Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

6601588138

CHEMISTRY **0620/31**

Paper 3 Theory (Core) **May/June 2022**

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 **20** pages. Any blank pages are indicated.

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[Turn over

1 **(a)** A list of symbols and formulae is shown.

CaO
CH_4
C_2H_4
C_2H_6
Cl^-
Cu^{2+}
H_2
He
K^+
N_2
Na^+
SO_2

Answer the following questions using these symbols or formulae.
Each symbol or formula may be used once, more than once or not at all.

State which symbol or formula represents:

(i) a compound produced by the thermal decomposition of calcium carbonate

..... [1]

(ii) a positive ion that gives a blue-green colour in a flame test

..... [1]

(iii) an element used as a fuel

..... [1]

(iv) the monomer used to produce poly(ethene)

..... [1]

(v) an ion formed when an atom gains an electron.

..... [1]

(b) Complete the table to show the relative charges of a proton, a neutron and an electron.

type of particle	relative charge
proton	+1
neutron	
electron	

[2]

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(c) Choose the two correct statements about nitrogen.
Tick (✓) **two** boxes.

Nitrogen molecules are monoatomic.	☐
All nitrogen atoms have seven protons.	☐
Nitrogen atoms cannot be split into simpler substances by chemical means.	☐
All nitrogen atoms have 14 neutrons.	☐
Nitrogen is 21% of clean, dry air.	☐

[2]

[Total: 9]

2 The table shows the masses of some ions in a 1000 cm^3 sample of toothpaste.

name of ion	formula of ion	mass of ion in 1000 cm^3 of toothpaste / g
	NH_4^+	0.2
calcium	Ca^{2+}	1.2
	Cl^-	0.9
fluoride	F^-	1.4
magnesium	Mg^{2+}	2.0
phosphate	PO_4^{3-}	24.4
sodium	Na^+	28.1
sulfate	SO_4^{2-}	9.2
tin(II)	Sn^{2+}	0.2
zinc	Zn^{2+}	0.1

(a) Answer these questions using only the information in the table.

(i) State which negative ion has the lowest mass in 1000 cm^3 of toothpaste.

..... [1]

(ii) Name the compound that contains NH_4^+ and Cl^- ions.

..... [1]

(iii) Calculate the mass of phosphate ions in 250 cm^3 of toothpaste.

mass = ... g [1]

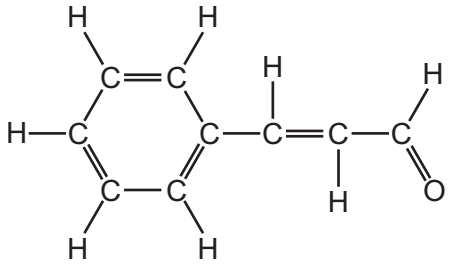
(b) Describe a test for sulfate ions.

test .....

observations .....
[2]

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(c) Toothpaste also contains cinnamal.
The structure of cinnamal is shown.



Deduce the formula of cinnamal to show the number of atoms of carbon, hydrogen and oxygen.

..... [1]

(d) Cinnamal can be oxidised to a carboxylic acid.

(i) Draw the structure of a carboxylic acid functional group to show all of the atoms and all of the bonds.

[1]

(ii) Ethanoic acid is a carboxylic acid.
Ethanoic acid reacts like a typical acid.

Complete the word equation for the reaction of ethanoic acid with sodium carbonate.

ethanoic acid	+	sodium carbonate	→	sodium ethanoate	+	....	+	.....

[2]

[Total: 9]

3 This question is about halogens and halogen compounds.

(a) Deduce the number of electrons, neutrons and protons in one atom of the isotope of chlorine shown.

$$^{37}_{17}Cl$$

number of electrons .....

number of neutrons .....

number of protons .....

[3]

(b) State why chlorine is used in water treatment.

..... [1]

(c) Aqueous chlorine reacts with aqueous potassium iodide.

(i) Complete the chemical equation for this reaction.

$$Cl_2 + ...KI \rightarrow .....KCl + I_2$$ [2]

(ii) Explain in terms of the reactivity of the halogens why aqueous iodine does **not** react with aqueous potassium chloride.

