... [2]

**(b)** The table gives information about the electrolysis of two electrolytes. Carbon (graphite) electrodes are used in each experiment.

**(i)** Complete the table to show the observations and products of electrolysis.

| | positive electrode (anode) | | negative electrode (cathode) | |
|---|---|---|---|---|
| electrolyte | observations | name of product | observations | name of product |
| aqueous copper(II) sulfate | colourless bubbles | | | |
| concentrated aqueous sodium bromide | | | colourless bubbles | hydrogen |

[5]

**(ii)** Hydrogen is produced at the negative electrode (cathode) during the electrolysis of concentrated aqueous sodium bromide.

Write the ionic half-equation for this reaction.

..... [2]

**(iii)** State **two** reasons why carbon (graphite) is suitable to use as an electrode.

1 .....

2 .....
[2]

**(iv)** Name the particle responsible for the conduction of electricity in the metal wires used in a circuit.

..... [1]

[Total: 12]

**3** Lead is a metallic element in Group IV. One of the ores of lead is galena, which is an impure form of lead(II) sulfide, PbS.

Lead also occurs in the ore cerussite, which contains lead(II) carbonate, $PbCO_3$.

**(a)** Calculate the relative formula mass, $M_r$, of $PbCO_3$.

$M_r$ of $PbCO_3$ = ..... [1]

**(b)** The $M_r$ of PbS is 239.

Calculate the percentage of lead by mass in PbS.

percentage of lead by mass in PbS = ..... [1]

**(c)** The percentage of lead by mass in $PbCO_3$ is 77.5%.

**Use this information** and your answer to **(b)** to suggest whether it would be better to extract lead from $PbCO_3$ or PbS.

Give a reason for your answer.

.....

..... [1]

**(d)** When lead(II) carbonate is heated it decomposes into lead(II) oxide, PbO, and carbon dioxide.

Write a chemical equation for this reaction.

..... [1]

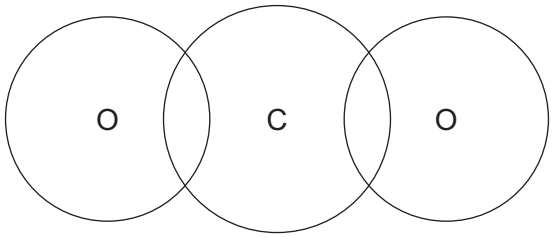
**(e)** Lead(II) carbonate reacts with dilute nitric acid. One of the products is aqueous lead(II) nitrate, $Pb(NO_3)_2$.

Write a chemical equation for this reaction.

..... [2]

**(f)** Lead(II) oxide and carbon dioxide are oxides of Group IV elements.

**(i)** Complete the diagram to show the electron arrangement in one molecule of $CO_2$. Show only the outer electrons.




[2]

**(ii)** The melting points of lead(II) oxide and carbon dioxide are shown.

| | melting point / °C |
|---|---|
| lead(II) oxide | 886 |
| carbon dioxide | –56 |

Use your knowledge of structure and bonding to explain why lead(II) oxide has a much higher melting point than carbon dioxide.

Your answer should refer to:

- the types of particles involved
- the relative strength of the forces of attraction between the particles.

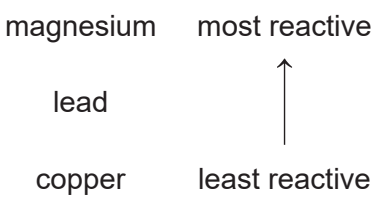
.....

.....

.....

..... [3]

**(g)** Part of the reactivity series is shown.




Aqueous lead(II) nitrate contains $Pb^{2+}$ ions.

Two experiments are carried out.

In Experiment 1, magnesium is added to aqueous lead(II) nitrate.

In Experiment 2, copper is added to aqueous lead(II) nitrate.

Write an ionic equation for any reaction that occurs in each experiment. If no reaction occurs write 'no reaction'.

Experiment 1 .....

Experiment 2 .....

[2]

**(h)** When lead(II) nitrate is heated it decomposes to produce the same gaseous products as when copper(II) nitrate is heated.

**(i)** One of the gaseous products is oxygen.

Describe a test for oxygen.

test .....

observations .....

[2]

**(ii)** Name the other gaseous product.

..... [1]

[Total: 16]

**4** Carbon is an important element.

**(a)** Carbon exists as the isotopes $^{12}_{6}C$ and $^{13}_{6}C$.

Complete the table.

| isotope | number of protons in one atom | number of electrons in one atom | number of neutrons in one atom |
|---|---|---|---|
| $^{12}_{6}C$ | | | |
| $^{13}_{6}C$ | | | |

[2]

**(b)** Name **two** forms of the element carbon which have giant covalent structures.

..... and ..... [1]

**(c)** The Avogadro constant is the number of particles in 1 mole.

The numerical value of the Avogadro constant is $6.02 \times 10^{23}$.