.....

..... [1]

(d) The table shows some properties of four halogens.

halogen	melting point / °C	boiling point / °C	density of liquid at boiling point in g / cm^3
fluorine	–220	.....	1.51
chlorine	–101	–35	.....
bromine	–7	59	3.12
iodine	114	184	4.93

(i) Complete the table by predicting:
- the boiling point of fluorine
- the density of liquid chlorine at its boiling point. [2]

(ii) Predict the physical state of chlorine at –105 °C.
Give a reason for your answer.

.....

..... [2]

[Total: 11]

4 This question is about acids and bases.

(a) Describe the colour of methyl orange in acidic and alkaline solutions.

in acidic solution .....

in alkaline solution .....

[2]

(b) Complete the word equation for the reaction of hydrochloric acid with calcium oxide.

hydrochloric acid	+	calcium oxide	→	....	+	.....

[2]

(c) Calcium oxide is lime.

Give **one** use of lime.

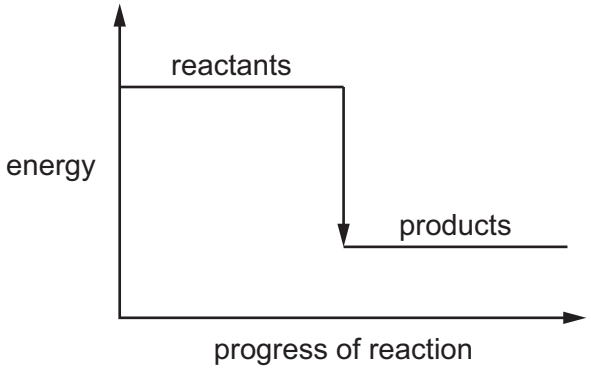
..... [1]

(d) The reaction of hydrochloric acid with calcium oxide is exothermic.

(i) State the meaning of the term *exothermic*.

..... [1]

(ii) The energy level diagram for the reaction of hydrochloric acid with calcium oxide is shown.



Explain how the energy level diagram shows that this reaction is exothermic.

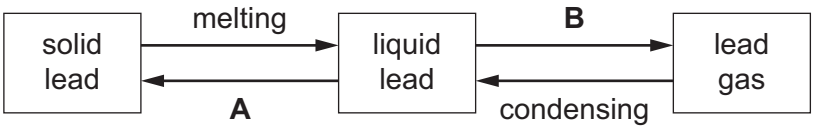
.....

..... [1]

[Total: 7]

5 This question is about Group IV elements and their compounds.

(a) The changes of state of lead are shown.



Name the changes of state represented by **A** and **B**.

A .....

B .....
[2]

(b) Use the kinetic particle model to describe the differences between liquid lead and lead gas in terms of:

- the separation of the particles .....

.....

.....

- the motion of the particles. .....

.....

.....
[4]

(c) Lead is extracted from lead(II) oxide by heating with carbon.

$$PbO + C \rightarrow Pb + CO$$

Describe how this equation shows that lead(II) oxide is reduced.

.....

..... [1]

(d) Lead is a pollutant of the air.

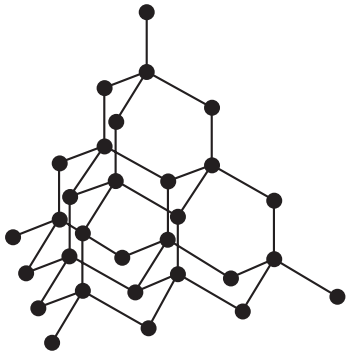
(i) State **one** source of lead in the air.

..... [1]

(ii) State **one** adverse effect of lead on health.

..... [1]

(e) Diamond is a form of carbon.
The structure of diamond is shown.



(i) Choose the word which best describes the structure of diamond.

Draw a circle around your chosen answer.

giant **ionic** **metallic** **simple** [1]

(ii) Name the type of bonding in diamond.

..... [1]

(iii) Give **one** use of diamond.

..... [1]

(iv) Deduce the electronic structure of carbon.

Use the Periodic Table to help you.