**(i)** Calculate the number of molecules in 22.0 g of carbon dioxide, $CO_2$.

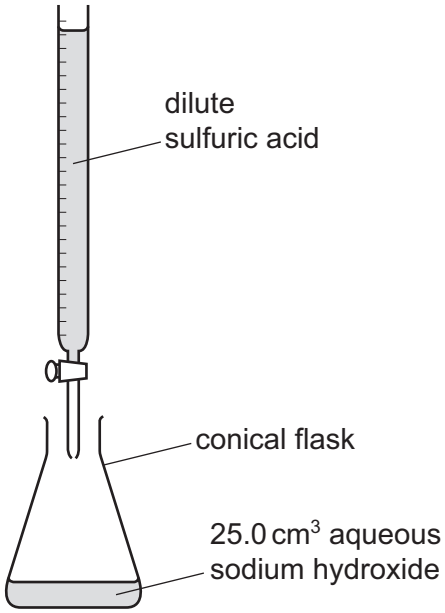
..... molecules [2]

**(ii)** Calculate the number of molecules in 6.00 $dm^3$ of carbon dioxide gas at room temperature and pressure.

..... molecules [1]

[Total: 6]

**5** **(a)** Dilute sulfuric acid and aqueous sodium hydroxide can be used to prepare sodium sulfate crystals using a method that involves titration.




**(i)** Suggest why universal indicator is **not** suitable for this titration.

..... [1]

**(ii)** Name an indicator that can be used in this titration.

..... [1]

20.0 $cm^3$ of dilute sulfuric acid neutralises 25.0 $cm^3$ of 1.00 $mol/dm^3$ aqueous sodium hydroxide. At the end of the titration the conical flask contains aqueous sodium sulfate with the dissolved indicator as an impurity.

**(b)** Describe how to prepare a **pure** sample of sodium sulfate crystals from the original solutions of dilute sulfuric acid and aqueous sodium hydroxide of the same concentrations.

**You are not required to give details of how to carry out the titration.**

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

**(c)** Sodium hydrogensulfate, $NaHSO_4$, dissolves in water to produce an aqueous solution, **X**, containing $Na^+$, $H^+$ and $SO_4^{2-}$ ions.

State the observations when the following tests are done.

**(i)** A flame test is carried out on **X**.

..... [1]

**(ii)** Copper(II) oxide is warmed with an excess of **X**.

.....

..... [2]

**(iii)** Acidified aqueous barium nitrate is added to **X**.

..... [1]

[Total: 11]

**6** A student investigates the decomposition of hydrogen peroxide in the presence of a catalyst of manganese(IV) oxide.

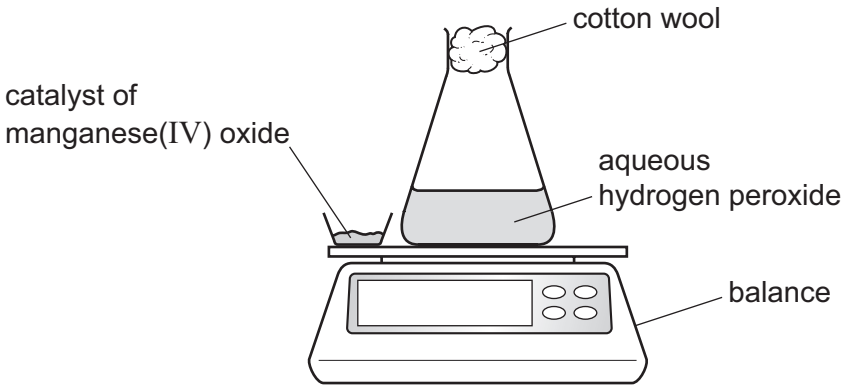
$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

**(a)** State the meaning of the term *catalyst*.

.....

..... [2]