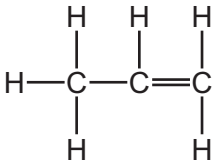
..... [1]

[Total: 13]

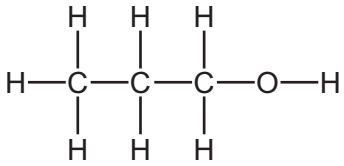
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6 **(a)** The structures of four organic compounds, **C**, **D**, **E** and **F**, are shown.

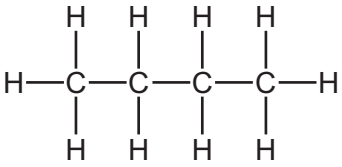
C



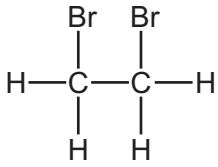
D



E



F



Answer the following questions about these compounds.
Each compound may be used once, more than once or not at all.

State which compound, **C**, **D**, **E** or **F**:

(i) decolourises aqueous bromine ..... [1]

(ii) is an alcohol ..... [1]

(iii) is unsaturated ..... [1]

(iv) is in the same homologous series as ethane. ..... [1]

(b) Petroleum is a mixture of hydrocarbons which can be separated into fractions with different boiling points.

Name the method used to separate these fractions.

..... [1]

(c) Complete the table to show the name and uses of some petroleum fractions.

name of fraction	use of fraction
refinery gas	
gasoline	
	waxes and polishes

[3]

(d) Some hydrocarbons are formed by the process of cracking.

(i) State the meaning of the term *cracking*.

.....

.....

..... [2]

(ii) Describe the conditions needed for cracking.

.....

..... [2]

[Total: 12]

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7 This question is about zinc and compounds of zinc.

(a) Zinc is a metal.

Give **three** physical properties of metals.

1 .....

2 .....

3 .....

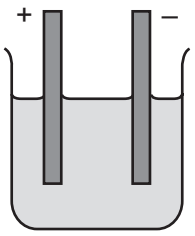
[3]

(b) Zinc reacts with phosphorus to form zinc phosphide, Zn_3P_2.

Complete the equation for this reaction.

$$.....Zn + ...P \rightarrow Zn_3P_2$$ [2]

(c) Molten zinc chloride is electrolysed.
The incomplete apparatus is shown.



(i) Complete the diagram by:
- completing the circuit to show the wires and power pack
- labelling the anode. [2]

(ii) Name the products formed at each electrode.

positive electrode .....

negative electrode .....

[2]

(d) Zinc chloride reacts with water as shown. The solution formed is acidic.

$$ZnCl_2 + 2H_2O \rightleftharpoons Zn(OH)_2 + 2HCl$$

(i) State the meaning of the symbol $\rightleftharpoons$.

..... [1]

(ii) Choose the pH value which is acidic.

Draw a circle around your chosen answer.

pH 3 pH 7 pH 9 pH 14 [1]

(e) A compound of zinc has the formula ZnC_4H_{10}.

Complete the table to calculate the relative molecular mass of ZnC_4H_{10}.

atom	number of atoms	relative atomic mass	
zinc	1	65	$1 \times 65 = 65$
carbon		12	
hydrogen		1	

relative molecular mass = ... [2]

[Total: 13]