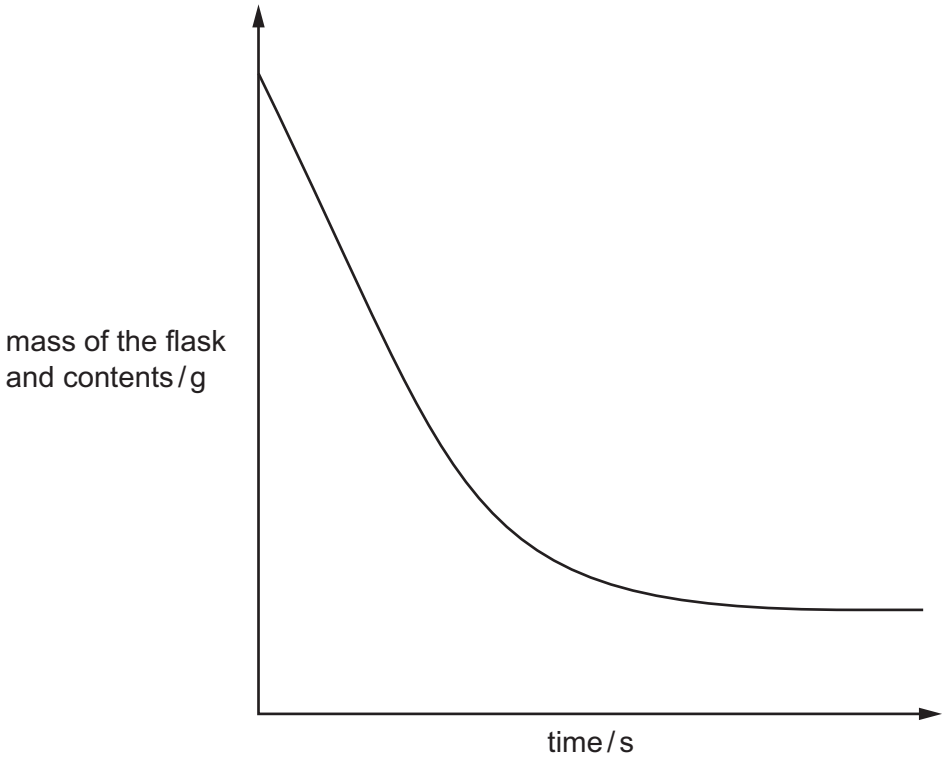
**(b)** The diagram shows the equipment the student uses.




The student uses this method:

- the catalyst is added to the aqueous hydrogen peroxide
- the stop-clock is started
- the mass of the flask and contents is recorded at regular time intervals.

A graph of the mass of the flask and contents against time is shown.




**(i)** Suggest why the mass of the flask and contents decreases as time increases.

..... [1]

**(ii)** Describe what happens to the rate of the reaction as time increases.

.....

..... [2]

**(c)** The student repeats the experiment at a higher temperature. All other conditions stay the same. The rate of reaction increases.

**(i)** Explain, in terms of collisions between particles, why the rate of reaction increases at a higher temperature.

.....

.....

.....

..... [3]

**(ii)** Draw a line on the graph in **(b)** for the experiment at a higher temperature. [2]

[Total: 10]



**[Turn over**

**7** **(a)** Ethanol is a member of the homologous series of alcohols.

Give **two** characteristics of members of a homologous series.

1 .....

2 .....
[2]

**(b)** Ethanol can be manufactured from ethene.

Ethene can be made from long chain hydrocarbons such as decane, $C_{10}H_{22}$.

Ethene is then converted into ethanol.

**(i)** Name the process used to obtain ethene from long chain hydrocarbons such as decane, $C_{10}H_{22}$.

..... [1]

**(ii)** Complete the chemical equation to show the formation of ethene from decane, $C_{10}H_{22}$.

$$C_{10}H_{22} \rightarrow C_4H_8 + \text{.....} + \text{.....}$$ [2]

**(iii)** Write the chemical equation for the conversion of ethene into ethanol.

..... [1]

**(iv)** Name the type of reaction occurring when ethene is converted into ethanol.

..... [1]

**(v)** Give **one** condition for the reaction in which ethene is converted into ethanol.

..... [1]

**(c)** Ethanol can also be produced by fermentation of carbohydrates such as glucose.

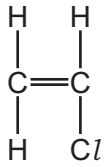
Give **two** advantages of manufacturing ethanol by fermentation compared to manufacturing ethanol from ethene.

1 .....

2 .....
[2]

**(d) (i)** Under certain conditions ethene can react with chlorine to produce chloroethene.

The structure of chloroethene is shown.



The equation for the chemical reaction is shown.

$$C_2H_4 + Cl_2 \rightarrow C_2H_3Cl + HCl$$

State the type of chemical reaction between ethene and chlorine that this equation shows.

..... [1]

**(ii)** Chloroethene monomers can be converted into a polymer called poly(chloroethene).

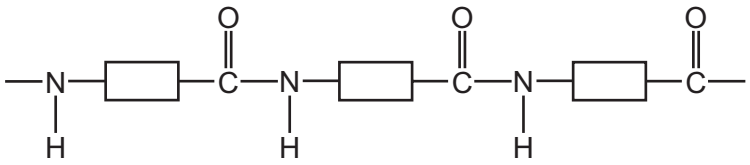
State the type of polymerisation that produces poly(chloroethene) from chloroethene.

..... [1]

**(iii)** Draw a section of the poly(chloroethene) molecule made from **two** monomer molecules.

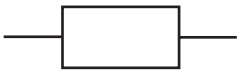
[2]

**(e)** The structure of part of a polymer is shown.




This polymer is made from one type of monomer only.

Complete the diagram to show the structure of the monomer used to produce this polymer. Show all of the atoms and all of the bonds in the functional groups.



[2]

[Total: 16]

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## The Periodic Table of Elements

| Group | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | II | | | | | | | | | | | III | IV | V | VI | VII | VIII |
| | | | | | | | 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**

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 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.).