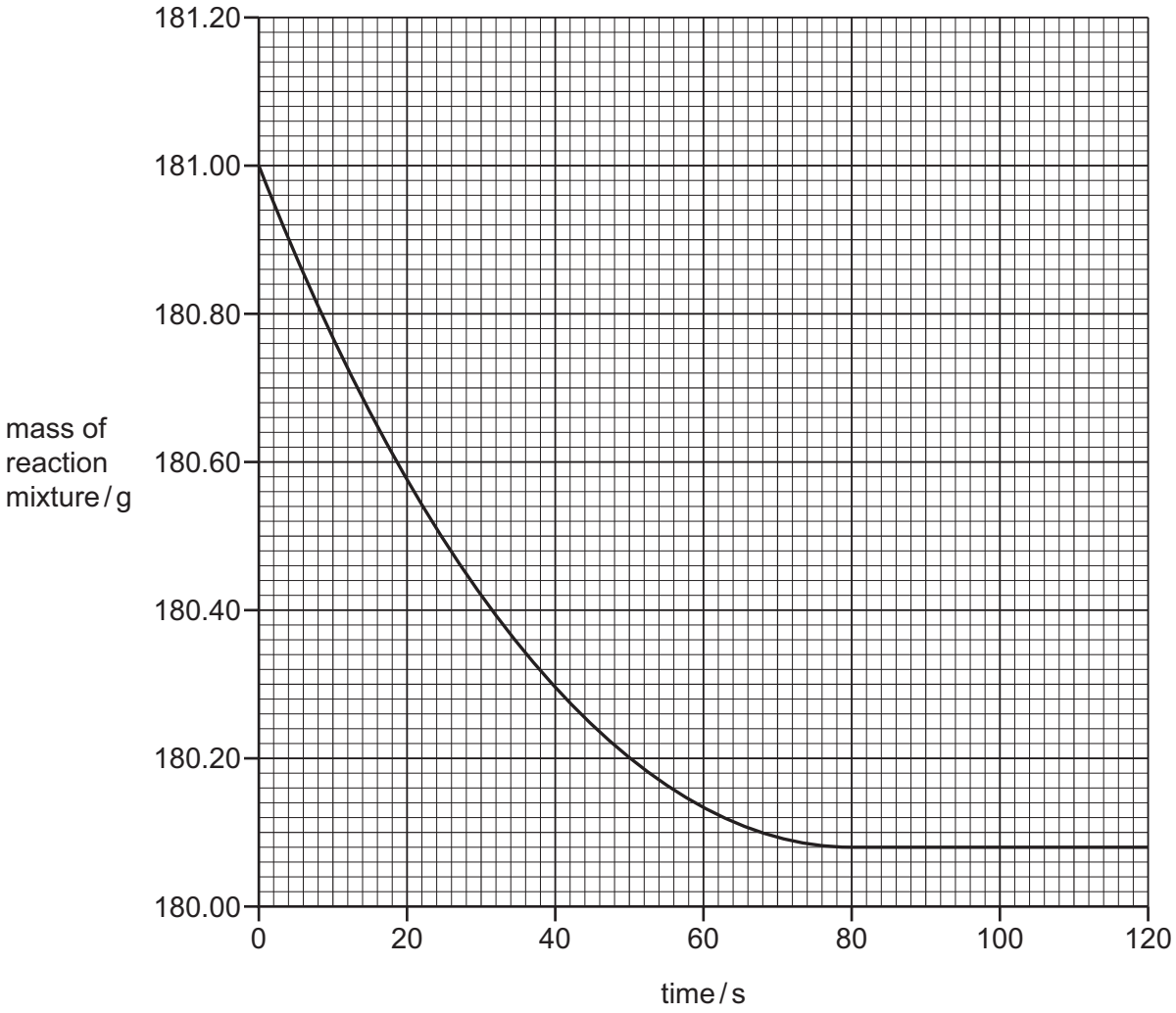
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8 A student investigates the reaction of large pieces of copper(II) carbonate with dilute hydrochloric acid. The hydrochloric acid is in excess.

$$CuCO_3 + 2HCl \rightarrow CuCl_2 + CO_2 + H_2O$$

The rate of reaction is found by measuring the mass of the reaction mixture as time increases.

The results are shown on the graph.



(a) Deduce the mass of the reaction mixture at 30 s.

mass = ... g [1]

(b) The experiment is repeated using smaller pieces of copper(II) carbonate.

All other conditions stay the same.

Draw a line **on the grid** to show how the mass of the reaction mixture changes as time increases. [2]

(c) Describe the effect each of the following has on the rate of reaction of copper(II) carbonate with dilute hydrochloric acid.

All other conditions stay the same.

- The reaction is carried out in the presence of a catalyst.

.....

- The reaction is carried out using a lower concentration of hydrochloric acid.

.....
[2]

(d) When 0.2 g of copper(II) carbonate is used, 38 cm^3 of carbon dioxide gas is produced.

Calculate the volume of carbon dioxide gas produced when 0.50 g of copper(II) carbonate is used.

volume of carbon dioxide gas = ... cm^3 [1]

[Total: 6]

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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.).